Funded by
European Union
Civil Protection

Final report

For the Wind Risk prevention project

University of Ljubljana
Technical University of Dortmund
University of Split
Municipality of Ajdovščina

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1. Project description

The project aims to improve the effectiveness of existing policies and financial instruments through guidelines for local-based disaster risk reduction actions and tools in instances of high wind and also take into account the influences of climate change.

During the two year project an improved knowledge of high wind through accurate high frequency measurement will be the basis for creating guidelines for urban risk assessment and improved links between relevant actors and policies (prevention-preparedness-response-recovery). The cooperation of three EU countries will provide a cross-country exchange of good practices which could then be applied to other areas in the EU and broader with high wind risk exposure. An automated system for alarming the local civil protection operators will be provided with a live online web-based streaming of accurate wind measurements in four different locations, one in each participating city, in three countries. Special guidelines for raising public awareness, regulations for transit both on land and in the harbour, improvement of existing and new building and infrastructure as well as better forest management will be prepared. Preliminary socio-economic analysis of the cost of civil protection and damage repair compared with local financial endorsement for safer/risk free building will be given. The findings and guidelines will be presented at different national and transnational conferences.

The main reason for the necessity of the project is to improve the understanding of high wind and wind gusts, to improve the awareness of wind risk and to improve the preparedness of national and civil protection, especially with regards to higher erratic winds due to the ongoing climate change.

Territorial planning recommendations aiming at minimizing the vulnerabilities need to be established. Recommendations concerning the physical investments that will be required to protect or upgrade the infrastructure assets and systems, important civil buildings (hospitals, kindergartens, schools…), transit communications (bridges, highways, roads…) and forest management. Recommendations concerning the institutional preparedness and emergency plans for local civil protection institutions in view of wind risk. Recommendations concerning additional building code, rules and regulations in all areas for high wind and wind gusts with a focus on materials used and fastening of these materials for residential buildings, infrastructure, transit design, harbour design, public buildings and forest management. Economical evaluation of local endorsements for construction of buildings, transit communication and infrastructure in compliance with the guidelines and compared with costs for civil preparedness, protections and disaster damage repair.

2. General summary of project implementation process

The Wind Risk prevention project is finished after two years. The project went according to the plan and work on most of the expected activities is done. In addition, due to some minor schedule changes, some additional activities were made. Big interest was noted by the general public, as well as by different official and unofficial stakeholders involved in prevention and preparedness.

In addition to the work done separately, joint workshops have been done at four project meetings in Ajdovščina (Slovenia), Split (Croatia), Dortmund (Germany) and Ljubljana (Slovenia). Several papers were published in local media as well as news conferences at all meetings. In addition to the meetings, live communication through different communication channels and forums was present almost on a monthly basis, as well as countless e-mails.

The reports for Actions within task C and D were completed on schedule. The articles published in specialized EU journals or magazines were rescheduled for the end of the project and will be finished in the end of March. Other activities had gone according to the original time schedule.

The resources have been used according to the plan. Minor changes were proposed, confirmed and made to the proposed plan. Some additional outsourcing was done to acquire expert knowledge and services (Technical University of Dortmund, University of Split). The staffs working on the project is according to the planned schedule. Thus the financial report is within the proposed budget.

The results produced within the final interim period have shown that the expectations of the project were fairly accurate. It was shown that climate change plays a big part in the magnitude and frequency of wind related disaster risk. The detailed analysis also showed the high vulnerability of project areas to high wind and to high wind in combination with snow and sleet as well. Since all countries are part of European Union, common laws of EU are applicable to all countries, but most space for improvements seems to be in local legislation. It was also found out that for future evaluation of social and economic impacts of wind risk disaster keeping register of damages such as Slovenian AJDA system is recommended. With such a tool it would be possible to evaluate total damage of each event with social and economic consequences, and not only extreme events, and better asses the causes and effects of the damages. Finally, the interaction between the local and national disaster preparedness institutions for wind disaster events was evaluated as a case study.

3. Evaluation of project management/implementation process

All project partners are very positive about the outcome of the project. The conclusions of Actions within task C showed new opportunities for improvements in the field of wind risk. Gathering quality data on weather and wind speeds from the recent history proved to be an external difficulty in some cases.

The cooperation with the Commission is done on regularly and promptly by the project coordinator. All changes concerning the financial, the personnel, the progress and the content have thus far been reported and approved. The response of the Commission is fast, clear and precise.

Although wind damage is a major problem not only in the countries participating in the project, but in the whole Europe, and beyond, too few studies are looking at wind related risk and ways to prevent future damage. Therefore it is essential that projects like this are co-funded by the European Commission to expand wind risk knowledge.

4. Activities

Task A: Project management
The actions under Task A have been started right at the beginning of the project and will continue until the very end. All deliverables planned for the final interim report period have been delivered on schedule.

Task B: Wind measurement
All actions in the Task B were meant to be finished by within the second interim report period and all have been done for the most part. Problems with the wind measuring systems, which are funded outside the budget of this project, have made some problems, but are being met.

Dortmund and Ljubljana have not yet produced a wind measuring system. Ljubljana is planning to do so by the end of the year. Dortmund has made arrangements to acquire records of wind measurements with local institutions outside the project and do not plan to have a live stream system within the project. Since in Ljubljana and Dortmund storms are the major problem and these occur without real notice, it is not as important as in Ajdovščina and Split, where Bora is present, to get the live stream system since warning will be difficult. The Alarm system for local civil protection units is not yet running entirely, since the stakeholders noted that the alarm will not be official. Thus the alarm is mostly meant for informational purposes for the local civil protection units.

Task C: Risk/Vulnerability assessment
All actions in the Task C were completed and the joint report was finished.

Task D: Action plan
All actions in the Task D were completed and the joint report was finished.

Task E: Dissemination
Within the dissemination several deliverables have been produced. Since the majority of the research work has been done till final interim report, most of the deliverables are focused on reporting the main focus and activities done within the project. Among the deliverables within the final interim report are: Newsletters, Articles and appearances in the local media, TV and Radio Interviews and Press conferences. The Facebook page, LinkedIn page and Project website are also updated according to activities. The number of workshop is reduced from 9 to 5. Every workshop was and still is planned to take place at the time of each project meeting. Two of Three articles published in specialized EU journals or magazines are in progress, while one article is submitted as a book chapter with title "Enhancing resilience towards summer storms from a spatial planning perspective – lessons learned from summer storm *Ela*".

The detailed presentation activities is given in the Annex of this report.

5. Evaluation of the technical results and deliverables

The Wind Risk Project has provided useful data by cooperation of four partners from three parts of Europe where wind-related events occur in great dimensions. In Croatia, Slovenia and Germany, high winds are the cause of different catastrophic events, but the results provided by cooperation throughout the Wind Risk Project, turned out to be similar and therefore can be summarized and may be used also in other regions that are influenced by weather phenomena caused by high winds. Results of the project may be used as guidelines for decreasing the costs related to the windstorm events as well as ensuring the probability for injuries and fatalities stays on the lowest level possible.

Wind risk comes along with natural meteorological risks that can cause devastating consequences in many aspects of people's life. Social impacts of wind disasters are mainly due to limited mobility of citizens, while economic impacts are mostly expressed in material damages and indirect losses. With a register of wind risk disasters, the evaluation of total social and economic impact of wind storms would be made possible, providing data for further studies of preparedness and protection of people, property and goods.

Some of the damage can be prevented with careful spatial planning and detailed construction design. Indirect losses might be greatly reduced with studies of wind speed and its flow over highways and designing correct infrastructure as well as building effective wind barriers along critical sections of highways and also designing the planting of trees in a way that heavily reduces the transport of soil during high winds. Other social impacts may be reduced with the preparedness of civil protection and other emergency units and making sure that the units have enough manpower and gear to act as needed. Also measurements, accurate forecasting and alarming in time have a great influence of people and services' preparedness.

Concerning climate changes, it is obvious, that not only the extreme temperature changes will affect the world population in the future. As seen in the last few decades, high-wind evens are more noticeable in the presented areas. Predictions so far show the possibility of stronger wind storms that could be expected over Europe in the future, but the lack of data strongly indicates that there is a need for further research activities on wind-based events. Higher winds are to be expected in the future, but there are also other events that require more attention. In particular, lower wind speeds should be considered as hazardous in the combination with other weather-concerned factors such as sleet and hail. As in case of North-Rhine Westphalia, also the case of seasonal non-predicted weather events should be taken into account as the weather-change factor, which can provide high risks that were not taken into consideration in the past.

Annex A: Comparison between initially planned and actually implemented activities (1st interim period)

Period	Task ID	Action	Deliverable	Description	Responsible	Status
1.2.2015	Task A	A.2	D.A.1	Legal agreement	Ljubljana	completed
1.2.2015	Task E	E.1	D.E.1	Communication Plan	Ljubljana	completed
1.2.2015	Task E	E.1	D.E.2	Project logo	Ljubljana	completed
1.2.2015	Task E	E.1	D.E.3	Integrated set of communication templates and materials	Ljubljana	completed
1.2.2015	Task E	E.1	D.E.8.1	Press releases, articles and appearances in the local media n. 1	Ljubljana	completed
1.3.2015	Task A	A.2	D.A.2	Detailed project plan	Ljubljana	completed
1.3.2015	Task E	E.1	D.E.4	Design and implementation of project website illustrating the entire WIND RISK project (partners, outputs, actions, results)	Ljubljana	completed
1.3.2015	Task E	E.1	D.E.5	Activation of Facebook page	Ljubljana	completed
1.3.2015	Task E	E.1	D.E.7.1	Newsletters n. 1	Ljubljana	completed
1.4.2015	Task A	A.2	D.A.3	Stakeholders and target groups communication list	Ljubljana	completed
1.4.2015	Task E	E.1	D.E.8.2	Press releases, articles and appearances in the local media n. 2	Ljubljana	completed
1.5.2015	Task A	A.2	D.A.4	Monitoring and evaluation procedure and plan	Ljubljana	completed
1.5.2015	Task E	E.1	D.E.7.2	Newsletters n. 2	Ljubljana	completed
1.6.2015	Task B	B.1	D.B.1	Wind measurement system with high frequency measurements in all participating countries	All	completed
1.6.2015	Task E	E.1	D.E.6	Virtual community and discussion forum	Ljubljana	completed
1.6.2015	Task E	E.1	D.E.8.3	Press releases, articles and appearances in the local media n. 3	Ljubljana	completed
30.6.2015	Task C	C.1	D.C.1	Report containing the detailed assessments of future climate change and probabilistic risk assessment of wind disasters	Dortmund	completed
30.6.2015	Task C	C.2	D.C.2	Report containing the detailed analysis of the vulnerability to high average wind and high wind gusts in aspect to population, infrastructure, buildings, transit and forest management	Ajdovščina	completed
30.6.2015	Task C	C.3	D.C.3	Report containing the assessment of the vulnerability to high wind in combination with snow or sleet	Ljubljana	completed
1.7.2015	Task B	B.2	D.B.2	Live stream measurement reading web page	Ljubljana	completed
1.7.2015	Task E	E.1	D.E.7.3	Newsletters n. 3	Ljubljana	completed
31.8.2015	Task B	B.3	D.B.3	Automatic alarm system at high wind for local civil protection units	Ajdovščina	scheduled for 31.10.2016
31.8.2015	Task E	E.2	D.E.11.1	Press conference n. 1	Ljubljana	completed
31.8.2015	Task A	A.3	D.A.7.1	First interim report	Ljubljana	completed

Annex B: Comparison between initially planned and actually implemented activities (2nd interim period)

Period	Task ID	Action	Deliverable	Description	Responsible	Status
1.9.2015	Task E	E.1	D.E.7.4	Newsletters n. 4	Ljubljana	completed
30.9.2015	Task C	C.4	D.C.4	Report containing the assessment of the vulnerability to high wind during storms	Dortmund	completed
30.9.2015	Task C	C.5	D.C.5	Report containing the assessment of the legislation in terms of protection against high average wind and high wind gusts for the population, infrastructure, transit, buildings and forest management	Split	completed
1.10.2015	Task E	E.1	D.E.8.4	Press releases, articles and appearances in the local media n. 4	Ljubljana	completed
1.10.2015	Task E	E.2	D.E.10	Promotional brochure (800 pc.)	Ljubljana	scheduled for 31.10.2016
1.11.2015	Task E	E.1	D.E.7.5	Newsletters n. 5	Ljubljana	completed
1.12.2015	Task E	E.1	D.E.8.5	Press releases, articles and appearances in the local media n. 5	Ljubljana	completed
31.12.2015	Task A	A.2	D.A.6.1	Long-term activity plan n. 1	Ljubljana	completed
31.12.2015	Task C	C.6	D.C.6	Report containing the evaluation of socio-economic costs of the impacts of high wind disasters	Split	completed
31.12.2015	Task C	C.7	D.C.7	Report containing the assessment of the roles and activities of national and local institutions in the territorial planning, infrastructure and disaster preparedness	Ajdovščina	completed
31.12.2015	Task C	C.8	D.C.8	Report on the civil initiative roles and obstacles in providing help at wind disaster events on the EU level, the country level and locally	Ajdovščina	completed
31.12.2015	Task E	E.1	D.E.9.1	Articles published in specialized EU journals or magazines n. 1	Ljubljana	scheduled for 31.10.2016
31.12.2015	Task E	E.1	D.E.9.2	Articles published in specialized EU journals or magazines n. 2	Ljubljana	scheduled for 31.10.2016
31.12.2015	Task E	E.1	D.E.9.2	Articles published in specialized EU journals or magazines n. 3	Ljubljana	scheduled for 31.10.2016
1.1.2016	Task A	A.3	D.A.8	Evaluation report on intermediate results	Ljubljana	completed
1.2.2016	Task E	E.1	D.E.7.6	Newsletters n. 6	Ljubljana	completed
1.2.2016	Task E	E.1	D.E.8.6	Press releases, articles and appearances in the local media n. 6	Ljubljana	completed
1.4.2016	Task E	E.1	D.E.7.7	Newsletters n. 7	Ljubljana	completed
1.4.2016	Task E	E.1	D.E.8.7	Press releases, articles and appearances in the local media n. 7	Ljubljana	completed
30.4.2016	Task E	E.2	D.E.11.2	Press conference n. 2	Ljubljana	completed
30.4.2016	Task A	A.3	D.A.7.2	Second interim report	Ljubljana	completed

Annex C: Comparison between initially planned and actually implemented activities (Final period)

Period	Task ID	Action	Deliverable	Description	Responsible	Finished
1.6.2016	Task E	E.1	D.E.7-8	Newsletters n. 8	Ljubljana	completed
1.6.2016	Task E	E.1	D.E.8.8	Press releases, articles and appearances in the local media n. 8	Ljubljana	completed
30.6.2016	Task D	D.1	D.D.1	Action plan section containing specific territorial planning recommendations aiming at minimizing the vulnerabilities	Split	completed
30.6.2016	Task D	D.2	D.D.2	Action plan section containing specific recommendations concerning the physical investments that will be required to protect or upgrade the infrastructure, transit, buildings and forests	Dortmund	completed
30.6.2016	Task D	D.3	D.D.3	Action plan section containing specific recommendations concerning the institutional preparedness and emergency plans for local civil protection institutions in view of wind risk	Ajdovščina	completed
1.9.2016	Task E	E.1	D.E.7.9	Newsletters n. 9	Ljubljana	completed
30.9.2016	Task D	D.4	D.D.4	Action plan section containing specific recommendations concerning additional building code, rules and regulations	Ljubljana	
30.9.2016	Task D	D.4	D.D.5	Action plan section containing specific recommendations concerning rules for forest management	Dortmund	completed
30.9.2016	Task D	D.4	D.D.6	Action plan section containing specific recommendations concerning rules for transit management	Ljubljana	completed
1.10.2016	Task E	E.1	D.E.8.9	Press releases, articles and appearances in the local media n. 9	Ljubljana	completed
31.10.2016	Task E	E.2	D.E.11.3	Press conference n. 3	Ljubljana	completed
1.11.2016	Task E	E.1	D.E.7.10	Newsletters n. 10	Ljubljana	
30.11.2016	Task D	D.5	D.D.7	Action plan section containing specific recommendations concerning rules for infrastructure	Dortmund	completed
30.11.2016	Task D	D.6	D.D.8	Action plan section of comparing new measured data with data from existing measurement stations and systems	Ljubljana	completed
31.12.2016	Task A	A.2	D.A.5	Short-term activity plans (8)	Ljubljana	completed
31.12.2016	Task A	A.2	D.A.6.2	Long-term activity plan n. 2	Ljubljana	
31.12.2016	Task A	A.3	D.A.9.1	Agenda, minutes and attendance lists from PSB meetings	Ljubljana	
31.12.2016	Task A	A.3	D.A.9.2	Agenda, minutes and attendance lists from TC meetings	Ljubljana	
31.12.2016	Task A	A.3	D.A.11	Evaluation report of the final results	Ljubljana	
31.12.2016	Task D	D.7	D.D.9	Action plan section containing specific recommendations concerning guidelines for local economical endorsements for construction of buildings that will reduce wind risk exposure	Split	completed
31.12.2016	Task E	E.1	D.E.8.10	Press releases, articles and appearances in the local media n. 10	Ljubljana	completed
31.12.2016	Task E	E.2	D.E.12	Final event with press conference	Ljubljana	completed

31.12.2016	Task E	E.2	D.E.13	Final report with studies and guidelines (400 pc.)	Ljubljana	
31.12.2016	Task E	E.2	D.E.14.1	Presentation of project implementation, results and outcomes on USB (400 pc.)	Ljubljana	completed
31.12.2016	Task E	E.2	D.E.14.2	Report on sustainability of project results and continuation of research after the project-end on USB (400 pc.)	Ljubljana	
31.12.2016	Task A	A.3	D.A.10	Final report	Ljubljana	
1.2.2017	Task A	A.3	D.A.12	Post-project evaluation report and continuation analysis	Ljubljana	

Annex D: Extensive joint report containing 673 pages with full Task C and D reports.

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Civil Protection

»With the contribution of the Civil Protection
Financial Instrument of the European Union«

Extensive joint report

For the Wind Risk prevention project

University of Ljubljana
Technical University of Dortmund
University of Split
Municipality of Ajdovščina

European Civil Protection

»With the contribution of the Civil Protection Financial Instrument of the European Union«

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European Union
Humanitarian Aid &
Civil Protection

WIND RISK

Task C – Risk/Vulnerability assessment

Action C.1: Updated and complete assessment of wind related risks in aspect of future climate change

For the Wind Risk prevention project

University of Ljubljana
Technical University of Dortmund
University of Split
Municipality of Ajdovščina

European Civil Protection

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WIND RISK

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Chapter C.1 - Updated and complete assessment of wind related risks in aspect of future climate change

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1. Modelling Climatic Changes

Climate is defined on the basis of long term measurements, usually not less than 30 years. On earth, climate conditions are mostly influenced by solar and astronomic activities. Overall the climate system is composed of:

- The atmosphere: gasses and liquid and solid particles of aerosol.
- The hydrosphere: oceans, seas, lakes and rivers.
- The cryosphere: ice cover of earth.
- The soil: topography, terrain, soil type, vegetation.
- The biosphere: all living beings on earth.

Since the industrial age, anthropogenic influence on the climatic system has risen. On the one hand and increased emission of greenhouse gasses into the atmosphere triggered and still triggers disperse heat radiation, including the reflection back to the earth. Over time, the lower layers of the atmosphere heat up, leading to an increased average (and extreme) temperature. On the other hand, the ongoing exploitation of forests decreases the capacity of CO_2 storing and the natural filter function of the air. Combined they trigger the greenhouse effect.

The greenhouse effect already leads to great variations of the climatic conditions on earth. They can be observed both on the spatial and the temporal scale. On the spatial scale, variations highly depend on the geographical latitude, altitude and also the vicinity to oceans. On the temporal scale the variations can be measured in long-term trends, years, seasons and on a daily basis.

The prediction of future climatic conditions always comes along with great uncertainties. Nevertheless, researchers are making progress in modelling climatic changes and predicting probable future conditions.
As the future climatic conditions highly depend on the development of the atmosphere, which again is mainly dependent on the amount of greenhouse gas emissions, different modelling scenarios were developed by researchers.
For many years, the guiding emission scenarios used by researches worldwide were taken from the Special Report on Emission Scenarios (SRES) by the Intergovernmental Panel on Climate Change (IPCC). The SRES scenarios comprised different scenarios on the future development of the worldwide industry and, as a consequence, the probable greenhouse gas emissions. Four storylines with different subgroups were used to describe the future worldwide development of the industry.

A1)
The A1 storyline and scenario family describes a future world of very rapid economic growth, global population that peaks in mid-century and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building and increased cultural and social interactions, with a substantial reduction in regional differences in per capita income. The A1 scenario family develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance[1] across all sources (A1B).

[1] where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end-use technologies.

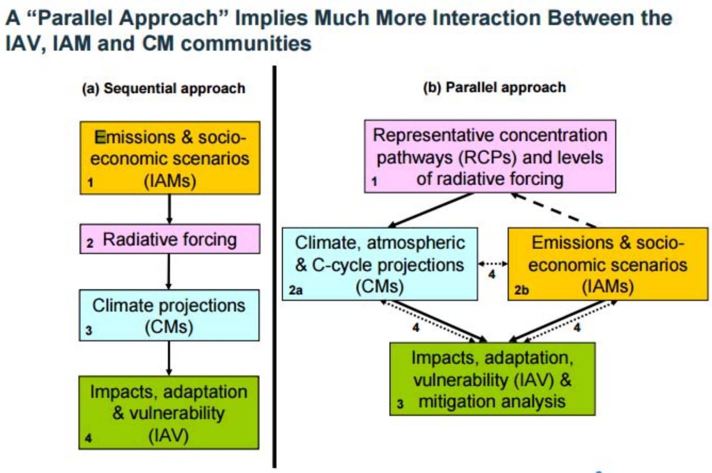
A2)
The A2 storyline and scenario family describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented and per capita economic growth and technological change more fragmented and slower than in other storylines.

B1)
The B1 storyline and scenario family describes a convergent world with the same global population, that peaks in mid-century and declines thereafter (as in the A1 storyline), but with rapid change in economic structures toward a service and information economy, with reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social and environmental sustainability, including improved equity, but without additional climate initiatives.

B2)
The B2 storyline and scenario family describes a world in which the emphasis is on local solutions to economic, social and environmental sustainability. It is a world with continuously increasing global population (at a rate lower than A2), intermediate levels of economic development, and less rapid and more diverse technological change than in the A1 and B1 storylines. While the scenario is also oriented towards environmental protection and social equity, it focuses on local and regional levels. (Cf. Website IPCC 2015)

However, there was some criticism that the SRES scenarios were non-mitigative and lacked decoupling of climate modelling from the emission scenarios. In 2005, the IPCC made the decision to adopt new scenarios for the fifth Assessment Report (AR5), named Representative Concentration Pathways (RCPs), which are following a parallel modelling approach (see Figure 1).

Figure 1: Sequential vs. parallel modelling approach



Source: Website UNFCCC 2010.

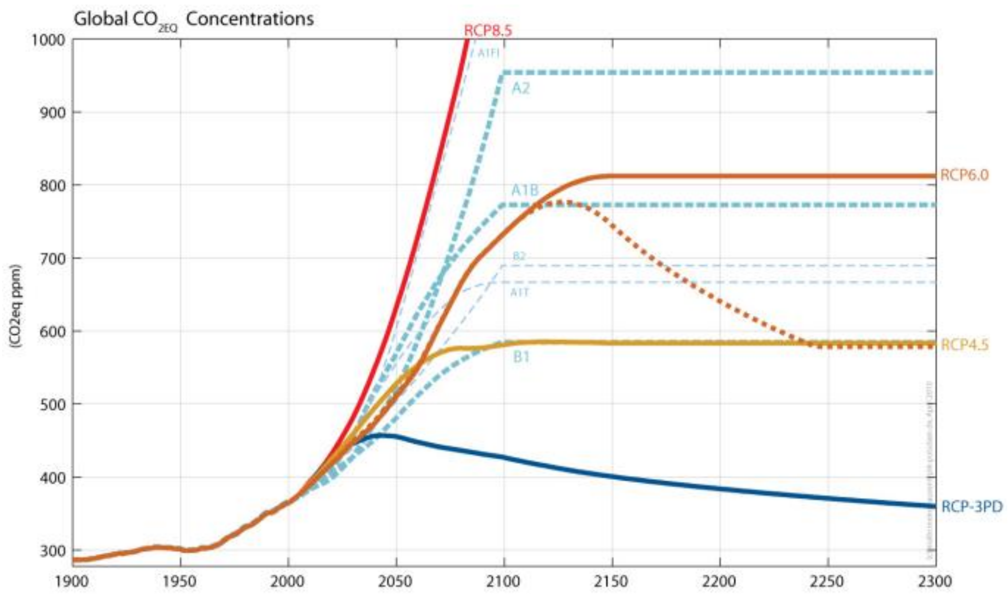
In comparison with SRES scenarios, RPCs are sets of projections of only the components of radiative forcing (the change in the balance between incoming and outgoing radiation to the atmosphere caused primarily by changes in atmospheric composition). These are meant to serve as input for climate modelling. Each RPC scenario is a representative for several scenarios that can result in such radioactive forcing pathways. The RCPs do not contain detailed socioeconomic narratives or scenarios.

Four RCPs were selected, defined and named according to their total radiative forcing in 2100.

- RPC 2.6 (sometimes referred to as RCP3-PD where PD stands for peak and decline)
- RCP 4.5
- RPC 6
- RPC 8.5

Comparing the resulting CO_2 global concentrations, analogues between SRES and RCP scenarios can be found (see Fig. 2 and Tab. 1).

Figure 2: Global CO_2 concentrations in SRES and RCPs



Source: Website UNFCCC 2010.

Table 1: Analogues between RCPs and SRES

RCP Scenarios	Scenario Characteristics	Comparison to SRES Scenarios
RCP 2.6	An extremely low scenario that reflects aggressive greenhouse gas reduction and sequestration efforts	No analogues in previous scenarios
RCP 4.5	A low scenario in which greenhouse gas emissions stabilize by mid-century and fall sharply thereafter	Very close to B1 by 2100, but higher emissions at mid-century
RCP 6.0	A medium scenario in which greenhouse gas emissions increase gradually until stabilizing in the final decades of the 21st century	Similar to A1B by 2100, but closer to B1 at mid-century
RCP 8.5	A high scenario that assumes continued increases in greenhouse gas emissions until the end of the 21st century	Nearly identical to A1F1

Source: own depiction following Website University of Washington 2013

The process of climate modelling is usually performed in two phases. In the first phase climatic conditions of the past are modelled with input conditions that are based on measured data. In the second phase the results of past conditions are used to model future periods under predicted circumstances. In this phase, the RCPs are applied.

Climate modelling takes place at a global scale (resolution grid of 100-200km grid) and is used for modelling atmosphere, ocean, soil and ice and includes carbon and sulphate cycles. Nevertheless, the global resolution is hardly applicable for practical purposes, which is why regional climate models are obtained from the global models by dynamical downscaling.

2. Impact of Climate Change on Storms in Europe

Since the pre-industrial era, the atmospheric concentrations of greenhouse gases (carbon dioxide, methane and nitrous oxide) increased distinctly and it is extremely likely that the dominant course is of anthropogenic nature. Especially the economic and population growth during and after the industrialization were and are drivers of greenhouse gas emissions and, resultant, of the observed global warming since the mid-20th century.
These climatic changes have severe impacts on both the natural and the human system and further climatic change will most likely intensify risks to these systems. (Cf. IPCC 2014: 4ff., 13)

The current state of research on possible impacts of climate change on frequency and magnitude of storms is, in comparison to other climate variables, in early stages. There still are considerable uncertainties in understanding current processes of storm activity, which make statements on probable future scenarios even vaguer.
This circumstance is aggravated by the fact that there are remarkably different types of European storms, as the local wind phenomena of the Wind Risk Prevention Project partners reflect. European storms may range from small, localized events to large features and from short occurrences with high maximum wind gusts to long-lasting events with strong sustained wind speeds (or combinations of both). (Cf. EEA 2012: 70f.)

Statements on present and future storm activities are highly uncertain which does not question their severe impact on nature and the built environment. Thus, it is remarkable that wind phenomena are almost ignored by the biannual national reports of the Wind Risk partner countries Slovenia, Croatia and Germany to the UNFCCC (United Nations Framework Convention on Climate Change); none of the three countries explicitly deals with their special wind phenomena; and only Germany disputes wind extremes. (Cf. German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety 2013; Slovenian Ministry of Agriculture and the Environment 2014; Croatian Ministry of Environmental and Nature Protection 2014)

The following subchapters contain the state of research on European storms in the past and present (see chapter 1.1) and give an outlook on how European storms may develop in the future (see chapter 1.2). In subchapters 3.1 – 3.3 the local wind phenomena of the Wind Risk partner countries are analyzed regarding future trend with respect to climate change.

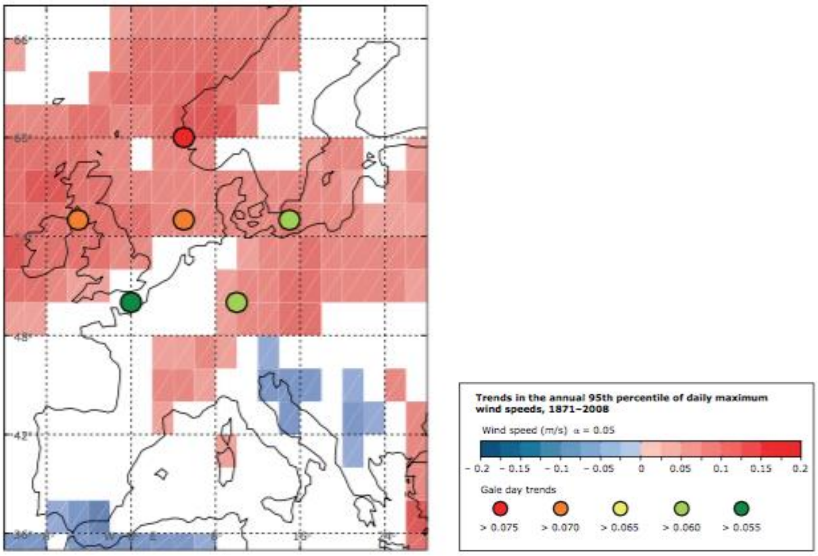
2.1. Storms in the Past and Present

Since the 20th century, storm records have shown remarkable variability in the locations, frequencies and intensities of European storms. When focusing on single regions across Europe it may be stated, that the average wind speed predominantly did not significantly change in the last 200 years. (Cf. EEA 2012: 70f.)
Although there are no universal trends in European storms, researchers came to the conclusion that the frequency of storms generally increased in the period from 1960 till 1990. Since then, records show a slight decrease in the frequency of occurrence, as e.g. Ulbrich and others state (cf. Ulbrich/Leckebusch/Pinto 2009: 122). According to Pinto et al., these findings especially apply to northern and north-western Europe (cf. Pinto/Zacharias/Fink et al. 2009: 718).

Even though the average wind speed did not significantly change over the last decades, however, a recent study basing on reanalysis of data sets from 1871 till 2008 shows promising results on changes in extreme wind speeds.

As can be seen in Fig. 3, extreme wind speeds enhanced over the northern parts of Central and Western Europe and decreased for southern Europe. The results base on a reanalysis data set (ensemble mean), covering the years 1871 till 2008. Trends are only depicted as far as the inter-annual standard deviation is significant. The colored circles show trends in the number of gale days for a specific location, indicating days with extreme wind speeds. (Cf. EEA 2012: 70)

Figure 3: Trends in extreme wind speeds in the period 1871-2008



Source: EEA 2012: 71.

In general it needs to be stated though, that the different research studies on storm frequency and magnitude in Europe often vary in their methodological approach. This circumstance makes the results hardly comparable. In fact there might even be different studies for one region, some showing an increase in maximum gust wind speeds, others showing a decrease in frequency. (Cf. EEA 2012: 71f.)

Nevertheless, there is broad consensus regarding the damage costs of storms. When comparing storms to other natural hazards in Europe, storm events were the costliest in terms of insured losses. Regarding casualties, storm events rank fourth highest natural hazard in Europe. This fact results not only from high sustained average and maximum gust wind speeds but also from heavy rainfalls and hail that are widely associated with the storms. In total, hydro-meteorological events like storms (and also floods) account for about two thirds of all losses from natural disasters since 1980. Insurance companies already observed an increase in losses from extreme weather events in the past decades. This increase in damage costs does not only come from more frequent and intense extreme weather events, but mainly from an increase in population and economic wealth. Another unneglectable fact is that also the procedure of reporting damages to the insurance companies improved and damages nowadays are reported more comprehensive. (Cf. EEA 2012: 17, 26, 71)

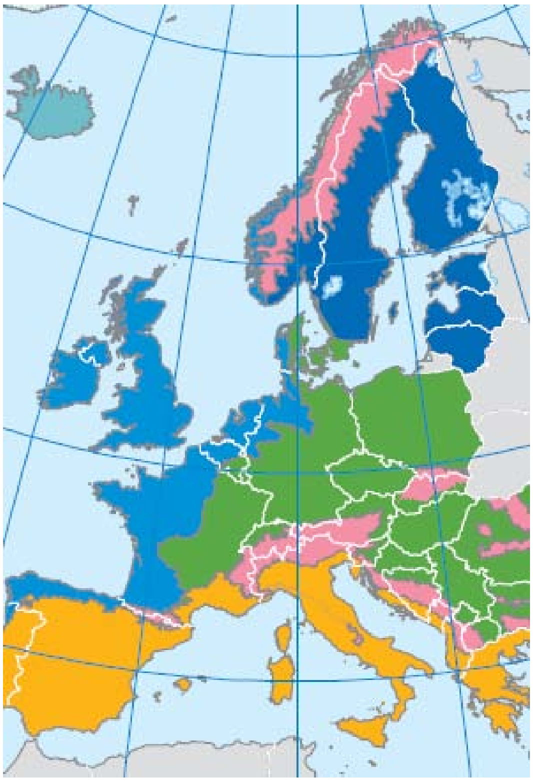
The European Environment Agency makes one clear statement on the expected future situation with storm-related damages with respect to climate change: “[t]he contribution of climate change to the damage costs from natural disasters is expected to increase in the future due to the projected increase in the intensity and frequency of extreme weather events in many regions" (26).

2.2. Storms in the Future

Although it can generally be expected that damages from extreme events like storms will increase in the future, the available climate change projections do not reveal a clear trend in the development of storm pathways or the intensity so far. Currently it can only be stated that researchers assume that the total number of storm events will decrease in Europe but that the strongest and most damaging storms are likely to increase. (Cf. EEA 2012: 70-72)

Tab. 2 shows general trends for past and future development of wind speed in Europe's main regions. The geographic definition of Europe's main regions can be seen in the alongside figure. Turquoise colored regions mark the Arctic, regions with dark blue color show Northern Europe. The light blue areas mark North-Western Europe, mountain areas have the color pink. In grey all costal zones and regional seas are colored, green regions are Central and Eastern Europe and orange colored areas mark the Mediterranean region.

Figure 4: Main regions in Europe according to the EEA



Source: EEA 2012: 27.

Table 2: Key climate variable – storms (wind speed)

Northern Europe (incl. Arctic)		North-Western Europe		Central and Eastern Europe		Mediterranean Europe	
Observed	Projected	Observed	Projected	Observed	Projected	Observed	Projected
+	(+)	+	(+)	(+)	(+)	o	(–)

Key:
+: Increase in variable throughout (most of the) region
−: Decrease in variable throughout (most of the) region
o: Only small changes in variable
(): Increase or decrease only in some parts of the region
Green: Beneficial change
Red: Adverse change

Note:

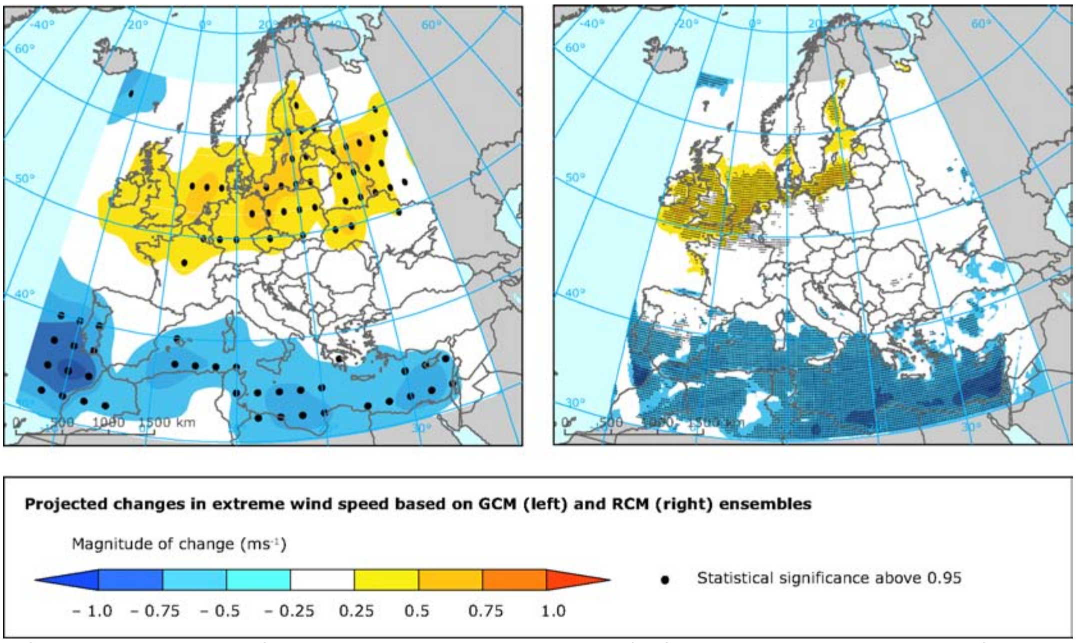
Emission scenario = A1B, Climate Models are 9 GCM and 11 RCM ensemble. Observed time period: 1961-1990. Projected time period: until 2080s

Source: EEA 2012: 39.

As the table shows, there was an increase in the variable wind speed throughout most of Northern Europe (including the Arctic) and North-Western Europe from 1961-1990. In Central and Eastern Europe there were also increases in wind speed, but only in some parts of the regions. Mediterranean Europe in comparison only shows small changes in the variable.
The projections of the variable show a further increase for the future. In Northern, North-Western as well as Central and Eastern Europe, increases in the wind speeds are projected for some parts of the regions. For Mediterranean Europe beneficial changes are projected until the 2080ies; wind speed is, compared to the reference period 1961-1990, expected to decrease in some parts of the region. (Cf. EEA 2012: 28, 39)

Another research study projected changes in extreme wind speeds, using the ensemble mean of changes in extreme wind speed (defined as the 98th percentile of daily maximum wind speed). Fig. 5 depicts the changes for the A1B scenario for the years 2071-2100 relative to a reference period from 1961-2000. The colors show the magnitude of changes in wind extremes in ms^{-1}. It again can be seen that extreme wind speeds (98th percentile) are projected to decrease in parts of Mediterranean Europe and the Mediterranean Sea and to increase in Central, Eastern and Northern Europe. (Cf. Website EEA 2012)
However, the 98th percentile does not depict real extreme events but rather shows wind speeds that occur about twice a year.

Figure 5: Projected changes in extreme wind speed



Info: Ensemble mean of changes in extreme wind speed (defined as the 98th percentile of daily maximum wind speed) for A1B (2071–2100) relative to 1961–2000. Colored areas indicate the magnitude of change (unit: ms−1). *Source: Website EEA 2012.*

Thus, it is important to remark that the simulation of storms in climate models "remains a scientific challenge in spite of significant recent progress" (EEA 2012: 72). It is, generally speaking, hardly projectable how the intensity of storm events might change and it also stays unclear, how the direction of storm paths may change. The fact researches know though, is that a poleward shift in storm tracks would increase the frequency of the most intense wind events in higher latitudes but that an equator-ward shift in the Atlantic storm track might even double the predicted increase in winter rainfall over Western and Central Europe. (Cf. EEA 2012: 72)

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3. Local Wind Phenomena and Climate Change

In the following the Wind Risk partners gathered information on the local wind phenomena and the possible impact of climate change on those. Beforehand it can be stated that – similar to the above outlined general information – statements on the impact of climate change on the local wind phenomena are highly uncertain.
Therefore the partners chose to approximate the possible future situation in their case study region with respect to climate change.

3.1. Slovenia // Ajdovscina and Ljubljana

Slovenia is a transitional climate area between the Mediterranean Sea, the Alps, the Dinaric Mountains and the Pannonian Basin (see Fig. 6). As a consequence, its climate displays wide local climatic variability and fairly large gradients (Ogrin, 2011; De Luis et al., 2012). This variety is also reflected in climatic variability over time, and is an important factor determining the impact of global climate change in the country.

Figure 6: Natural regions in Slovenia

Source: Website Slovenian Environmental Agency 2008.

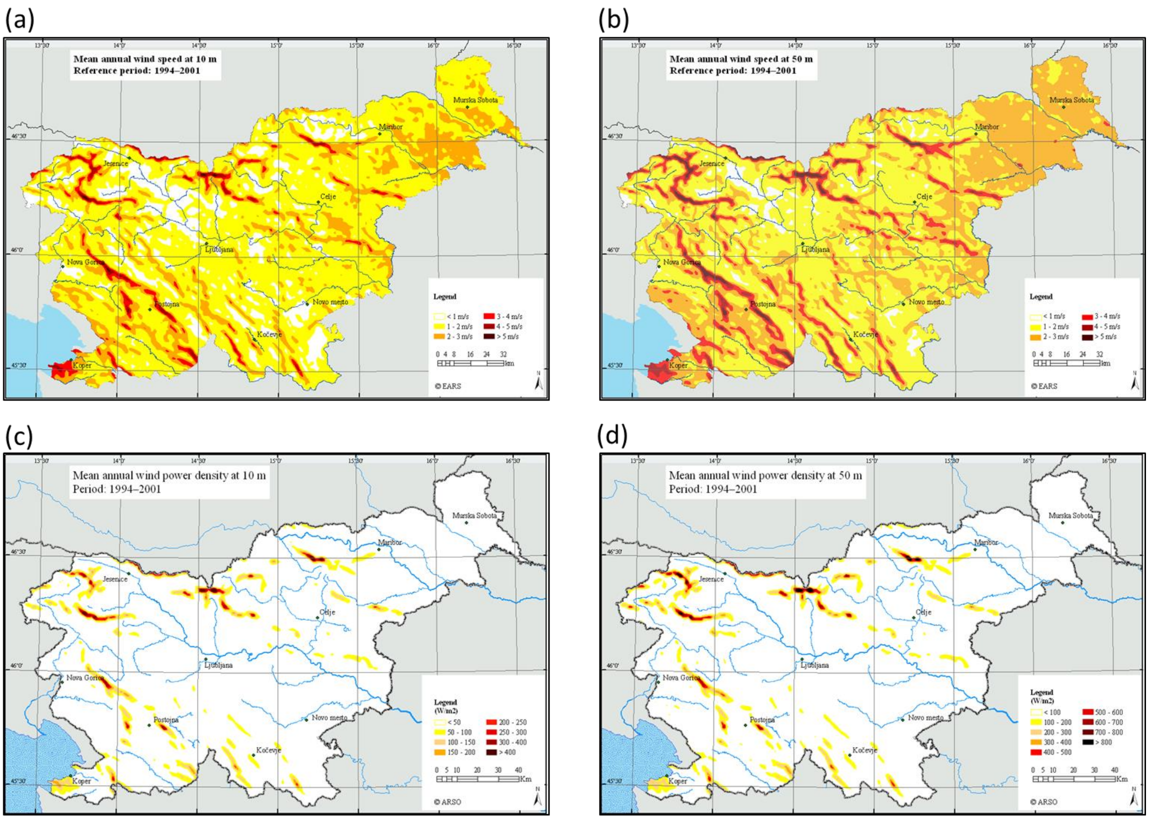
Strong winds are not very frequent in Slovenia. With the exception of strong wind gusts that usually accompany storms, the bora (*burja*) is the strongest and most exceptional gusty wind in Slovenia. The gusts in a bora reach a velocity of up to 130 km/h. It is typical for the Vipava valley, the Karst and the coastal region. It blows mostly from the northeastern (NE) direction, but due to the surface of the relief, it deviates locally also to the east (E) and to the north (N). In locations where bora is the strongest, sometimes traffic is disturbed or – in case of extremely strong bora events – interrupted for longer and larger vehicles. Ljubljana and other areas in Slovenia are mostly subjected to winds as a result of storms.

3.1.1. Regional Climate Model for Slovenia

Slovenia is, regarding to its complex terrain, relatively underserved by the network of wind measurements. It is quite often that a single site wind measurements is not significant for the wider region. Meteorological measurements are mainly used for monitoring the weather in urban areas. There, however, the measurements are strongly influenced by wind obstacles (buildings, trees, etc.) in the vicinity of instruments. Another problem is the duration of the measurement. The accurate wind measurements are carried out only in the last decade by the Slovenian Environmental Agency. Before that, continuous measurements were captured and carried out only by few mechanical anemometers. Thus, the estimation of wind in Slovenia is very difficult to predict, especially for a thirty year climatological reference period.

However, the Environmental Agency estimated wind speeds for the whole country with dynamic models with a relatively dense resolution of 1 km. The models also required a good correlation between the model-based estimation and measurements obtained on site. The wind field was modeled by meteorological models and the input data came from the European Centre for Medium-Range Weather Forecasts (ECMWF), specifically from the reanalysis ERA-40.

Figure 7: Model-based estimation for wind



Info: Mean annual wind speed at (a) 10 m (b) 50 m. Mean annual wind power density at (c) 10 m (d) 50 m. *Source: Website Slovenian Environmental Agency 2008.*

The Agency modeled the results shown in Fig. 7 by three models: ALADIN, SIDA and AILOS. The results of the models were nested, which means that the results of one model ran the next and thus reduced the area and increased the resolution. As a result, wind fields at 10 m and 50 m above ground were generated for the whole area of Slovenia in an eight-year period (1994-2001).

For most areas of Slovenia the results of the model are in a good correlation compared with the actual measurements, even on the subalpine and alpine station (Kredarica) as well as in Ljubljana area. A mismatch exists for the Vipava valley, where bora is underestimated due to an inaccuracy of the model.

3.1.2. Future Impact of Climate Change

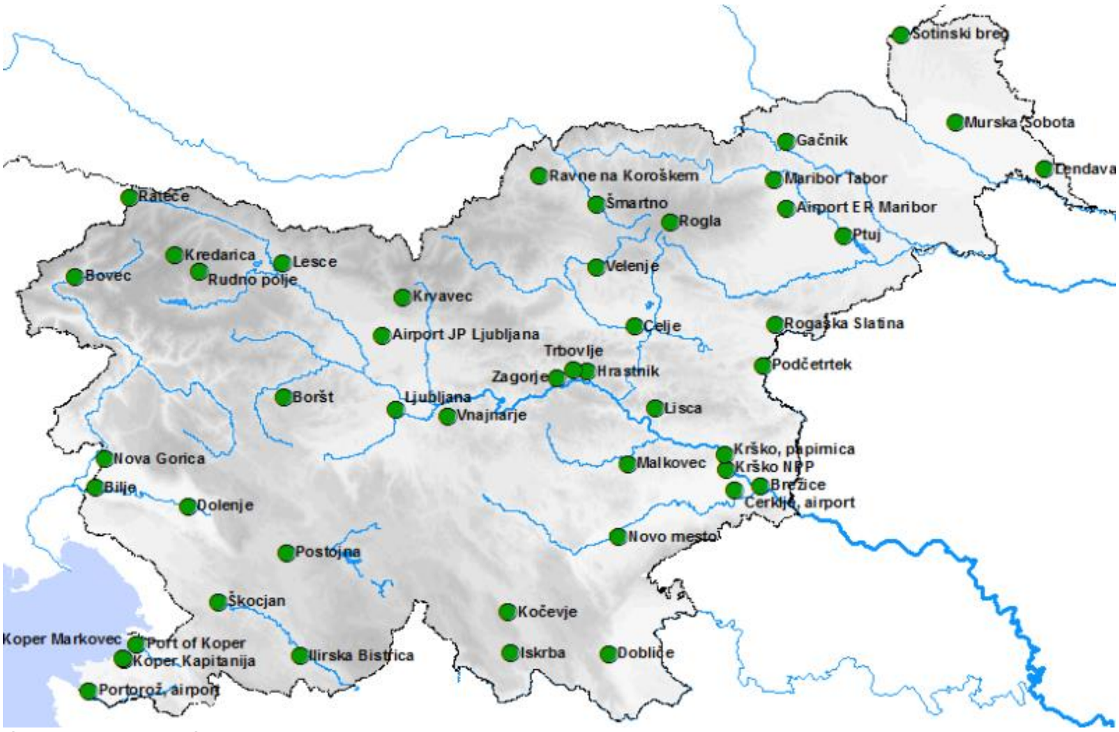
In reference to chapter 1, the IPPC has produced a Special Report on Emission Scenarios (SRES) which has been the basis for projections of possible future climate change. The differences between scenarios show the primary source of uncertainty in projections. With climate change, which is the result of global warming, the amount of energy in the atmosphere increases, causing intense developments in the atmosphere (wind in combination with storms). The details of the climate system and its response to changes in atmospheric structure as well as other changes in climatic factors are unknown. Even if the dependence of the response of the climate system in the atmospheric structure was known in detail, the climate can only be modelled with limited spatial precision, and therefore not capture all regional and local climate characteristics of the selected area. Slovenia, where Alpine, Mediterranean and Pannonian climate impacts are present, is particularly exposed to this phenomenon. This represents a major challenge for dynamic as well as empirical modelling of the climate in the future, but till now, this is the main reason that the projections of Slovenian climate changes are subjected to large uncertainty, especially when only one meteorological variable is considered. (GRS 2015; Bergant 2010)

For the following remarks, available data and studies on how climate change might affect the wind/storm situation in Slovenia were gathered. The data and studies were elaborated by the Slovenian Environmental Agency and reveal how the trends were in the last few years.

In general, systematic studies that investigate the effect of climate change on wind in Slovenia do not exist. This is due to a lack of data. Before the middle of the 90’s, the wind speed was not measured continuously over the whole day, but only three times daily. This was by far not enough to draw conclusions on the daily distribution of wind speed. Previously, the wind speed was estimated as an effect on the surroundings (by the Beaufort scale). Continuous measurements exist since the setup of automated stations, but there are some problems such as short time period of measurements, sparse distribution of stations to obtain homogeneous data, relocation of station sites, changing types of instruments and their position above ground etc. (Bertalanič 2016)

Since 2001, the Slovenian Environmental Agency made some analysis for each of the measuring stations, which are presented in the following figure.

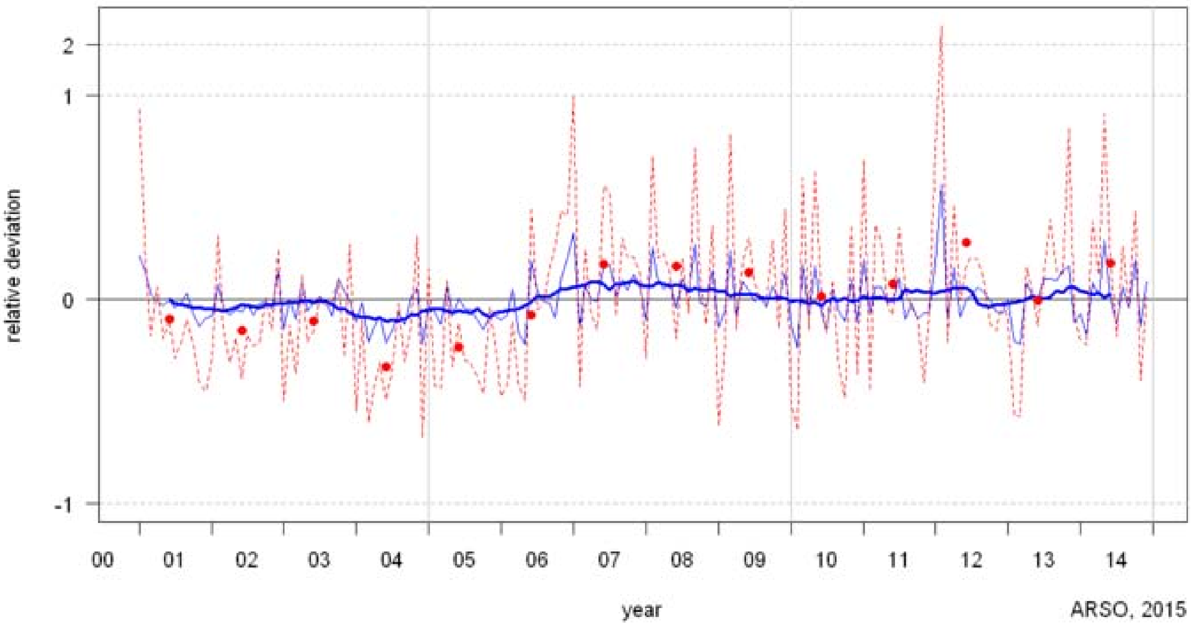
Figure 8: Wind climatology in Slovenia



Source: Website Slovenian Environmental Agency 2016.

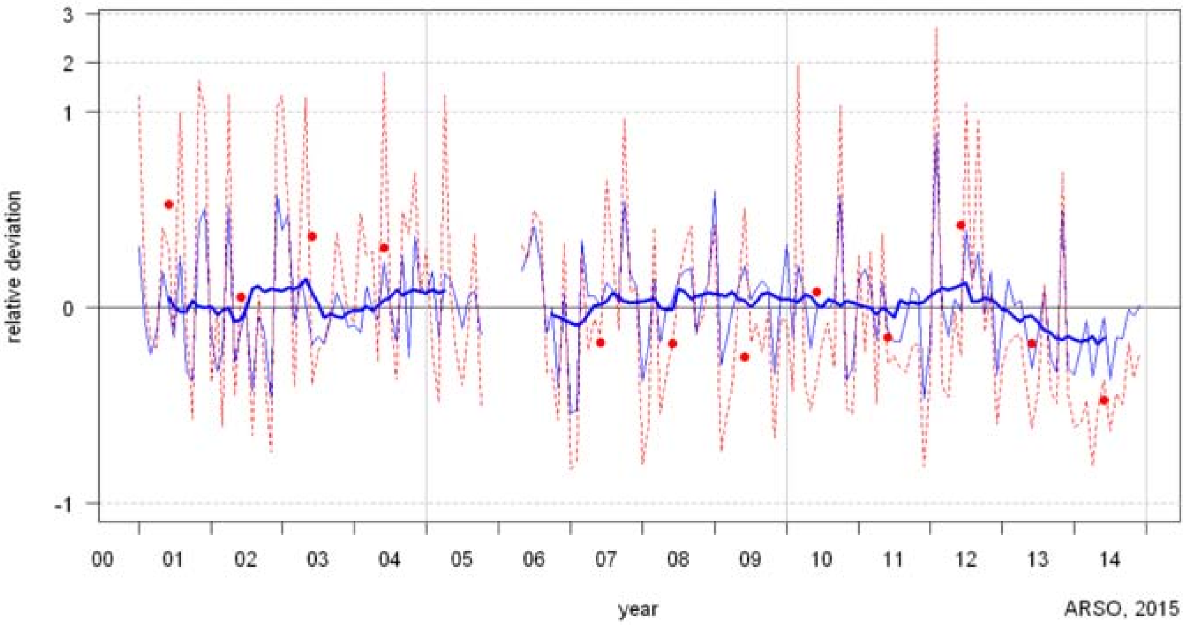
In the following the data belonging to Ljubljana and Ajdovščina (Dolenje) station are summarized. The relative monthly deviation of speed and cube of speed for Ljubljana and Ajdovščina Dolenje are shown in Fig. 9 and 10.

Figure 9: Relative monthly deviation of average wind speed and cube of wind speed for Ljubljana



Source: Website Slovenian Environmental Agency 2016.

Figure 10: Relative monthly deviation of average wind speed and cube of wind speed for Ajdovščina Dolenje



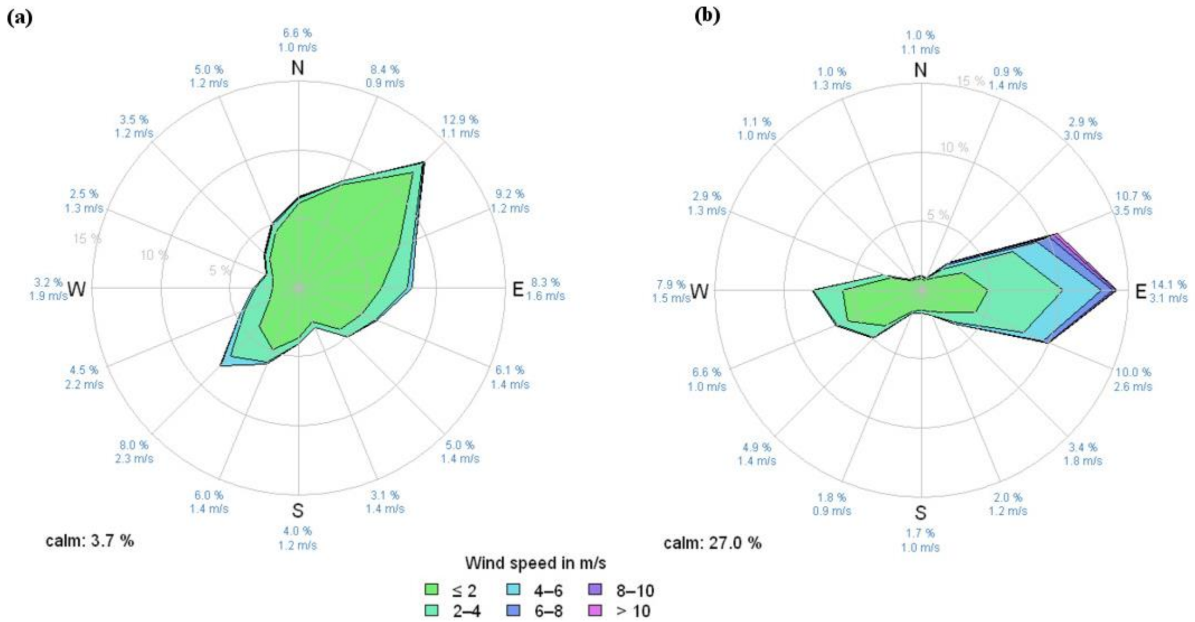
Source: Website Slovenian Environmental Agency 2016.

For each month of the period the average speed and cube of speed are calculated and subtracted from each month's value. The relative deviation of speed is shown by the thin blue line and the relative deviation of the cube of speed is shown by the the red dotted line. The smoother and thicker blue line shows the year by year relative deviation from the average of the period. The red circles show annual deviation of the cube of speed from the average cube of speed of the period. The vertical scale is linear from values between –1 and 1, larger and smaller deviations are compressed.

Further, in Fig. 11, the wind roses for Ljubljana and Ajdovščina are presented. Numbers at the circumference of the circle show the relative frequency of winds coming from each of the 16 directions and the average wind speed of those winds. The colors show the cumulative relative frequency of the wind speed. Some higher wind speed classes can be so small that they might not be visible. Calm is defined as wind with speed less or equal 0.3 m/s.

As the Agency explained, the graphs, presented in Fig. 9-11, must be used with caution. The obvious jumps in wind speed are due to a change in the type of instrument or a relocation of the stations. Moreover, due to unhomogenized data, the trends should be taken with reserve as well. For rough approximation, it may be said that there is no major difference in average wind speed in Slovenia in the last two decades. (Verhovec, 2002)

Figure 11: Wind roses for (a) Ljubljana and (b) Ajdovščina



Source: Website Slovenian Environmental Agency 2016.

The problems due to the lack of data occur also when analyzing storms. The observers usually record storms, but only as a phenomenon, i.e. phenomenon of thunder and lightning. This is very subjective and therefore there is no data about the power of the storms. Further, the systematic changes in the number or the strength of storms were not analyzed.
At the meteorological stations in Slovenia more than 50 storms are observed annually. The storm activity is strongest in the late spring and early summer months (from May to July). Thunderstorms classified as a natural disaster appear only a few times per year. The lifetime of these storms is usually a few hours, but the strongest storm clouds can last up to 12 hours (Verhovec, 2002).

At this point, it is concluded that more detailed studies are required in this research field. Long-term measurements of wind could be further statistically analyzed and determined if there is a statistically significant trend. Nonstationary time series data due to climate variability is, in fact, different from station to station and in most stations it is statistically insignificant.

3.2. Croatia // Split ; Dalmatia

Croatia is situated in moderate geographical latitudes with moderate climate, but its atmospheric situations are highly variable.
According to Köppen classification for a standard period 1961-1990, the largest part of Croatia belongs to the climate type C, a moderately warm rainy climate. The southernmost part of the island of Lošinj, the Dalmatian coast and islands have Mediterranean climate with dry and hot summers, whereas the coastal areas of Istria, the Kvarner littoral and the

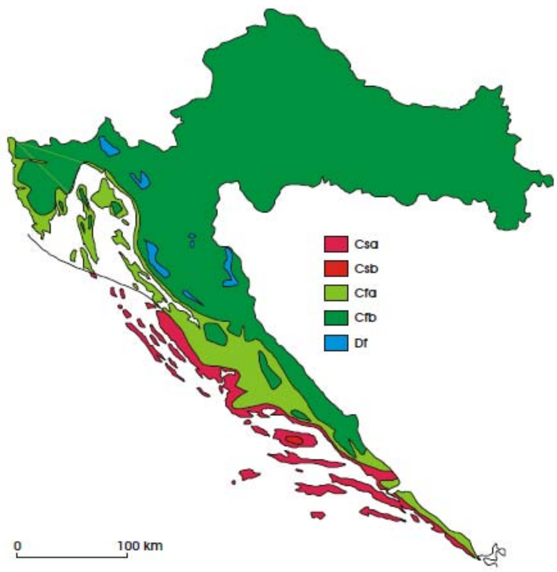
Dalmatia's interior have a moderately warm and humid climate with hot summers. The moderately warm and humid climate with warm summers prevails in the major part of Croatia, in the continental Pannonian region and the interior of Istria. Only the regions of Gorski Kotar, Lika and the Dinaric Alps above an altitude of 1,200 m belong to the climate type D, subtype Df, a humid snowy forest climate. (Cf. University of Rijeka 2014)

The annual mean air temperature in the lowland area of northern Croatia is 10-12 °C, at altitudes above 400 m it is under 10 °C and in the mountains it is 3-4 °C. In the coastal area it is 12-17 °C. January is in average the coldest month, with the temperature in the Pannonian region ranging from 0 to -2 °C. Along the Adriatic coast winters are milder; January temperatures are 4-6 °C. In the north and east of Croatia average July temperatures are 20-22 °C and on the Adriatic coast 23-26 °C.
The least precipitation in Croatia is recorded in the open part of the central Adriatic (Palagruža, 304 mm) and in the eastern Slavonia and Baranja (Osijek, 650 mm). Central Croatia and the coastal zone have an annual precipitation between 800 and 1,200 mm. The amount of precipitation in the Pannonian region decreases from the west towards the east. From the coast towards the inland the precipitation increases. Most of the precipitation is recorded on the coastal slopes and peaks of the Dinarides (Risnjak, 3,470 m), from Gorski Kotar in the northwest to the southern Velebit in the southeast.

According to Köppen classification coastal Dalmatia is mostly classified as Csa (cf. Zaninović et al. 2008). The 'CSa' class is often referred to as 'olive climate' and is described as moderately warm, with hot and dry summers where most of the rain falls in autumn.

- C class of Köppen classification has moderately warm rainy climate with average monthly temperature of coldest month higher than -3°C and lower than 18°C.
- Label 'S' means that the driest month has less than 40 mm of rainfall and the wettest winter month has about 3 times more precipitation when compared to the driest summer month.
- Label 'a' means that the warmest month has an average temperature over 22°C, and that for more than four months per year the average temperature is over 10°C.

Figure 12: Köppen climate classification for Croatia



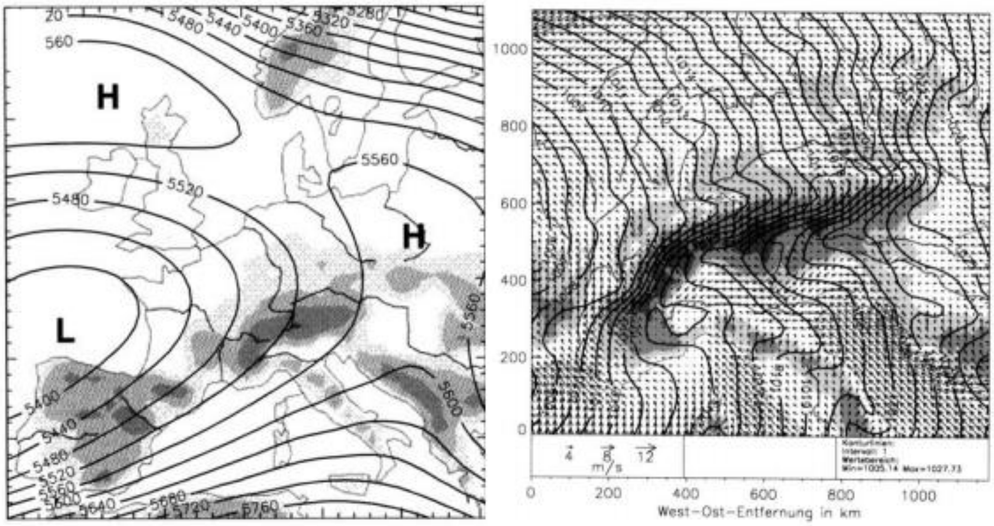
Source: SegotaFilipcic 2003.

Winds in Croatia are influenced by the Alpes in the northwest, Dinarid mountain along the Adriatic coast and Panon valley in northeast part of the country, therefore each of those geographical sectors have different wind regimes.

The Croatian wind regime is very variable, both location and season wise. Variations are on hourly, daily and seasonal time base. The main factors of wind climate are position near to Alps on northeast, Dinarid mountain range along coast and Panonian plain in northeast part of the country. Coastal areas and islands have more frequent and higher top wind speeds than continental areas but in all areas winds (above 17 m/s; Beaufort class 3) are recorded. Coastal areas can also be split in two subregions – the north coast with stronger winds and the south coast and islands with less wind speed. The Dinarid mountain range behind the north coastal area acts as a sharp obstacle and amplifies strong Bora sessions, while in the southern part of the mountain range wind speeds are not much amplified on the downslopes of the mountains. During the cold seasons of the year, winds are generally stronger than in warm seasons, although in continental parts short term storms can occur in summer followed by rain and hail. (Cf. DUZS 2013)

The two most prominent local winds are Sirocco (local name *Jugo*) and Bora (local name *Bura*). Sirocco is a warm, damp and uniform wind originating from North Africa mostly associated to low atmospheric pressure and rainy weather. The typical synoptic situation regarding Sirocco wind is represented in Fig. 13.

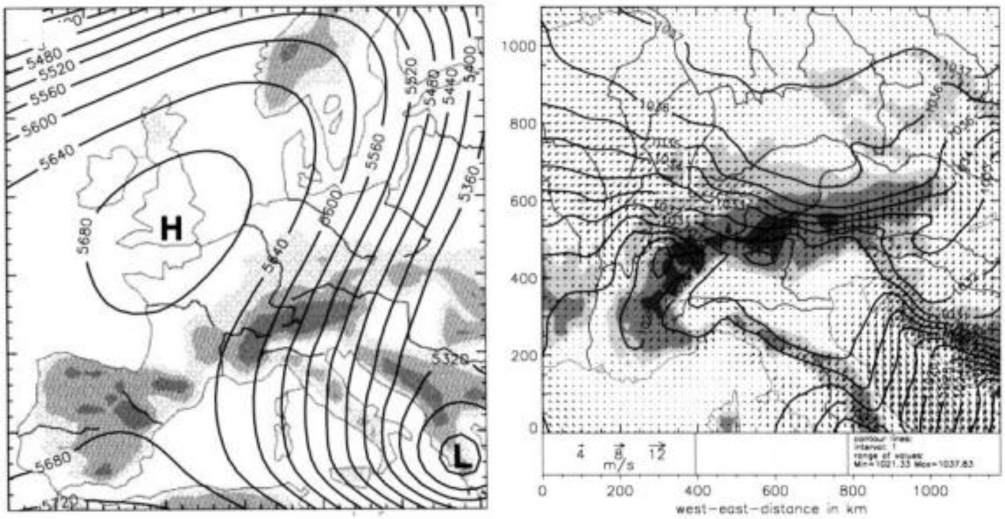
Figure 13: Mean geopotential height (m) isobaric surface 500 hPa (left) and mean atmospheric pressure on sea level (hPa) taken December 3rd-6th, 1987 (right).



Source: Heimann 2001.

Bora is a strong, gusty and cold wind of which the usual genesis is along the seaside of the Dinarids mountain range in accordance with the wave brake theory and driven by intrusion of cold air from north or northeast. Both of them can reach high wind speeds but generally Bora is considered more dangerous to constructions due to higher wind speed and stronger gusts. The typical synoptic situation regarding Bora is represented in Fig. 14.

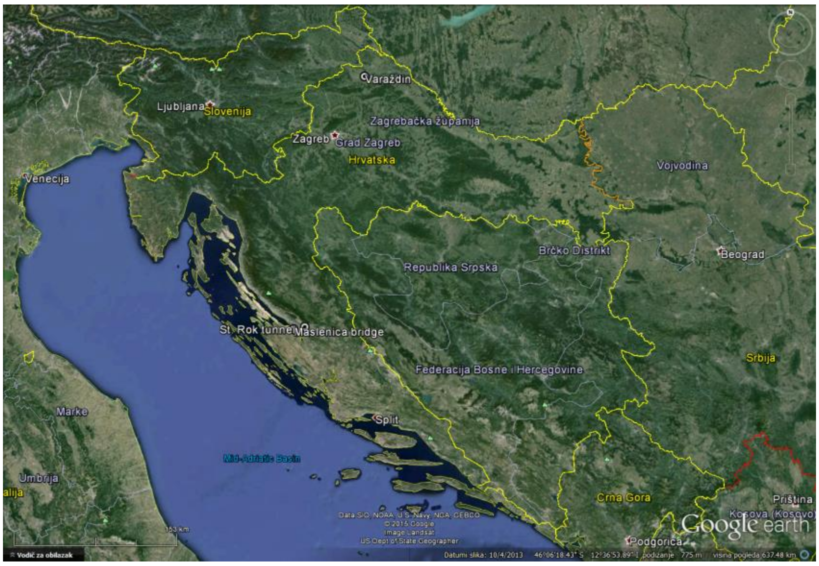
Figure 14: Mean geopotential height (m) isobaric surface 500 hPa (left) and mean atmospheric pressure on sea level (hPa) taken December 7th - 10th, 1987 (right).



Source: Heimann 2001.

The unofficial highest wind speed recorded during Bora wind is 85 m/s, recorded December 24th 2003 on the A1 highway between St. Rok tunnel and Maslenica bridge[2]. The measurement is unofficial due to a lack of calibration of the recording device. The official highest speed recorded is 69 m/s, recorded December 21st 1998 at Maslenica bridge.

Figure 15: Position of highest recorded wind speeds



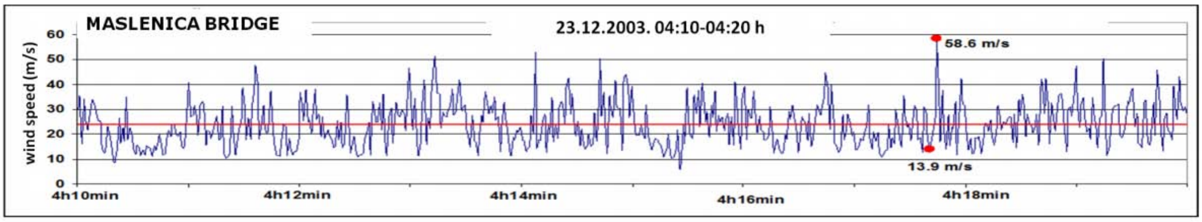
Source: Google Earth.

The highest recorded Sirocco wind speed is 45 m/s, recorded at a meteorological service station in Split, in August 1969.
In the continental part of Croatia, the highest recorded wind speed is 39.5 m/s on a meteorological service station in Varaždin in June 2004.

2 http://crometeo.hr/koje-su-najvece-brzine-vjetra-izmjerene-u-hrvatskoj/

Bora's wind gust behaviour can be simulated by Kelvin-Helmholtz instability. A time series of Bora wind speeds with its visible pulsations is presented in Fig. 16. The figure represents the record of one second resolution overlaying mean wind speed. The pulsations are described by high frequency oscillation superpositioned to mean wind speed.

Figure 16:Time series of Bora



Source: Bajic 2013.

3.2.1. Observed Climatic Changes in Croatia

In Croatia, climate observation started during 19th century on several meteorological stations observing different climate conditions:

- Continental climate (Osijek),
- Continental climate with mild Mediterranean influence (Zagreb),
- Continental climate of mountain Croatia with shorn maritime influence (Gospić),
- Maritime climate of east coast of northern Adriatic sea (Crikvenica),
- Maritime climate of Dalmatian islands (Hvar).

Temperature, rainfall and dry period lengths have been analysed (cf. Ministry of Environmental Protection, Physical Planning and Construction 2010).

Temperature: An increase of the annual average temperature in the 20th century has been observed. The decadal increase till 2004 was between 0,04°C and 0,08°C, but till 2008 it has increased to 0,05-0,1°C. This increase is even more evident in the Adriatic region. Taking into the account other indices of meteorological parameters proposed by WMO-CCL CCL (World Meteorological Organization - Commission for Climatology) and CLIVAR (Research Programme on Climate Variability and Predictability), almost all indices have a statistically significant increasing trend.
Rainfall: A decrease of rainfall has been noticed in all area of Croatia, but is strongest in the Adriatic region (-1.8% /10 years in Crkvenica and -1,2%/10 years in Hvar) and during summer.

3.2.2. Modelled Climatic Changes

Two models are engaged for predicting climate changes in Croatia:

a) Meteorological and Hydrological Service **DHMZ – RegCM**: Results of ECHAM5-MP-OM, downscaled using egional regCM models that are published in IPCC AR 5 for A2 scenario.
b) **ENSEMBLES:** Dynamic downscaling of various combinations of global and regional models resulting from ENSEMBLES project with IPCC scenario A1B (cf. Website ENSEMBLES-EU 2016).

DHMZ RegCM

Future climate prediction is gained by simulation of regional RegCM model for two 30-year periods (near future 2011-2040 and far future 2041-2070) (cf. Brankovic et al. 2012).

Temperature

All areas will experience an increase of temperature for all seasons. In the far future the increase will be larger, with an even more significant increase at the coast.

Rainfall

In the near future (2011-2040) the change in rainfall amounts will be insignificant and limited. The biggest change will be in the Adriatic coast in fall. In the far future, rainfall change will be more emphasised – the country is statistically expecting a significant decrease of rainfall in the mountain parts of Croatia during summer and an insignificant increase in northwest and on the coast during winter.

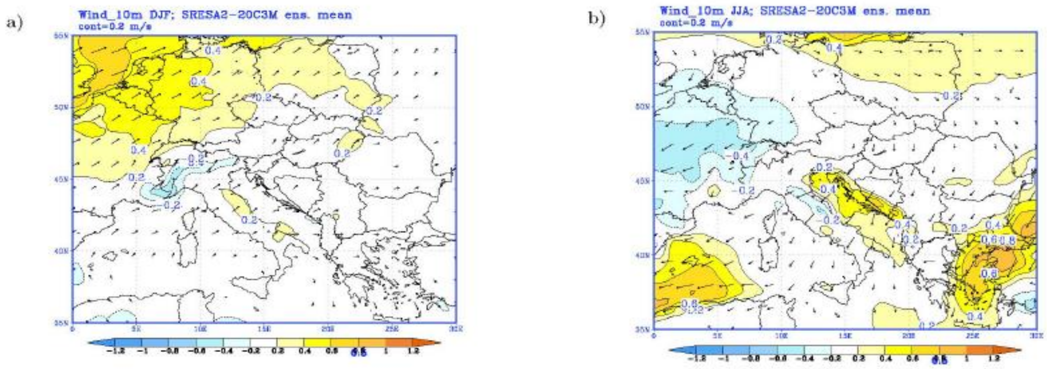
Wind

The increase of geopotential above South-Europe in winter reflects as an increase in mean surface pressure in future climate. This increase in surface pressure is statistically significant for southern Croatia, but not for other areas. A tendency towards an increased pressure can result in an increased frequency of anticyclonic weather types. In summer, the Croatian regions will be affected by a relatively insignificant change of mean pressure – the pressure will be slightly higher in northern areas and slightly lower in south Croatia. However, regardless of the small change in amplitude, the pressure decrease in south Croatia is statistically significant. Therefore, the middle and southern Adriatic will be exposed to an increased cyclonic activity in summer, which will cause more frequent unstable weather types. (Cf. Ministry of Environmental Protection, Physical Planning and Construction 2010)[3]

In the future climate, associated with an intensification of the Atlantic storm path, westerly upper-level winds will become stronger; in particular in winter within the free atmosphere above north-western Europe. Similar is true for wind at 10 m (surface wind), which will be intensified in winter in the north of the Alps and weakened at its southern slopes. Above the Croatian areas the differential wind (the difference between mean wind in future climate and mean wind in the 20th century climate) will retain similar intensity as in the 20th century, but will slightly turn to the north-east direction, i.e. will get stronger south-western component. Such a differential surface wind will bring a slightly increased humidity from the western Mediterranean and the Adriatic to the Croatian areas, causing a slight increase in winter precipitation in the littoral and mountain areas. (Cf. Brankovic et al. 2012)

[3] The latest, sixth UNFCCC report (UNFCCC 2014) does not discuss the influence of future climate conditions on wind. However, wind is discussed in the previous, fifth UNFCCC report.

Figure 17: Wind at 10 m, future climate minus climate of 20th century: a) winter, b) summer Isolines every 0.2m/s



Source: Website UNFCCC 2010.

In spring and autumn, future climate surface wind will remain unchanged, while in summer the north-eastern component will be intensified. Related to this intensified wind from the inland of the Balkan Peninsula (where in summer the humidity in the near-surface layer is smaller than humidity above the Adriatic Sea) the associated precipitation decreases at the coastal part of Croatia.

ENSEMBLES

ENSEMBLES simulations are the average results of various regional models. The models included follow an A1B scenario for industrial growth, by combining several global and regional climate models. Climate models chains used in these simulations are shown in Tab. 3.

Table 3: Analyzed regional climate models (RCMs), organisations which performed simulations and sources of the boundary conditions

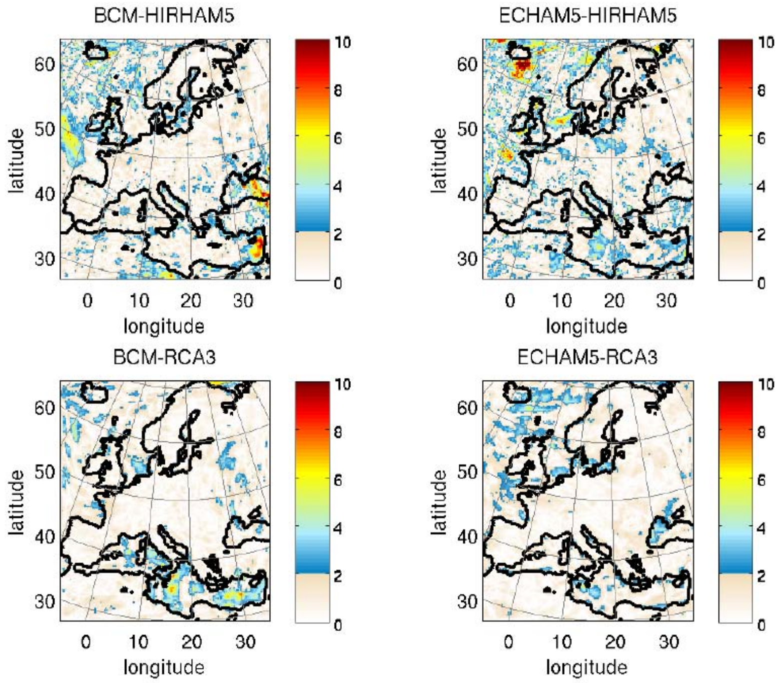
	Regional climate model	Organisation	Global climate model that provides boundary conditions
1.	RCA3	C4I	HadCM3Q16
2.	RM5.1	CNRM	HadCM3Q1
3.	HIRHAM5	DMI	ARPEGE
4.	**HIRHAM5**	**DMI**	**ECHAM5**
5.	HIRHAM5	DMI	BCM
6.	CLM	ETHZ	HadCM3Q0
7.	**RegCM3**	**ICTP**	**ECHAM5**
8.	**RACMO2**	**KNMI**	**ECHAM5**
9.	HadRM3Q0	MetoHC	HadCM3Q0
10.	HadRM3Q16	MetoHC	HadCM3Q16
11.	HadRM3Q3	MetoHC	HadCM3Q3
12.	**REMO**	**MPI-M**	**ECHAM5**
13.	RCA3	SMHI	BCM
14.	**RCA3**	**SMHI**	**ECHAM5**
15.	RCA3	SMHI	HadCM3Q3
16.	HIRHAM	Met.No	BCM
17.	HIRHAM	Met.No	HadCM3Q0
18.	PROMES	UCLM	HadCM3Q0

Source: Ministry of Environmental and Nature Protection 2014.

The simulations are done for four periods – P_0 is the current climate (1961-1990) and future simulations are done for P_1 (2011-2040), P_2 (2041-2070) and P_3 (2071-2099). The simulation results are discussed in the scope of UNFCCC national report. (Cf. Ministry of Environmental and Nature Protection 2014)
In the following a short summary of the expected changes is given.

Temperature
A statistically significant increase of temperature is expected for all seasons. Temperature will be more increased during winter in the east and middle of Croatia, while during summer a more increased temperature is expected in the southern part of the country.
Rainfall
The majority of simulations predict an increase of rainfall during winter and a decrease during summer.
Wind
Changes in wind speeds and directions are not discussed in literature for Dalmatia or Croatia. However, a research paper of Outten/Esau (2013) discusses the 50 year return period for 10 m wind speeds over Europe in four different downscaling models using peaks over threshold methods and generalized Pareto distribution. The simulation suggests changes in U50 of around 1-2 m/s, although some models predict greater changes in some areas. But the models base on different spatial areas. The major source of uncertainty of these results is the use of 30 year data for the prediction of a 50 year period. (Cf. Outten/Esau 2013)

Figure 18: The magnitude of the change in 50 year return 10m wind speed between the reference 30 year period (1961–1990), and the future 30 year period (2070–2099)



Info: The estimates are in in ms−1 and show the results for the four different downscalings. The beige regions indicate locations where the projected changes in the 50 year return 10m wind speeds of 2ms−1 or less, while the blue to red regions indicate those locations with 50 year winds between 2 and 10ms−1.
Source: Outten/Esau 2013.

3.3. Germany // Essen; North Rhine-Westphalia

As presented in chapter 1, the current state of research mainly bases on percentiles of average (extreme) wind speeds in order to project the possible future storm situation. This approach has the disadvantage that extremely seldom occurring storms cannot be covered. Even the 98^{th} percentile of wind speeds eventually describes wind speeds occurring every second year.

As *Ela* was a storm phenomenon with an expected return period of more than 50 years (cf. DWD 2015: 25), not even the hypothetical 99.9^{th} percentile could cover an event like *Ela*. And as storm records usually are not established long enough in order to have a reliable statistical population for these extreme events, in fact no such analyses exist.
Another matter with the available projections is that they do not distinguish in summer and winter events. But as outlined in previous chapters exactly this methodical approach would be needed in order to extract summer storms like *Ela* from the weather records.

The approach chosen therefore is to indirectly approximate the possible future situation of very seldom occurring storms like *Ela* by using macro weather situations with a high convective potential as an indicator for future trends.

3.3.1. Regional Climate Models for Germany

The sixth national communication to the UNFCCC, published in 2013, states that regarding wind speeds no significant trend has emerged so far for Germany, but that long-time weather records show some periodic fluctuations in average wind speeds (cf. German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety 2013: 32).
For Germany there are four main regional climate models (RCM) that are used to project climatic situations. These RCM show no significant changes in the frequency of storm days for the future and it is stated that additional, more detailed studies are required in this research field.

Remarkable is though that two of the four RCM (WETTREG and REMO) give indication that extreme storm events might increase in the future – both in magnitude and frequency. (Cf. German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety 2013: 34f.)

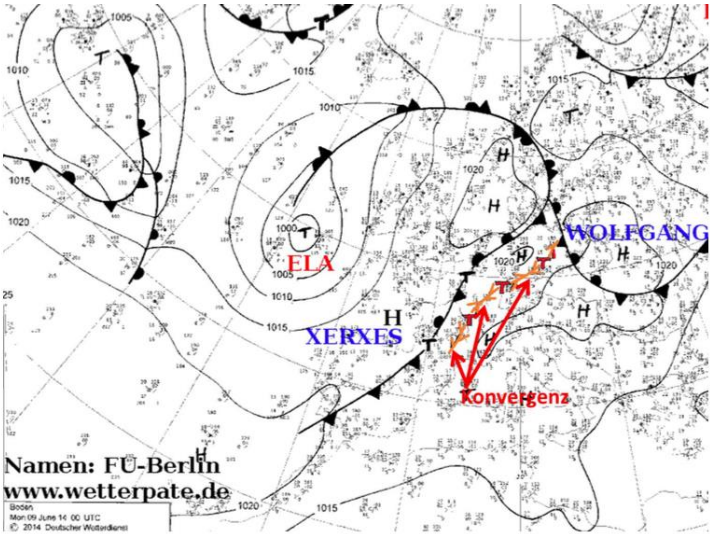
3.3.2. Approximation Indicator – Macro Weather Situations

In Central Europe strong winds typically result from extra-tropical cyclones that evolve due to the energy coming from temperature contrasts over the Atlantic Ocean. These cyclones develop atmospheric fronts that lead to changes in the temperature, humidity of the air, wind direction, wind speed and atmospheric pressure. The most (and most severe) cyclones usually occur*(red)*[4] during the meteorological winter half year, mainly between November and February. (Cf. EEA 2012: 70f.)

[4] As outlined in chapter C.2/C.4 *Ela* was more damaging than winter storms with comparable maximum wind speeds, which is why in this sentence is would be correct to use the past tense.

When summer storm *Ela* occurred there also was a distinct meteorological front (convergence line) that was resulting from a cyclonic south westerly macro weather situation, in which extra-tropical cyclone *Ela* (southwest, cyclonic; 950 hPa) moved towards anticyclone *Wolfgang* (anti-cyclonal; 500 hPa). (Cf. Halbig 2015)

Figure 19: Extra-tropical cyclone *Ela* meets anticyclone *Wolfgang*



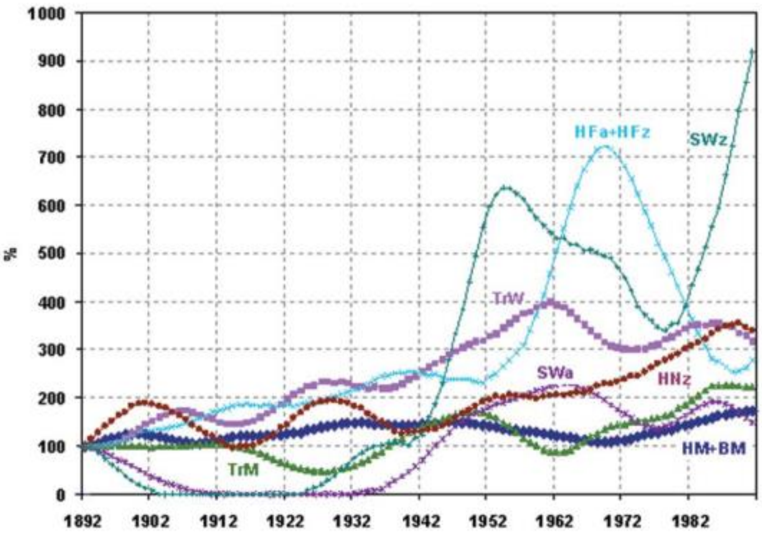
Source: German Meteorological Service 2015: 4.

A recent research study on thunderstorm occurrence and their characteristics in Central Europe presents that there are some macro weather situations with which thunderstorm occurrence is mainly associated. These are Sz (Cyclonic Southerly), SEa (Anticyclonic South- Easterly), SWz (Cyclonic South-Westerly), TrW (Trough over Western Europe) and TB (Low over the British Isles). All of these macro weather situations move from a direction broadly south-west to north-east, which corresponds with the (in Germany) prevailing wind direction. (Cf. Wapler/James 2014: 240f.)

A study of the Potsdam Institute for Climate Impact Research shows that especially the macro weather situation SWz, that triggered thunderstorm *Ela,* shows a significant increase in the long-term measurements (cf. PIK 2009: 34). This significant increase can also be seen in the following figure of the German Meteorological Service (see Fig. 20).

Furthermore the German Meteorological Service states that during the summer months (June, July, August) SWz increased from 2 days in 1881 up to 14 days in 2008 (cf. DWD 2009).

Figure 20: Macro weather situations with a significant increase during the summer



Source: DWD 2002:169.

For the future the German Meteorological Service assumes that, triggered by global warming, warm air masses have a higher energy potential and therefore the probability of occurrence for thunderstorms rises (cf. DWD 2015: 25).

Therefore, as a conclusion it can be stated that the macro weather situation SWz is a suitable indicator for future trends in climatic conditions that trigger the probability of occurrence of thunderstorms. The long-term measurements show a distinct and significant increase in especially summer days with SWz. It can be assumed that this trend will proceed as also global warming proceeds. It therefore is likely that with the increase of the number of summer days with SWz macro weather situation also the convective potential and the probability of occurrence for summer storms like *Ela* increases.
Nevertheless "[t]he probability of occurrence for a summer thunderstorm complex with a similar spatial extent of the hurricane wind field like Ela is probably distinctly larger than 50 years." (DWD 2015: 25).

4. Conclusions

The current state of research on frequency and magnitude of storms is still in early stages. So far it is widely agreed that due to anthropogenic greenhouse gas emissions major changes in the atmosphere are taking place. These are generally associated with changes in the intensity and probability of occurrence of extreme wind speeds but still there are considerable uncertainties. Accordingly statements on probable future scenarios are even vaguer.

The lack of understanding current processes of storm activity also becomes apparent when analyzing the local wind phenomena of the Wind Risk Prevention Project partners. This chapter especially revealed that there is a need for long-term, frequent and small-scale wind recordings for all the countries. It also became apparent that so far wind phenomena are almost ignored in national reports on climate change. (Cf. German Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety 2013; Slovenian Ministry of Agriculture and the Environment 2014; Croatian Ministry of Environmental and Nature Protection 2014)

It also became apparent that local wind extremes already have severe impacts on nature and the built environment in all three Wind Risk Prevention Project partner countries. Due to atmospheric changes it is most likely that further climate change will intensify the risks directly and indirectly resulting from storms. (Cf. IPCC 2014: 4ff., 13)

The Wind Risk Prevention Project therefore concludes that there is an urgent need for further research activities on present and future storms and the interlinkage with climate change for Europe. Also it is important to reduce the different sources of uncertainty, e.g. by continuing inherent wind speed recordings on various spatial scales.

Also the project recommends to a stronger inclusion of storms in European, national and local adaptation and mitigation strategies. In 2014 Slovenia and Croatia i.e. did not have a national adaptation strategy (cf. EEA 2014). Germany on the other hand has an adaptation strategy since 2008 but there are no direct statements on storms and extreme wind events. The most concrete statement in the German Adaptation Strategy is that ‘it is so far unknown how the wind regimes may change’ (Cf. Federal Government of Germany 2008, 48).

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WIND RISK

Task C – Risk/Vulnerability assessment
<u>Action C.2/C.4:</u>

- **Assessing the risk/vulnerability of the local area to high wind gusts in five major aspects: population, infrastructure, transit, buildings and forests;**
- **Assessing the risk/vulnerability of areas to high wind during storms**

For the Wind Risk prevention project

University of Ljubljana
Technical University of Dortmund
University of Split
Municipality of Ajdovščina

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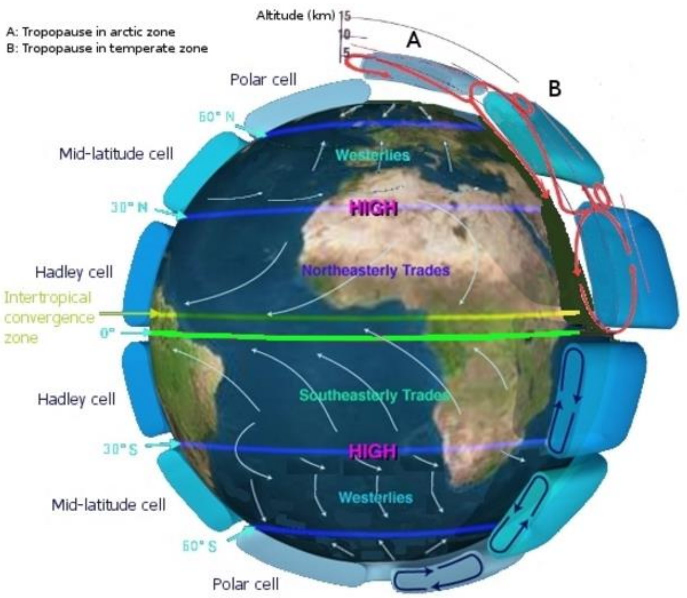
1. General and local winds over Earth

In order to assess the vulnerability of the local area to high wind and high wind gusts in five major aspects population, infrastructure, transit, buildings and forest, we have something to review about wind conditions. Wind is created by a variety of different conditions. In order to help understand them better, we divide them into two categories, namely general and local wind.

General winds are named because of the gradient that exists between a high and low pressure system. A high pressure system is a large invisible mountain of air in the atmosphere. A low pressure system is like a sinkhole. Around a low pressure system the air flows in a counterclockwise manner into the area of low pressure. Around a high pressure system the air flows in a clockwise manner. These highs and lows are caused by the differential heating of the Earth's surface.

Figure 1: Winds are part of Earth's atmospheric circulation.



Source: Wind, https://en.wikipedia.org/wiki/Wind

Local winds are small scale convective winds of local origin caused by temperature differences. Local terrain has a very strong influence on local winds, and the more varied the terrain, the greater is the influence. These occur on a small spatial scale, their horizontal dimensions typically several tens to a few hundreds of kilometers. They also tend to be short-lived lasting typically several hours to a day. There are many such winds around the world.

Most common local winds are sea breezes and land breezes, anabatic and katabatic winds. These two breezes occur along coastal areas or areas with adjacent large water bodies. Water and land have different heating abilities. Water takes a bit more time to warm up and is able to retain the heat longer than land does.

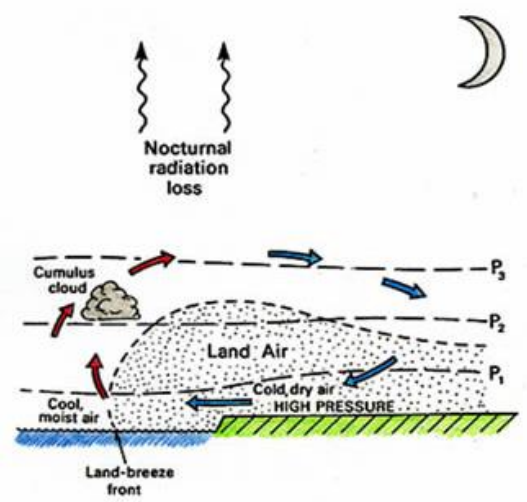
1.1. Sea breezes

Sea breezes are the result of differential heating of the land and the sea. Sea breezes occur by day, when the land becomes warmer than the sea. Warm air from the land cannot expand into the sea as the air is cooler and more dense, so it expands up into the atmosphere. Cumulus clouds tend to form as the warm air rises over the land to about 500-1500m.
Air in sea breezes is cool and moist compared to the air over the land. Sea breezes can move 70km inland in temperate climates by 9 in the evening. Sea breezes can be noticed several kilometres out to sea. In the tropics they can be felt 20km from the land. Wind speeds from sea breezes can be about 4-8 m/s but can be even stronger. [1]

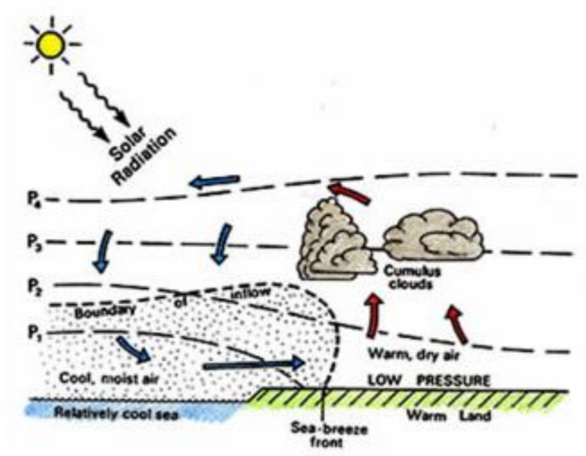
1.2. Land breezes

Land breezes occur at night and in the early morning, when the land is cooler than the sea. This is because as the air cools in the night time (as there is less heating from the sun) it contracts. The pressure is higher over the land than the sea. This causes the air to flow from the land to the sea which is known as a land breeze. The circulation is completed by air rising and moving towards the land at 100-300 m. Land sea breeze fronts tend to only affect a small area of 10-15 km out to sea, in comparison to the much larger effect of sea breezes. Wind speeds are also lower at 2-3 m/s. [2]

Figure 2: The process of sea breeze (left) and land breeze (right)



[1] Source: Royal Meteorological Society. MetLink. Weather for teachers in England, Scotland and Wales and N. Ireland (http://www.metlink.org/other-weather/weather-hazards/local-winds/)
[2] Source: Royal Meteorological Society. MetLink. Weather for teachers in England, Scotland and Wales and N. Ireland (http://www.metlink.org/other-weather/weather-hazards/local-winds/)



Source: Royal Meteorological Society. MetLink. Weather for teachers in England, Scotland and Wales and N. Ireland (http://www.metlink.org/other-weather/weather-hazards/local-winds/)

1.3. Anabatic wind

Anabatic (upslope) winds occur over slopes which are heated by the sun. Air which is in contact with slopes that are warmed expands upward and cool and sinks over neighbouring valleys. Anabatic winds are usually slow, at only 1-2 m/s and are rarely importance expect near coasts where they can increase the strength of sea breezes. [3]

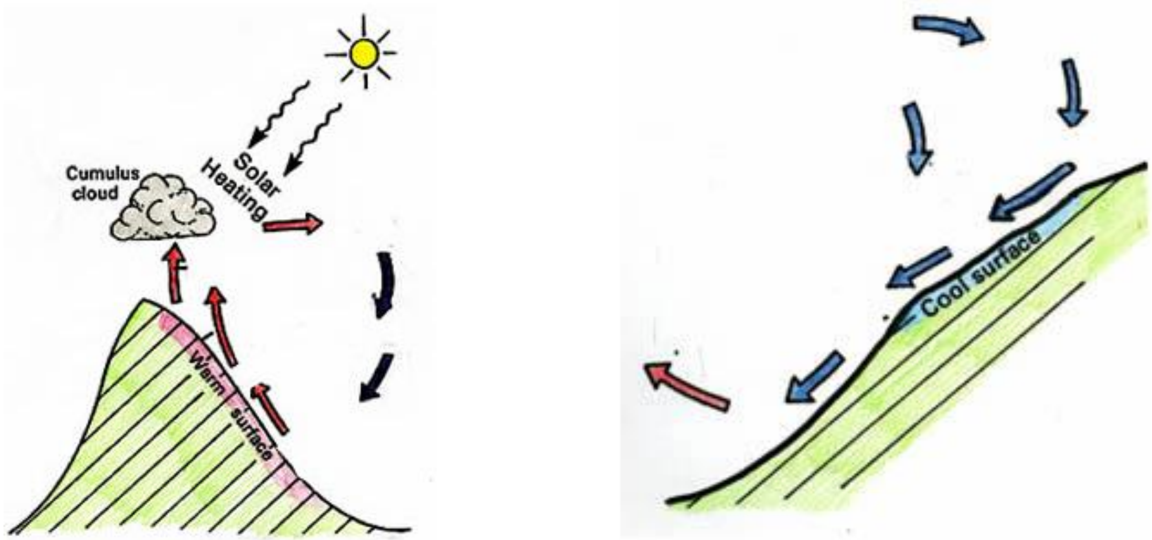
1.4. Katabatic wind

Katabatic winds occur where air in contact with sloping ground is colder than air at the same level away from the hillside over the valley. Katabatic winds are nocturnal phenomena in most parts of the world (i.e. they tend to happen at night) as there is surface cooling, especially when there is little katabatic cloud and due to lack of heating by the sun. Katabatic wind speeds typically do not exceed 3 or 4 m/s. However, where the ground is covered with snow or ice, katabatic winds can occur at any time of day or night with speeds often reaching 10 m/s, or even more if funnelling through narrow valleys occurs. Katabatic winds may lead to the formation of frost, mist and fog in valleys. [4]

[3] Source: Royal Meteorological Society. MetLink. Weather for teachers in England, Scotland and Wales and N. Ireland (http://www.metlink.org/other-weather/weather-hazards/local-winds/)

[4] Source: Royal Meteorological Society. MetLink. Weather for teachers in England, Scotland and Wales and N. Ireland (http://www.metlink.org/other-weather/weather-hazards/local-winds/)

Figure 3: The process of anabatic (left) and katabatic wind (right)



Source: Royal Meteorological Society. MetLink. Weather for teachers in England, Scotland and Wales and N. Ireland (http://www.metlink.org/other-weather/weather-hazards/local-winds/)

2. Winds in Europe

As well as local winds and local weather phenomena, the following description includes seasonal winds with local names. We will focus only on winds over Europe and additionally on winds over the treated local areas. The prevailing winds are bora, mistral, foehn, etesian, helm and levant.

Figure 4: Wind map of Europe

Source: The competition World (http://www.thecompetitionworld.com/)

2.1. Bora

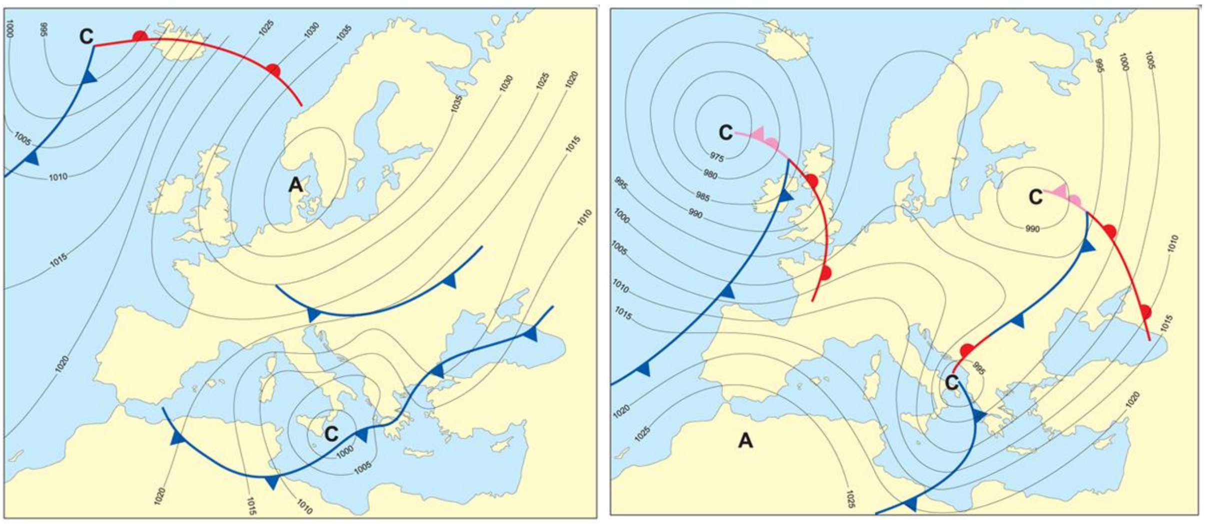
The bora is a strong, cold, typically very dry and gusty north-easterly wind which descends to the Adriatic Sea from the Dinaric Alps, the mountains behind the Dalmatian coast. The peak frequency occurs in the cold season (November - March). In general, the frequency of gusty force, bora winds varies from one day per month, or less, in the summer to six days per month during winter months. The bora is most common blowing down from the mountains on the eastern side of the Adriatic Sea where it flows mainly from the northeast through gaps in the Dinaric Alps. On occasion, the bora can be very localized, extending only a few miles offshore. At other times, the bora will dominate the entire Adriatic Sea and, when the area of steep pressure gradient is large enough, the bora can extend as far south as Malta. The strongest winds occur along the eastern shores of the Adriatic Sea from Trieste to the Albanian border.

There are two primary weather patterns associated with the bora and both are locally classified as being an anticyclonic bora and a cyclonic bora. In either case, the pressure is higher on the European side of the mountains and lower on the Mediterranean side. However, it always takes a cold pool of air accumulating over the Balkan at first. When the depth of the cold air pool reaches the height of mountain passes, the bora will commence breaking through the numerous passes that lie along the mountain barrier and sweeping westwards towards the coast.

The anticyclonic bora: A large high pressure cell is presented over central Europe and generally lower pressure without a well-defined low pressure center to the south over the Mediterranean Sea. The anticyclonic bora is basically a dry and very gusty wind due to its katabatic nature. An anticyclonic bora is characterized by cold, clear weather and good visibilities in the lee of the coastal mountains, while thick clouds associated with up-slope motions are found on the mountain crests. These clouds subsequently dissipate in the descending air on the lee side, and appear as ‘cap’ clouds to an observer on their west side.

The cyclonic bora: A low pressure center is presented in the southern Adriatic Sea so that the weather across the area is cloudy and rainy. The cyclonic bora winds are less gusty than those in an anticyclonic bora, but might bring substantial amounts of rain or snow to the region. With the cyclonic pattern, the bora is often accompanied by low clouds and reduced visibilities associated with rain and/or drizzle. These conditions are more noticeable over the open water areas than along the coastal area.

Figure 5: The synoptic maps with anticyclonic bora (left) and cyclonic bora (right)



Source: Nautical guide of the Slovenian sea and cost. Republic of Slovenia. Ministry of infrastructure.

The greatest intensity of the bora occurs where the mountain peaks are at least 600 m above sea level and not more than two or three miles inland. Anticyclonic bora winds are most intense to the north, decreasing somewhat moving southward, while the strongest cyclonic bora winds are usually found in the southern Adriatic Sea.

The bora does not usually start with a sudden gust but will build up at a relatively moderate pace. The average duration of a continuous gale force bora over the Adriatic Sea is about 12 hours but the winds sometimes will last up to two days. The average duration of a bora that reaches a high wind gust (> 50 km/h) during its history is 40 hours with a maximum duration of 5 days. [5]

Winds are usually less intense over the open water of the Adriatic Sea, but wind gusts (greater than or equal to 62 km/h) are common. The frequency of the wind gusts of bora wind in the open sea is greater for the cyclonic type of pattern than for the anticyclonic pattern. There is a noticeable diurnal variation at stations along the eastern coast of the Adriatic Sea during bora conditions. During the day, the sea breeze counteracts the offshore flow of the bora, which decreases the strength of the bora between noon and 6pm local time. [6]

2.2. Mistral

The mistral is also a strong and often violent wind. It blows offshore with great frequency along the Mediterranean coast from northern Spain to northern Italy, and that is particularly frequent in the lower Rhone valley in south-eastern France blowing way out into the Golfe du Lion. The wind may persist for several days, and it is best developed when a depression is forming in the Gulf of Genoa to the east of a ridge of high pressure. It might also be a purely katabatic wind. The air-stream that feeds the mistral is commonly derived from polar air of maritime origin. It is most violent in winter and spring and its strength is increased by the funneling effect of the Rhone valley. The mistral might easily reach a speed of 130 km/h over the Rhone delta, compared with the typical 70 km/h experienced along the coast. It may blow continuously for a day or two, causing considerable damage to crops and making driving conditions difficult in

[5] Source: Beaufort wind scale force (https://en.wikipedia.org/wiki/Beaufort_scale)
[6] Source: Weather Online (http://www.weatheronline.co.uk/reports/wind/The-Bora.htm).

the Rhone valley. It clears clouds and pollution out of the air. In the Rhone valley in France, trees lean to the south because of the force of the mistral. [7]

2.3. Etesian

The etesian is the strong northerly wind which blows at times over the Aegean Sea and eastern parts of the Mediterranean Sea during the period from May to October. It is the prevailing annually recurring summer wind, blowing over large parts of Greece, the Aegean Sea and eastern Mediterranean. It blows steadily from northern to northwestern directions, which bring cold continental air and clear skies between May and October. It is usually dry, rather cool and moderate, however, it might reaches high wind gust over offshore areas, reaching its maximum wind speed around early afternoon.

The wind gusts of etesian may occur as a result of thermal lows deepening over Turkey. Due to the extended duration of this wind, it can produce significant seas along the Egyptian and Israeli coasts. The etesian gust is induced by the interaction of the seasonal trough along the south coast of Turkey and high pressure over Eastern Europe.

2.4. Foehn

The foehn is a warm, dry, gusty wind which occurs over the lower slopes on the lee of a mountain barrier. It is a result of forcing stable air over a mountain barrier. Originally applied to winds in the European Alps region, the term is now used for all similar winds. Foehn type winds are known for their rapid temperature rise, their desiccating effect and the rapid disappearance of snow cover.

A foehn like situation can last from less than an hour to several days. The high crest of the wave creates a distinctive elongated cloud parallel to the mountains, known as a foehn wall (helm cloud). Further wave crests more distant to the obstacle form the popular lenticularis clouds.

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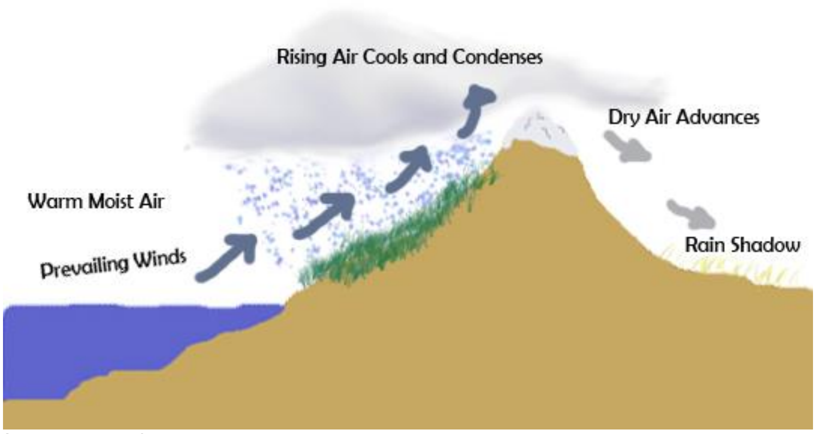
[7] Source: Royal Meteorological Society. MetLink. Weather for teachers in England, Scotland and Wales and N. Ireland (http://www.metlink.org/other-weather/weather-hazards/local-winds/)

Figure 6: The formation of foehn wind



Source: The foehn wind. https://en.wikipedia.org/wiki/Foehn_wind

The danger of a foehn wind where there are steep snow-covered slopes is that avalanches may result from the sudden warming and blustery conditions. In foehn conditions, relative humidity may fall to less than 30 %, causing vegetation and wooden buildings to dry out. This is a long-standing problem in Switzerland, where so many fire disasters have occurred during foehn conditions that fire-watching is obligatory when a foehn wind is blowing. [8]

2.5. Helm

The helm wind is a strong, blustery easterly wind that descends the western slope of the Cross Fell Range in Cumbria, northern England. The Cross Fell area of the northern Pennines forms one of England's largest stretches of upland higher than 800 m above sea level. To the west, there is a steep drop to the Eden Valley and beyond the valley lie the mountains of the Lake District.

The helm wind is basically a foehn-type lee wave caused by a prevailing north-easterly flow, blowing at a more or less right angle to the Cross Fell Range. The helm wind can last for days and is most strongly felt at Milburn, but is also noticeable all along the Fellside. The wind speed is intensified as it drops the steep 600 m escarpments to the Eden Valley. Near Penrith it ceases abruptly, though its roaring can still be heard, only to rise again a few kilometers away as the normal gusty north-easter.

The helm wind can be recognized by a bank of cloud which appears along the mountain tops or just above them, sometimes covering the summit of Cross Fell. This is the 'helm cloud'. At times, a further narrow stationary, but rotating roll cloud forms roughly parallel about 8 to 10 km downwind (west) to the helm cloud. This is the helm bar. The helm bar is a rotor cloud and the surface winds die away beneath it. Farther away from the Fells there may be a light westerly wind towards the mountains.

The gap between the helm cloud and the helm bar represents the descending air and will vary according to temperature and pressure conditions. Within the helm bar, air is moving

[8] Source: Royal Meteorological Society. MetLink. Weather for teachers in England, Scotland and Wales and N. Ireland (http://www.metlink.org/other-weather/weather-hazards/local-winds/)

turbulently as convection currents operate. Warm air has risen from the ground, has cooled, become denser and sunk to the ground. Here it is warmed again, begins to rise and so the circular motion continues. The helm ends when the direction of the wind changes again.

2.6. Levant

Levant is a moist wind which blows from the east over the Strait of Gibraltar. It is frequently accompanied by haze or fog and may occur at any time of year, though it is most common in the period June to October. A feature is the occurrence of a 'banner cloud' extending a kilometer or more downwind from the summit of the Rock of Gibraltar.

Levant wind can synoptically occur in three ways, namely:

- high pressure over western Europe and low pressure to the southwest of Gibraltar over the Atlantic or to the south over Morocco,
- high pressure cell over the Balearic Islands, and
- an approaching cold front from the west toward the Strait of Gibraltar. As it usually occurs within stable air under an inversion the levant is often, but not always, accompanied by local low clouds, fog and sometimes by light rains.

Levant wind may occur at any time of the year, but it is most frequent from July to October and in March. It reaches high wind gusts in spring (February to May) and autumn (October to December). In the summer (June to September) it is usually not more than a moderate light wind (breeze). During the winter months, the wind gusts of levant often follow to the end of wind gusts of levant events. Oftentimes, satellite imagery can depict the onset of levant wind gusts when low stratus clouds dam up along the eastern side of the Strait of Gibraltar. During the summer, the wind gusts of levant is generally confined to the Strait of Gibraltar.

Levant wind is occasionally intensified by the presence of an active depression, to the south by which it suddenly may intensify bringing heavy thundery rain. A good example for such an event took place during November 20th to 24th in 2001. The Levanter was blowing at Beaufort 7 with sustained wind speeds 55 km/h. Peak gusts reached Beaufort 9 (77 km/h).

2.7. Sirocco

Sirocco (*Slovenian: jugo*) is a Mediterranean wind that comes from the Sahara and can reach a high value of the speed in North Africa and Southern Europe. It arises from a warm, dry, tropical air mass that is pulled northward by low-pressure cells moving eastward across the Mediterranean Sea, with the wind originating in the Arabian or Sahara deserts.[9] The hotter, drier continental air mixes with the cooler, wetter air of the maritime cyclone, and the counter-clockwise circulation of the low propels the mixed air across the southern coasts of Europe.[10]

The sirocco wind causes dusty dry conditions along the northern coast of Africa, storms in the Mediterranean Sea, and cool wet weather in Europe. The sirocco's duration may be as short as half a day or may last several days. Many people attribute health problems to the sirocco either because of the heat and dust along the African coastal regions or because of the cool moisture in Europe. The dust within the sirocco wind can cause abrasion in mechanical devices and penetrate buildings.

9 Source: Golden Gate Weather Services. Names of Winds. (http://ggweather.com/winds.html)
10 Source: Source: Weather Online (http://www.weatheronline.co.uk/reports/wind/The-Bora.htm).

Sirocco wind with speed of up to 100 km/h is most common during the autumn and the spring. It reaches a peak in March and November, when it is very hot.

3. Wind conditions in Slovenia

Wind conditions in Slovenia are mainly determined by geographic location, the Alps and heterogeneous surface. Slovenia lies in the middle latitudes in Northern Hemisphere. Over the European mid-latitudes region as well as over Slovenia, the westerly winds are predominated. The air flow, viewed through the large-scale, mostly waves and consequently it turns to the north and south as well. The wind speed and wind direction are formed by high and low-pressure areas, in which the air circulates and from time to time large closed eddies emerge from it. These eddies are known as cyclones and anticyclones. Extensive pressure ridges and related subtropical anticyclones are relatively stationary structures with a life period even up to several weeks. Winds are week when there are subtropical anticyclones across South Europe, on the contrary, winds are stronger on the northern, western and eastern edges of subtropical anticyclones than in their centre.

In Slovenia, the high winds are not very frequent when compared to the prevailing high winds over Western Europe since it is located in the lee-side of the Alps. On the one hand, the hills and mountains create a barrier to the wind, and on the other hand, they deflect the air flows, which have to adjust to the surface. For the local conditions, the distribution of water surfaces as well as a daily heating and cooling of the atmosphere are also very important.

The average wind speed in Slovenia is in general lower, when compared to the average wind speed over the flat surfaces of a Western and Central Europe. Due to variable surface the local wind may occur. By this, the surface properties cause that land surfaces become warmer than water surfaces during the daytime. As a result of this local-scale temperature and pressure difference, a sea wind begins to flow inland from over the water, forcing the warm air over the land to rise and to cool adiabatically. In the absence of strong general winds, this air flows seaward aloft to replace air which has settled and moved toward shore, and thus completes the circulation cell. The surface sea wind begins around midmorning, strengthens during the day, and ends around sunset. [11]

The winds in Slovenia with their range of activity of around 100 km are the results of general winds and the effect of Alpine and Dinaric mountain barrier as well. Over the Slovenia surface three 'regional' winds can be seen: bora, jugo and foehn.

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[11] Source: Wildland Resources. http://ocw.usu.edu/Forest__Range__and_Wildlife_Sciences/Wildland_Fire_Management_and_Planning/Unit_6__Local_and_General_Winds_5.html

3.1.1. Bora (Slovenian: *burja*)

The bora is the strongest wind in Slovenia. After the passing of the cold front of the Mediterranean cyclone cold air folds up around the eastern border of Alps. After rising over the Dinaric mountain plateau (Trnovski gozd, Nanos, Javorniki, Snežnik, Kras) this cold air accelerates down western and southern slopes towards the Adriatic Sea. The bora begins suddenly with some initial gusts. When it reaches its strength, it is a very gusty wind. Its velocity can increase or decrease 10-fold within a very short period. The bora wind is a regular phenomenon in west Slovenia (Primorska, Obala and Notranjska region). The normal bora reaches speeds of up to 10 m/s (35 km/h), but its gusts are several times stronger. Even the normal bora wind can obstruct traffic.

Figure 7: Region with the bora wind

Source: Bertalanič, R. Wind. http://www.arso.gov.si/en/Weather/climate/Wind.pdf

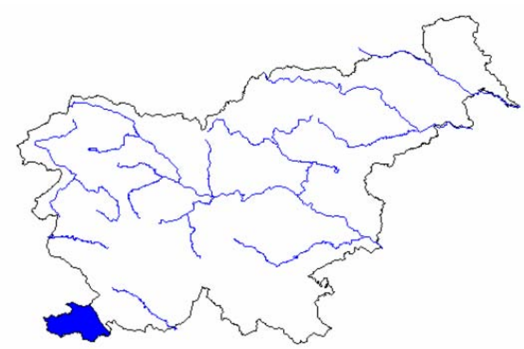
An exceptional strong bora appears when there is a big temperature difference between the air over the continent and the air over the Mediterranean Sea and a large pressure gradient is also present. Bora gusts can then reach and exceed 40 m/s (> 145 km/h). This strong bora in the Vipavska valley breaks trees, unroofs houses and makes traffic impossible. Such a strong bora is actually a regional phenomenon. It is strongest on the slopes and close below them where the wind flow accelerates or converges. The strongest bora is found in Vipavska valley, especially from Razdrto to Vipava, in Karst and along the ridge of Trnovski gozd and Nanos.

In general, bora wind blows in a stable atmosphere when cold air flows under warm air. The bora speed can be in local areas increased by converging wind (winds flowing together). On the contrary there are many calm positions where settlements have been established.

3.1.2. Sirocco (Slovenian: *jugo*)

The sirocco wind appears as a strong wind from the southwest to southeast before a cold front of a passing Mediterranean cyclone. It appears exclusively in the coastal area and moves inland no further than the ridge of Karst. The duration of sirocco wind is linked to the movement of the Mediterranean cyclone, and mostly lasts up to two days. There are about 20 such weather situations annually. The sirocco frequency is as like as bora's since both phenomena are related to the same synoptic process.

Figure 8: Region with the sirocco



Source: Bertalanič, R. Wind. http://www.arso.gov.si/en/Weather/climate/Wind.pdf

3.1.3. Foehn (Slovenian: *fen*)

The Karavanke foehn is, comparing to bora or scirocco (jugo), less frequent phenomenon in Slovenia. It annually occurs once or twice, especially in the cold part of the year. It can become very strong every ten years. It is a very strong northerly wind which affects the southern slopes and valleys of the Karavanke and Kamniško-Savinjske Alps. It can also reach the Julian Alps and Ljubljana basin. It is a relatively warm and dry wind. The foehn wind is katabatic wind and appears when the Mediterranean cyclone moves over Eastern Europe.

Figure 9: Region with the Karavanke foehn

Source: Bertalanič, R. Wind. http://www.arso.gov.si/en/Weather/climate/Wind.pdf

3.2. Presentation of Municipality of Ajdovščina study area

In order to assess the vulnerability of the Municipality of Ajdovščina to high wind and high wind gusts, understanding and knowledge of the local area and its specific characteristics is essential. To this end, we will have a closer look at five major risk/vulnerability aspects, namely 1. population, 2. infrastructure, 3. transport, 4. buildings and 5. forests according to current situation, trends and high wind risk/vulnerability aspect. Thus, we will analyse Bora effect in the local environment in order to validate it as a main cause of wind disaster events. We need to stress that the present report was made out of directly accessible and readily available data and other relevant materials.

3.2.1. Population

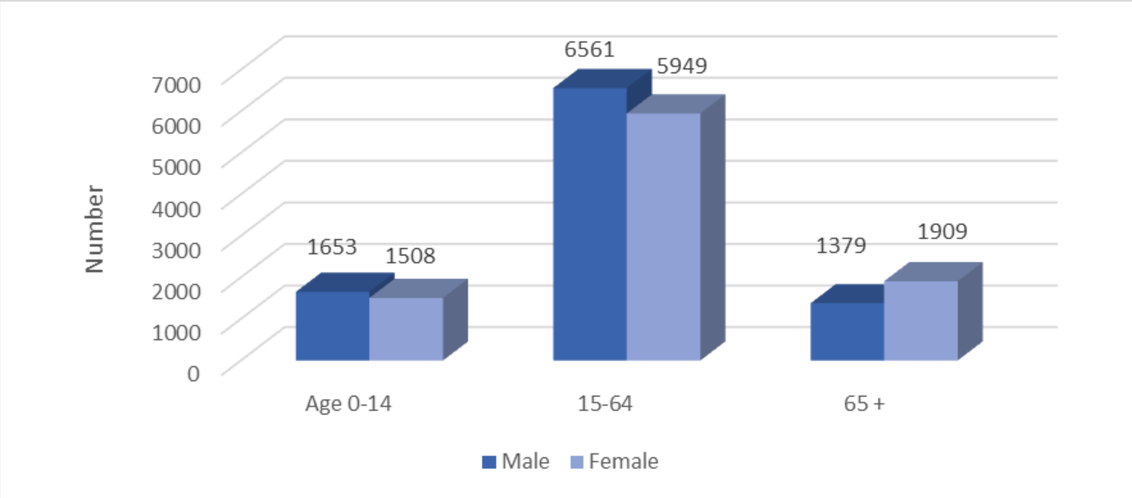
According to the Statistical office of Slovenia, the municipality of Ajdovščina had, on the 1/1/2015, 18959 inhabitants (9.593 men and 9.366 women) in the area of 245 km^2.The average population density is 77.3 people per km², which is lower than national figures 101.8. The average age of residents was 41.9 years, compering to the national average of 42.5 years old. Average age of male population was 41.50, while female was 44.11.[12] In Municipality of Ajdovščina the aging index was 107.3. The percentage of active working people was 64.7%.[13]

There were 12 graduates per 100 inhabitants and 2.3 sentenced persons per 1000 inhabitants.[14] Among the total inhabitants there were 7236 employed and 1067 unemployed persons. The registered unemployment rate was 12.9%, which is less than the national 13.1% average.[15]

The municipality has 26 local communities and 45 settlements, with the average area of 5.4 km2. Ajdovščina town is the most populated, with it's 6505 inhabitants, while the smallest settlement is Križna Gora with 10 inhabitants. Other larger settlements are Lokavec, Planina, Vrtovin, Col, Budanje…

12 Source: Kaliopa – http://gis.iobcina.si/gisapp/Default.aspx?a=ajdovscina
13 Source: Statistical Office of the Republic of Slovenia, Ministry of the Interior.
14 Source: Kaliopa – http://gis.iobcina.si/gisapp/Default.aspx?a=ajdovscina
15 Source: Statistical Office of the Republic of Slovenia, Ministry of the Interior.

Figure 10: Residents by age and gender



Source: Kaliopa – http://pxweb.stat.si/pxweb/Dialog/Saveshow.asp

Table 1: Surface, number of residents, density and average age in the 45 local communities in Ajdovščina

Number	Settlement	Surface (m²)	Residents	Density	Average age
1	AJDOVŠČINA	6838723.9	6505	951.20	43.25
2	BATUJE	2823255.95	359	127.16	46.46
3	BELA	4907857.36	38	7.742	36.53
4	BRJE	5338211.47	392	73.43	44.25
5	BUDANJE	5278542.08	847	160.46	40.46
6	CESTA	2747146.00	554	201.66	42.46
7	COL	2617365.9	528	201.73	40.34
8	ČRNIČE	5345334.31	433	81.01	44.10
9	DOBRAVLJE	3178530.60	480	151.01	42.88
10	DOLENJE	1143085.94	103	90.11	51.59
11	DOLGA POLJANA	2313623.37	369	159.49	40.82
12	GABERJE	4586448.07	175	38.16	39,62
13	GOJAČE	5002348.66	198	39.58	39.96
14	GOZD	6911906.83	130	18.81	42.92
15	GRIVČE	3657818.41	73	19.96	44.06
16	KAMNJE	4406547.57	210	47.66	43.78
17	KOVK	8848596.71	139	15.71	42.30
18	KOŽMANI	431282.99	113	262.01	41.93
19	KRIŽNA GORA	8127735.20	10	1.23	62.83
20	LOKAVEC	13744200.48	1137	82.73	42.55
21	MALE ŽABLJE	1145005.81	318	277.73	41.67
22	MALO POLJE	7906169.73	76	9.61	43.04
23	MALOVŠE	710295.94	133	187.25	41.55
24	OTLICA	12166693.99	309	25.40	46.20
25	PLAČE	2763010.99	247	89.40	40.94
26	PLANINA	6494167.24	478	73.60	41.42
27	PODKRAJ	19515122.84	436	22.34	41.91
28	POTOČE	3048969.42	233	76.42	40.72
29	PREDMEJA	20735831.24	386	18.62	43.15
30	RAVNE	12605166.46	148	11.74	42.65

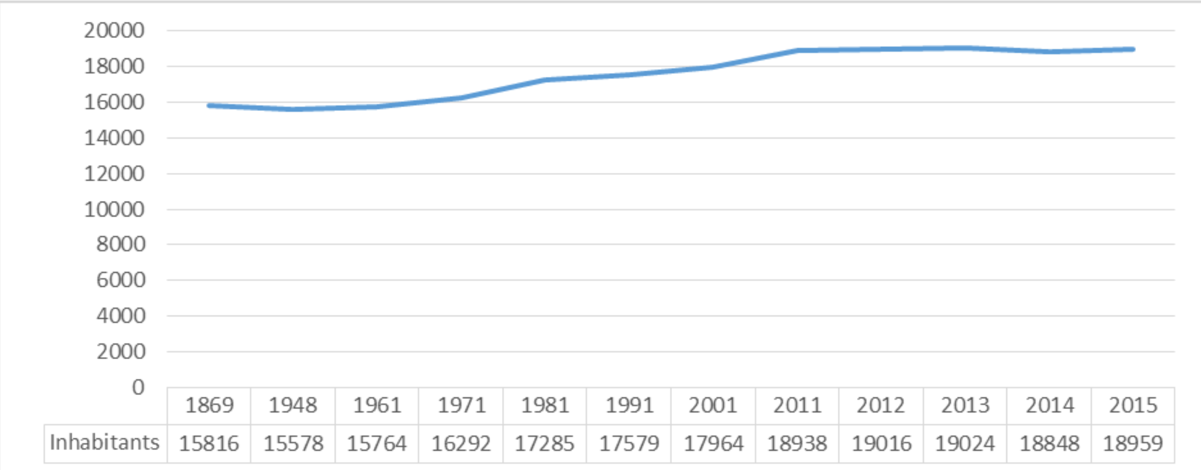
31	SELO	3983171.79	470	118.00	39.42
32	SKRILJE	1448369.51	319	220.25	41.60
33	STOMAŽ	7402604.60	299	40.40	40.98
34	ŠMARJE	5813720.45	189	32.51	45.77
35	TEVČE	418457.25	92	219.86	40.70
36	USTJE	2771980.83	376	135.64	45.01
37	VELIKE ŽABLJE	3123870.37	343	109.80	42.37
38	VIPAVSKI KRIŽ	484916.98	178	367.07	44.42
39	VIŠNJE	2749490.71	182	66.19	43.29
40	VODICE	7006597.70	70	10.00	37.68
41	VRTOVČE	1809009.44	112	61.91	47.64
42	VRTOVIN	16136417.97	476	29.50	45.59
43	ZAVINO	2102502.03	84	39.95	44.34
44	ŽAGOLIČ	2854903.19	134	46.94	40.61
45	ŽAPUŽE	1788515.97	361	201.84	43.45

Source: Kaliopa - http://gis.iobcina.si/gisapp/Default.aspx?a=ajdovscina

3.2.1.1. Population trends

The demographic age structure of the Municipality of Ajdovščina is more favourable than the national average. In 2014 the natural increase in Slovenia was 3.7 per 1.000 people, comparing with Ajdovščina where it was 1.1.[16] The proportion of young people (under 26 years) exceeds 25%, the proportion of elderly (over 65 years) is lower than 20% (2702 inhabitants).[17] Nonetheless, positive demographic trends can, swiftly turn into negative trends. The population growth in the municipality is slightly too low.

Figure 11: Population changes until 1.1.2015

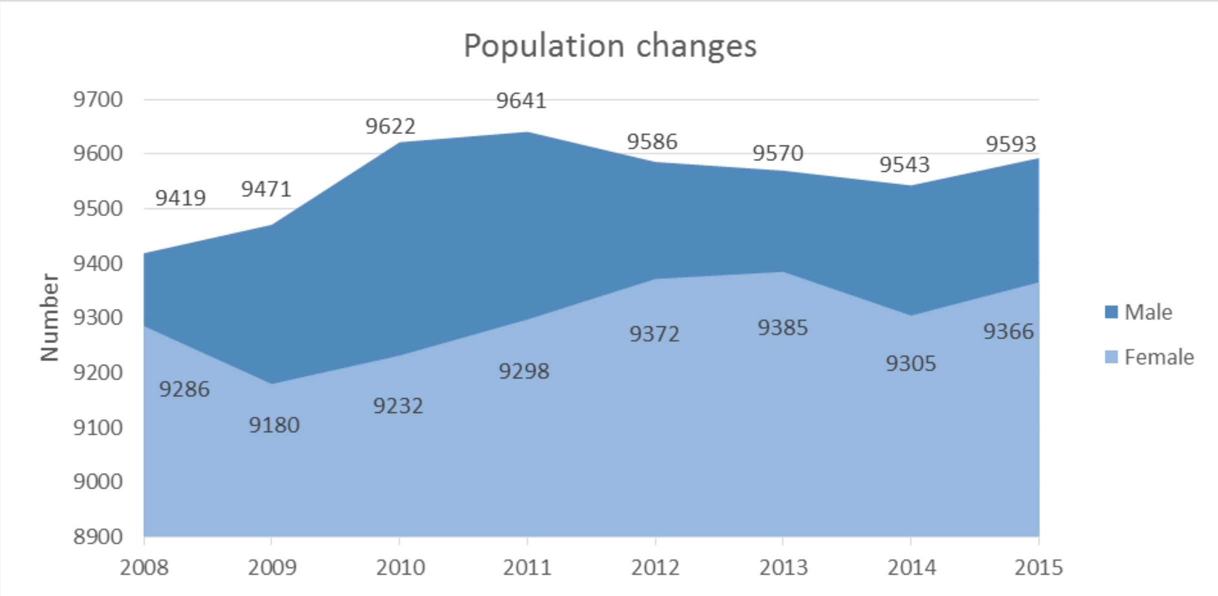


Source: Statistical Office of the Republic of Slovenia, Ministry of the Interior.

Figure 12: Population changes by gender

[16] Source: Statistical Office of the Republic of Slovenia, Ministry of the Interior.

[17] Source: Občina Ajdovščina: Ocena ogroženosti pred naravnimi in drugimi nesrečami v občini Ajdovščina, Ajdovščina julij 2014. (Municipality of Ajdovščina: Risk Assessment against natural and other disasters, July 2014).



Source: Statistical Office of the Republic of Slovenia, Ministry of the Interior.

The Strategy of demographic and economic development for the Municipality of Ajdovščina envisages three different demographic projection plans for year 2021. According to the optimal plan, the municipality will have, about 25000 residents, while the realistic plan foresees, about 22000 residents. According to the linear trend, the municipality will have about 19300 inhabitants. It also emphasizes that the minimum basis for appropriate wellbeing and the viability of supply is 19000.[18]

Development trends in urban and rural populated areas follow the development of urbanized and suburbanized areas and depopulation and economic stagnation in remote rural areas. In urban areas, further increase in the population is expected and in rural areas, the population is expected to decline. In the hinterland, there is still a trend of depopulated areas. Over the municipality, there is a noticeable increase in population in the valley settlements, particularly around the motorway exit Selo.[19]

3.2.1.2. Bora Risk/Vulnerability of the population

Although the local population is well adapted to this local meteorological phenomenon, injuries and damage due to flying objects blown away by wind may occur. In the periods of extremely strong bora, children and elders should stay at home for safety reasons. Workers cannot come to work. Furthermore a reduction in the number of travelers through the town does occur.

3.2.2. Infrastructure

Municipality of Ajdovščina is responsible for number of public infrastructure services, such as municipal roads, water supply and sewage systems, gas pipelines, landfills, public lightning, utility services etc. On top of that it is also responsible for cultural and general education and health care as well as others services.

[18] Source: Koda d.o.o.: Strategija demografskega in gospodarskega razvoja, Ajdovščina Marec 2007 (Strategy of demographic and economic development for the Municipality of Ajdovščina).
[19] Source: Občina Ajdovščina: Ocena ogroženosti pred naravnimi in drugimi nesrečami v občini Ajdovščina, Ajdovščina julij 2014. (Municipality of Ajdovščina:Risk Assessment against natural and other disasters, July 2014).

For example, in 2012 there was a total of 349.4 km of roads in the Municipality of Ajdovščina, out of which there was 93.5 km of state roads and 255.9 km of municipal roads. From municipal roads there are 97.3 km of local roads (LC), 5.7 km urban roads (LZ), 19.1 km of urban (local) roads (LK) and 133.8 km of public paths (JP). Municipal roads, connects individual villages among them and to the national road network.[20]

Domestic water supply in the Municipality of Ajdovščina is sufficient. Hubelj water supply system supplies major part of Vipava Valley and Goriška region. There are also a number of village water basins, which supply 50 households.[21] The overall length of drinking water pipes is 350824 m. Furthermore municipality is in charge of its sewage system, with the total pipe length of 157772 m. The average communal waste amount is 560 kg per person.[22] Through the area of the Municipality of Ajdovščina there is also a main pipeline Hrušica-Vipava-Volčja Draga-Nova Gorica. It is used primarily for residential heating.[23]

Table 2: Length of water pipes by settlements

Settlement	Length **(m)**
AJDOVŠČINA	74210.84
BATUJE	13917.04
BRJE	9018.81
BUDANJE	13100.51
CESTA	11929.22
COL	9684.99
ČRNIČE	8098.45
DOBRAVLJE	6849.13
DOLENJE	2933.77
DOLGA POLJANA	6248.16
GABERJE	2953.61
GOJAČE	7397.51
GOZD	8604.41
GRIVČE	139.91
KAMNJE	383.78
KOVK	12107.82
KOŽMANI	2072.04
LOKAVEC	21456.53
MALE ŽABLJE	4427.95
MALO POLJE	2207.28
MALOVŠE	3728.9
OTLICA	15123.8
PLAČE	2849.3
PLANINA	15397.44
PODKRAJ	5563.99

[20] Source: Statistical Office of the Republic of Slovenia, Ministry of the Interior.

[21] Source: Občina Ajdovščina: Ocena ogroženosti pred naravnimi in drugimi nesrečami v občini Ajdovščina, Ajdovščina julij 2014. (Municipality of Ajdovščina:Risk Assessment against natural and other disasters, July 2014).

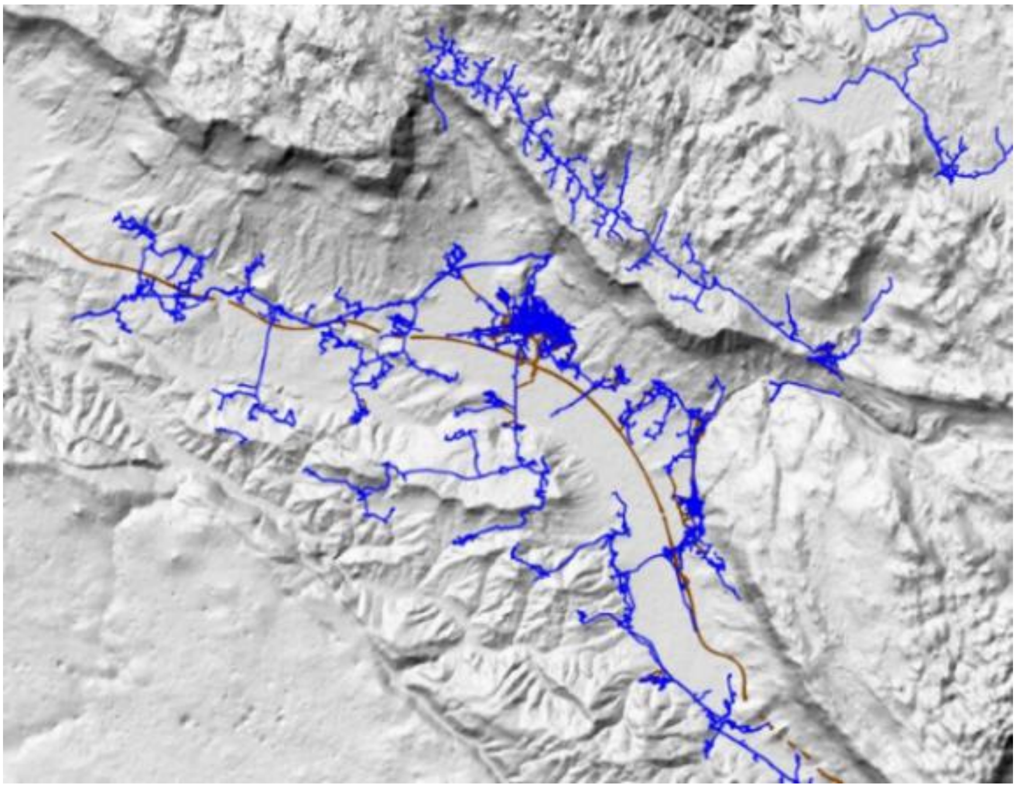
[22] Source: Kaliopa - http://gis.iobcina.si/gisapp/Default.aspx?a=ajdovscina

[23] Source: Občina Ajdovščina: Ocena ogroženosti pred naravnimi in drugimi nesrečami v občini Ajdovščina, Ajdovščina julij 2014. (Municipality of Ajdovščina:Risk Assessment against natural and other disasters, July 2014

POTOČE	8543.43
PREDMEJA	21122.1
SELO	9832.31
SKRILJE	7064.95
ŠMARJE	5555.4
TEVČE	1382.06
USTJE	7629.07
VELIKE ŽABLJE	3920.37
VIPAVSKI KRIŽ	2011.12
VRTOVČE	4228.66
VRTOVIN	9460.27
ZAVINO	2113.66
ŽAGOLIČ	4087.57
ŽAPUŽE	3468.83

Source: Kaliopa - http://gis.iobcina.si/gisapp/Default.aspx?a=ajdovscina.

Figure 13: Wastewater network



Source: Kaliopa - http://gis.iobcina.si/gisapp/Default.aspx?a=ajdovscina

3.2.2.1. Infrastructure trends

The whole area of the Municipality of Ajdovščina, requires planning and regulation of traffic flows and surfaces. However, investments in infrastructure must be effective in order to cover its costs and they need to follow a selective and organized approach.[24]

In the municipality, it is necessary to continue with the implementation of the water supply network Hubelj, remediate the village water supply and connect it to the municipal water supply.[25]

3.2.2.2. Bora Risk/Vulnerability of the infrastructure

Strong wind easily tears down the electricity and telephone cables. Lack of electrical power affects also the supply of drinkable water. Therefore, all overhead lines (electric and telephone lines) should gradually be replaced by the ground cable ducts in order to withstand the wind.[26]

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[24] Source: Koda d.o.o.: Strategija demografskega in gospodarskega razvoja, Ajdovščina Marec 2007 (Strategy of demographic and economic development for the Municipality of Ajdovščina).

[25] Source: Strategija prostorskega razvoja Občine Ajdovščina, Analiza stanja in teženj, Studio 3 d.o.o., november 2005, Ajdovščina (Strategy of spatial development of the Municipality of Ajdovščina).

[26] Source: Strategija prostorskega razvoja Občine Ajdovščina, Analiza stanja in teženj, Studio 3 d.o.o., november 2005, Ajdovščina (Strategy of spatial development of the Municipality of Ajdovščina).

3.2.3. Transport

Ajdovščina is situated on the strategically international important V and X Pan-European transport crossing, between the central Slovenia and Friuli Venezia Giulia (Italy). All through the Vipava valley there is a modern main road H4 highway Razdrto-Vrtojba.[27] In the section between Ajdovščina – Selo the highest average daily traffic in 2013 was 12069 vehicles (that is 3.2% less than in 2012 when it was 12467 vehicles) of which HGV represented 1654 vehicles (that is 1.9% more than in 2012 when it was 1615 vehicles).[28]

Table 3: Daily traffic burden

Cat road	No. road	No. section	Transport section	Total vehicles	Trucks above 3.5t	Percentage of cargo vehicles
HC	H4	0375	VIPAVA - AJDOVŠČINA	**10987**	1837	17
HC	H4	0376	AJDOVŠČINA - SELO	**12069**	1870	15
HC	H4	0378	SELO - VOGRSKO	**11874**	1838	15
HC	H4	0443	PRIKLJ. SELO - AJDOVŠČINA	**1595**	82	5
HC	H4	0443	PRIKLJ.SELO - VRTOJBA	**1398**	50	4
R1	207	1413	COL - AJDOVŠČINA	**2452**	142	6
R2	444	0346	AJDOVŠČINA - SELO	**6510**	109	2
R2	444	0347	SELO - TRI HIŠE	**4927**	75	2
R2	444	0387	AJDOVŠČINA (OBVOZNICA)	**4064**	338	8
R2	444	1473	VIPAVA - AJDOVŠČINA	**5679**	142	3
R3	611	1024	DORNBERK - SELO	**1746**	74	4

Source: Direkcija RS za ceste 2013

3.2.3.1. Transport trends

With increasing transit and commuter traffic, the state of the road infrastructure is deteriorating. Slow modernization of transport network and a steady increase in road traffic causes demands for new infrastructure. Furthermore, public transport is losing significance, while the use of personal transport increases. Therefore, road maintenance investment requires a systematic approach.[29]

3.2.3.2. Bora Risk/Vulnerability of the transport

Bora is a serious problem for vehicles in transit. When bora blows 90 km/h the roads must be closed for light trucks, when it blows 130 km/h – roads must be closed for buses and trucks,

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27 Source: Občina Ajdovščina: Ocena ogroženosti pred naravnimi in drugimi nesrečami v občini Ajdovščina, Ajdovščina julij 2014. (Municipality of Ajdovščina: Risk Assessment against natural and other disasters, July 2014).

28 Source: http://www.dars.si/Dokumenti/O_avtocestah/Prometne_obremenitve/Obremenjenost_cest_97.aspx

29 Source: Strategija prostorskega razvoja Občine Ajdovščina, Analiza stanja in teženj, Studio 3 d.o.o., november 2005, Ajdovščina (Strategy of spatial development of the Municipality of Ajdovščina).

and when it blows 150 km/h the roads must be closed for all traffic. This causes a major economic deficit to the entire region. In addition, Bora carries debris on roads and streets which also cause damage on other structures such as fences, traffic lights and signs etc.

3.2.4. Buildings

Ajdovščina town is the only centre of regional importance in the municipality and is defined as such in all spatial documents.[30] Settlement in the area is highly fragmented: alongside Ajdovščina there are only two settlements above 500 inhabitants (Lokavec and Budanje). There are few integrated villages e.g. Batuje, Selo, Vipavski križ, Šmarje, but stretched villages dominates e.g. Brje, Kamnje, Vrtovin, Planina.[31] In 2013 there were 389 flats per 1000 inhabitants. Approximately 73 % dwellings had at least three rooms, with the minimum area of 89 m^2.[32]

Table 4: Households in 45 settlements

No.	Settlement	Households
1	AJDOVŠČINA	1437
2	BATUJE	144
3	BELA	9
4	BRJE	159
5	BUDANJE	255
6	CESTA	162
7	COL	168
8	ČRNIČE	172
9	DOBRAVLJE	164
10	DOLENJE	43
11	DOLGA POLJANA	118
12	GABERJE	99
13	GOJAČE	88
14	GOZD	45
15	GRIVČE	23
16	KAMNJE	93
17	KOVK	57
18	KOŽMANI	32
19	KRIŽNA GORA	11
20	LOKAVEC	382
21	MALE ŽABLJE	120
22	MALO POLJE	26
23	MALOVŠE	51
24	OTLICA	131
25	PLAČE	78
26	PLANINA	160
27	PODKRAJ	146
28	POTOČE	82
29	PREDMEJA	187
30	RAVNE	49
31	SELO	160

[30] Source: Strategija prostorskega razvoja Občine Ajdovščina, Analiza stanja in teženj, Studio 3 d.o.o., november 2005, Ajdovščina (Strategy of spatial development of the Municipality of Ajdovščina).
[31] Source: Občina Ajdovščina: Ocena ogroženosti pred naravnimi in drugimi nesrečami v občini Ajdovščina, Ajdovščina julij 2014. (Municipality of Ajdovščina:Risk Assessment against natural and other disasters, July 2014).
[32] Source: Statistical Office of the Republic of Slovenia, Ministry of the Interior.

32	SKRILJE	122
33	STOMAŽ	105
34	ŠMARJE	82
35	TEVČE	34
36	USTJE	125
37	VELIKE ŽABLJE	129
38	VIPAVSKI KRIŽ	81
39	VIŠNJE	47
40	VODICE	21
41	VRTOVČE	43
42	VRTOVIN	193
43	ZAVINO	38
44	ŽAGOLIČ	30
45	ŽAPUŽE	110
	TOTAL	6011

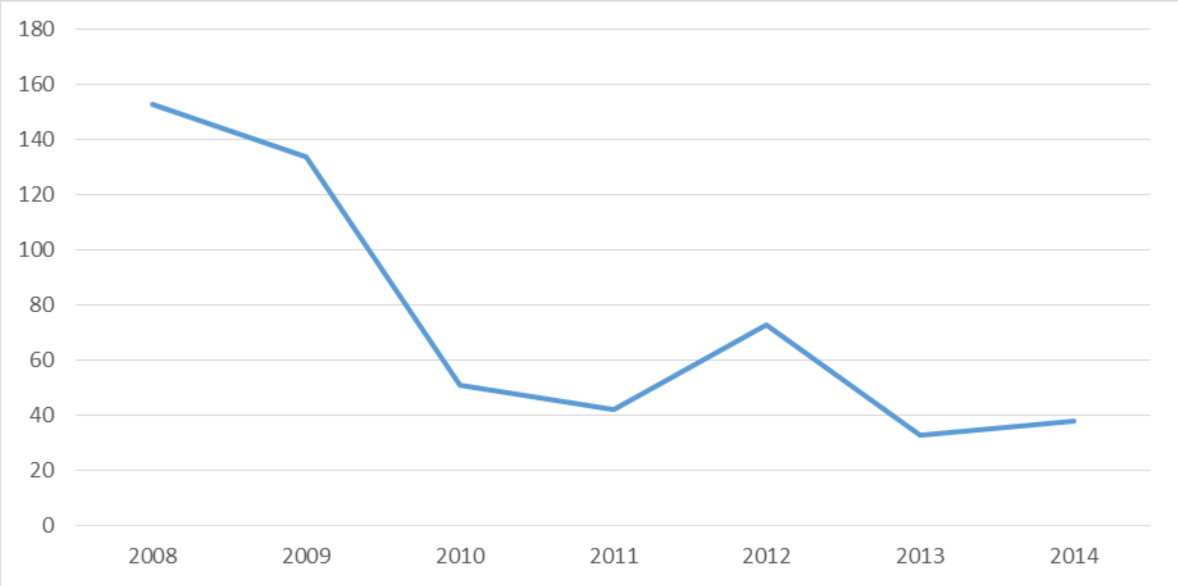
Source: Kaliopa - http://gis.iobcina.si/gisapp/Default.aspx?a=ajdovscina.

3.2.4.1. *Building trends*

In areas with highly dispersed settlements, the development of local centers is encouraged in order to provide appropriate allocation of supply facilities, social care and other activities. Moreover provisions needs to be made to revitalize abandoned, poorly utilized or even depopulated premises in the center of Ajdovščina.[33]

[33] Source: Strategija prostorskega razvoja Občine Ajdovščina, Analiza stanja in teženj, Studio 3 d.o.o., november 2005, Ajdovščina (Strategy of spatial development of the Municipality of Ajdovščina).

Figure 14: New housing



Source: Statistical Office of the Republic of Slovenia, Ministry of the Interior.

In previous development industrial areas, infrastructure facilities and commercial buildings were focused mainly to the urban area of Ajdovščina city. Recently they have moved also to other zones, which can develop into employment centers such as Gojače, Selo, Črniče and Batuje. Furthermore, the area Selo-Batuje together with Gojače developed into an important centre around the motorway exit. In a further development, it is also necessary that Ajdovščina take advantage as an important inter-municipal center within the northern Primorska region.[34]

3.2.4.2. Bora Risk/Vulnerability of the buildings

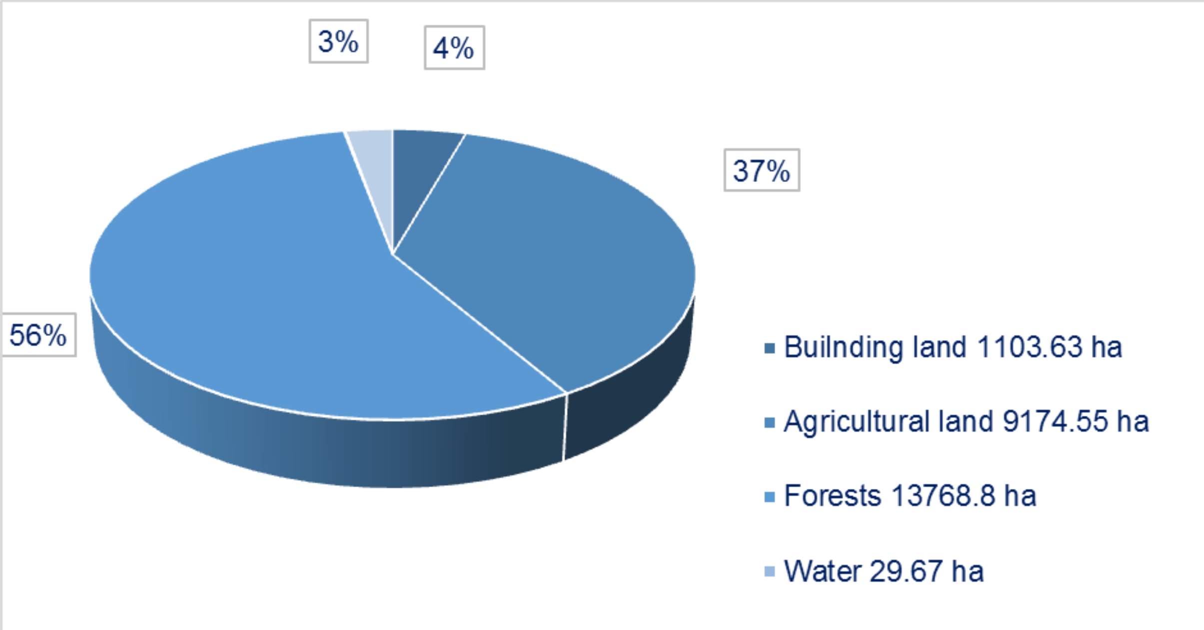
In the periods of extremely strong bora public buildings, factories and even medical center are closed due to safety reasons. Therefore, school curriculum interferences, production interruptions etc. often occurs. Furthermore, smaller and bigger damage done on buildings due to strong Boras is inevitable. Most common damage due to strong Bora winds is lifting off roofs and roof tiles on new, improperly design and inadequately constructed buildings.

[34] Source: Strategija prostorskega razvoja Občine Ajdovščina, Analiza stanja in teženj, Studio 3 d.o.o., november 2005, Ajdovščina (Strategy of spatial development of the Municipality of Ajdovščina).

3.2.5. Forests

Municipality of Ajdovščina spatial plan defines that 56% of the total area are forests, 37% agricultural land, 4% building land area and less than 3% other.[35]

Figure 15: Land use



Source: Prostorski plan Občine Ajdovščina (Ur. glasilo 7-97, ULRS 96-2004).

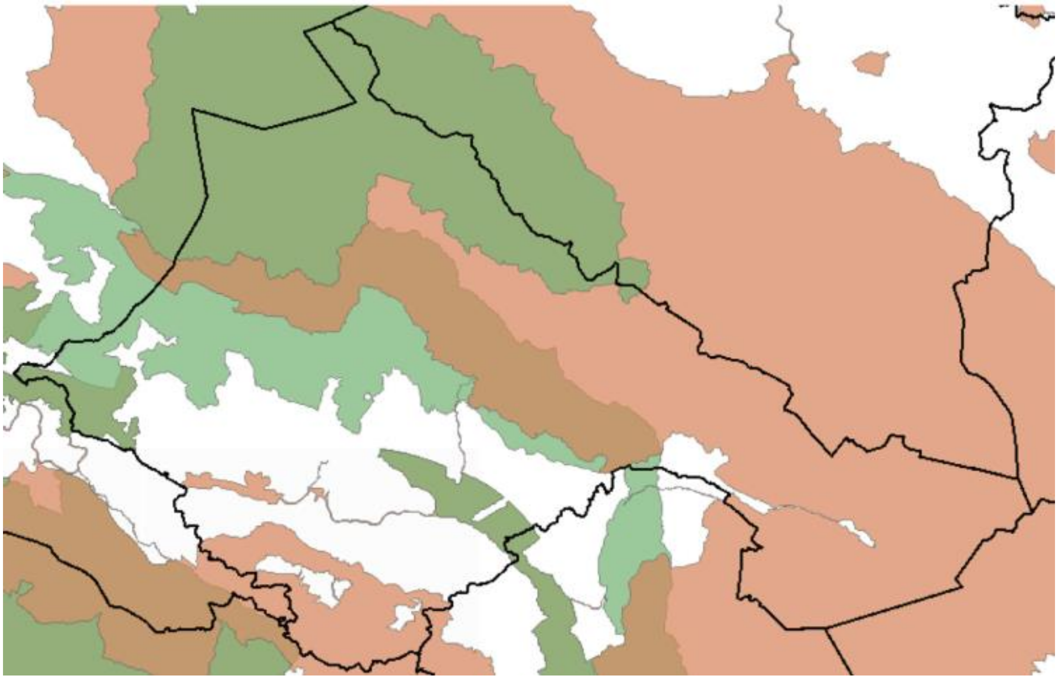
According to the Slovenian forestry Institute beech forests prevail in the area. Soft and hard deciduous trees are more represented in the younger forests, whereas, other valuable deciduous trees are more represented in the older forests. Most of the forests are privately owned (67.73 %), followed by state forests (31.83 %). Municipal forests are represented with only 0.44 %.[36]

According to the Slovenian forestry Institute, state forests occupy 5724.10 ha and the growing stock is 1753403.21 m^3, whereas deciduous trees represent 56.64 % and conifers 43.36 %. The annual increment is 34885.34 m^3. On the other hand, private forests occupy 12181.33 ha and growing stock is 2283045.51 m^3, with a 72.63 % of deciduous and 27.37 % of conifers. The annual increment is 59886.08 m^3.[37]

An important fact is that 179 km^2 or 70% of the municipality's area belongs to the protected Natura 2000 areas: SI5000021 Vipavski rob, SI3000225 Dolina Branice, SI3000226 Dolina Vipave and SI3000255 Trnovski gozd – Nanos.[38]

[35] Source: Prostorski plan Občine Ajdovščina (Ur. glasilo 7-97, ULRS 96-2004).
[36] Source: Todora Rogelja, Špela Ščap, Matevž Triplat, dr. Nike Krajnc: Availability of forest biomass in the Municipality of Ajdvoščina,Ljubljana September 2014.
[37] Source: Todora Rogelja, Špela Ščap, Matevž Triplat, dr. Nike Krajnc: Availability of forest biomass in the Municipality of Ajdvoščina,Ljubljana September 2014.
[38] Source: Občina Ajdovščina: Ocena ogroženosti pred naravnimi in drugimi nesrečami v občini Ajdovščina, Ajdovščina julij 2014. (Municipality of Ajdovščina: Risk Assessment against natural and other disasters, July 2014).

Figure 16: Natura 2000 in the Municipality of Ajdovščina



Source: Kaliopa - http://gis.arso.gov.si/atlasokolja

3.2.5.1. Forests trends

According to the Slovenian forestry Institute the share of conifers is gradually decreasing and this trend will continue in the future. Decrease of fir and pine is especially notable.[39] Increased utilization of private and public forests potential and its management must became a good practice.

3.2.5.2. Bora Risk/Vulnerability of forests

Bora can break or uproot trees. Damage most likely occurs in winter and spring, when bora shakes off the tree blossoms. Furthermore, local areas where Bora is at its highest, threes grow inclined with asymmetric crowns.[40]

[39] Source: Todora Rogelja, Špela Ščap, Matevž Triplat, dr. Nike Krajnc: Availability of forest biomass in the Municipality of Ajdvoščina,Ljubljana September 2014,

[40] Source: Občina Ajdovščina: Ocena ogroženosti pred naravnimi in drugimi nesrečami v občini Ajdovščina, Ajdovščina julij 2014. (Municipality of Ajdovščina: Risk Assessment against natural and other disasters, July 2014).

3.3. Identification of trends in Bora hazard aspects

All existing threats of natural and others hazards in the area of the Municipality of Ajdovščina are evaluated, specified and identifies in the Natural and Other Risk Assessment document in the Municipality of Ajdovščina.[41]

Bora is in the Natural and Other Risk Assessment in-depth defined according to:

- **SOURCE:** An intensive exchange of air masses over mountain barriers into the valley couses striking windiness in the area of Municipality of Ajdovščina.

- **CAUSE**: The main cause represent the different Atmospheric pressures that occur and cannot be influenced.

- **SPATIAL AND TEMPORAL PROBABILITY OF OCCURRENCE**: Probability of occurrence of strong winds from various direction and summer or autumn storms is high. In Vipava valley extremely strong Bora wind is blowing about 30 days per year. When it appears together with rain or snow, the disaster risk is even higher.

- **RISK TYPES, SHAPES AND LEVEL**: Unstable buildings and their roofs are endangered by the force from high wind and wind gusts. Consequences are felt also on the transit, infrastructure, forests, agriculture etc. The population is at risk of falling and getting injured with flying objects and debris by bora.

- **THE COURSE AND POTENTIAL EXTENT OF THE DISASTER**: Formation of storms are usually of short duration and devastate smaller areas. Thunderstorms with Bora usually accompanied by heavy rainfall and lightning damage roofs, tear overhead electrical and telephone wiring, deposit debris on roads and streets, ravage agricultural crops.

- **NUMBER OF PEOPLE AND ANIMALS AT RISK:** People and animals are not directly at risk by high wind and wind gusts. But often, the debris carried by wind, leads to injuries.

- **THE EXTENT OF JEOPARDIZED PROPERTY AND CULTURAL HERITAGE:** In the affected area, mostly properties, such as roofs, cars, agricultural crops etc. are under threat. In the affected area Most of the older buildings are well constructed against high wind.

- **POTENTIAL DISASTER CONSEQUENCES:** Injuries or even humans and animals death, material damage to property and crops, interruption of electricity supply and telephone connections, traffic disruption…

- **PROBABILITY OF CHAIN-REACTION ACCIDENT:** Lightning strikes or torn power lines can cause fires in buildings or in natural environment, that can rapid escalate with wind; road accidents…

- **DISASTER PREDICTABILITY:** In accordance with the available meteorological data it is possible to predict the development of storms, high wind and wind gusts.

[41] Source: Občina Ajdovščina: Ocena ogroženosti pred naravnimi in drugimi nesrečami v občini Ajdovščina, Ajdovščina julij 2014. (Municipality of Ajdovščina: Risk Assessment against natural and other disasters, July 2014).

- **PROTECTION, RESCUE, RELIEF, PREVENTION, MITIGATION AND DISASTER RECOVERY PROPOSALS**: In the Municipality of Ajdovščina it is essential to operate in accordance with The plan for mobilizing and informing providers of protection and rescue measures of the Municipality of Ajdovščina. The public has to be informed about the consequences of high wind and wind gusts and instructions for handling must be provided. Eventual infrastructure damage (on electricity, water, telecommunications, sewer, roads and supply) must be repaired and restored. In the case of larger disasters, the damage must be examined and evaluated. Proper construction of roofs must became a good practice. Soundness of auxiliary facilities must be ensured. For unsecured materials vulnerable to wind scattering, appropriate storage must be provided."[42]

[42] Source: Občina Ajdovščina: Ocena ogroženosti pred naravnimi in drugimi nesrečami v občini Ajdovščina, Ajdovščina julij 2014. (Municipality of Ajdovščina: Risk Assessment against natural and other disasters, July 2014).

4. Wind conditions in Croatia

4.1. Presentation of Central Dalmatia (Split-Dalmatia County) study area

In this report, we assess the vulnerability of Central Dalmatia to high wind and high wind gusts. By Central Dalmatia we assume the territory covered by Split-Dalmatia County. To assess such vulnerability, understanding and knowledge of the local area and its specific characteristics is essential. Five major risk/vulnerability aspects are covered, i.e., 1. population, 2. infrastructure, 3. transport, 4. buildings and 5. forests according to current situation, trends and high wind risk/vulnerability aspect.

Two main winds that represent hazard in this area are Bora (bura) from the North-east and South wind (Jugo or Šiloko) from the South-east. Both of these winds can blow for several days and can be strong enough to cause interruption of land, air and sea transportation.

We need to stress that the present report was made out of directly accessible and readily available data and other relevant materials.

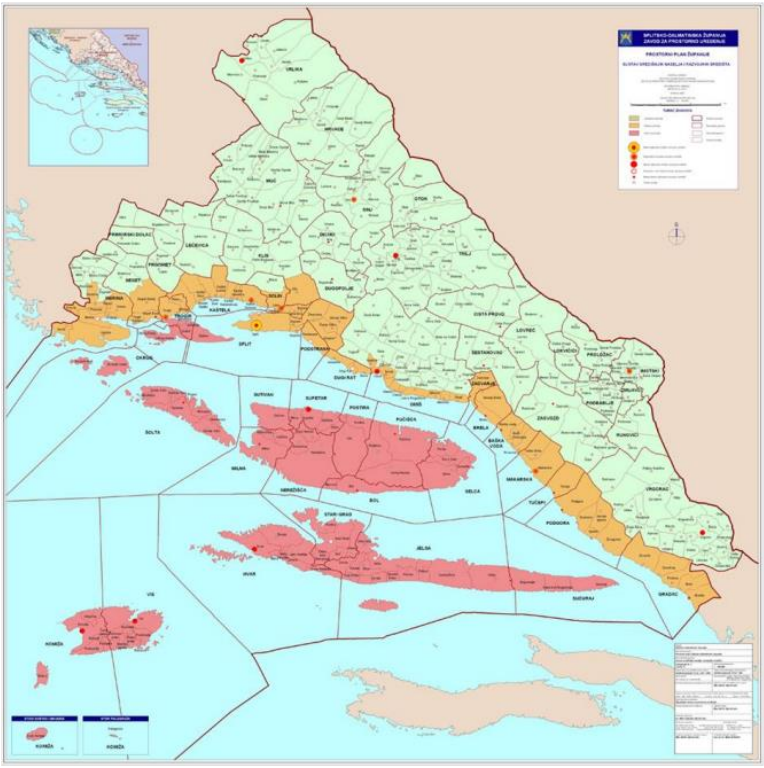


Figure 17: Spatial distribution of area in Central Dalmatia: islands, coastal area and hinterlands[43]

4.1.1. Population

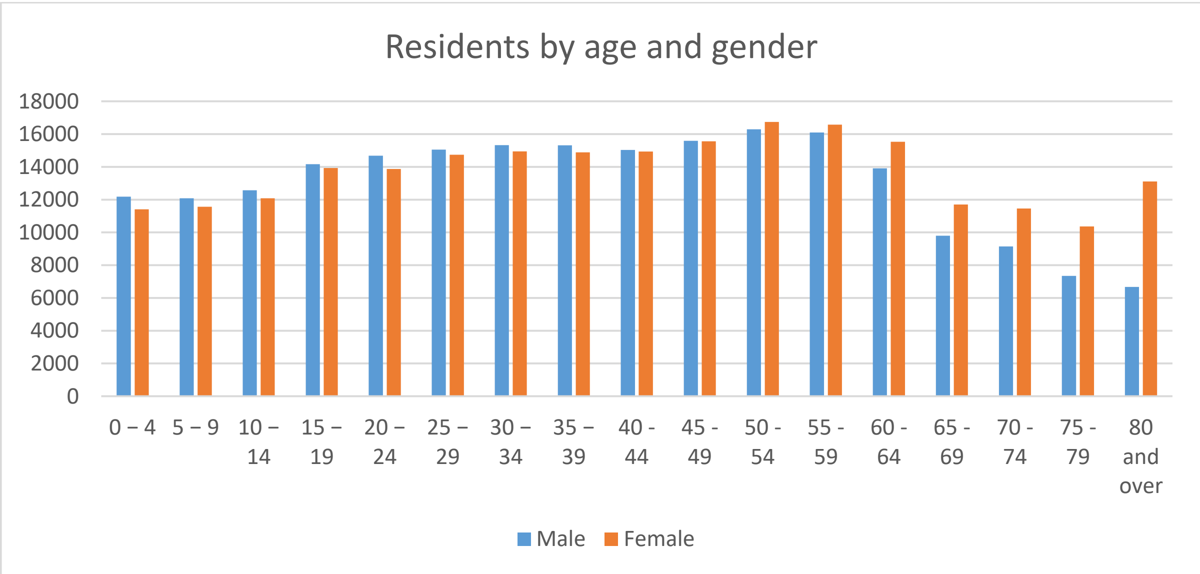
[43] Izvješće o stanju okoliša u Splitsko-dalmatinskoj županiji za razdoblje 2008. - 2011. godine

According to the Croatian bureau of statistics for the year 2014[44], in approximation for the year 2013 the Split-Dalmatia County (from now on Central Dalmatia) had 454798 inhabitants, with altogether 154528 households. Approximation for male/female distribution the year 2013 was: 221286 male inhabitants and 233425 female inhabitants. Surface area of Central Dalmatia is 4523.64 km^2. The population density per km^2 for Central Dalmation for year 2013 was 100.2 which is higher that the national average of 75.7 inhabitants per km^2.

The average age of Croatian inhabitants is 41.65 years, or 39.9 years for males and 43.4 years for females. Total of 129140 inhabitants were employed, with 68578 being male and 60562 being female inhabitants. Average number of unemployed for 2013 was 45893.

Central Dalmatia consists of 16 towns/cities, 39 municipalities and 368 settlements. From the data available for the year 2011, Split was the most populated with 178192 inhabitants, while the smallest was Zadvarje with only 293 inhabitants.

STATISTIC: Residents by age and gender[3]



STATISTIC: Residents in towns and municipalities in Central Dalmatia[45]

Towns/Cities	Residents
Hvar	4.239

[44] Statistički ljetopis Republike Hrvatske 2014 (Statistical Yearbook of the Republic of Croatia 2014), Državni zavod za statistiku Republike Hrvatske (Croatian bureau of statistics)
[45] http://www.dalmacija.hr/zupanija/stanovnistvo

Imotski	10.902
Kaštela	38.474
Komiža	1.509
Makarska	13.984
Omiš	14.872
Sinj	24.832
Solin	23.985
Split	178.192
Stari Grad	2.686
Supetar	4.096
Trilj	9.417
Trogir	13.260
Vis	1.920
Vrgorac	6.501
Vrlika	2.159
Municipalities	
Baška Voda	2.728
Bol	1.645
Brela	1.643
Cista Provo	2.377
Dicmo	2.820
Dugi Rat	7.091
Dugopolje	3.465
Gradac	3.308
Hrvace	3.653
Jelsa	3.560
Klis	4.739
Lećevica	588
Lokvičići	866
Lovreć	1.712
Marina	4.597
Milna	1.009
Muć	3.835
Nerežišća	864
Okrug	3.458
Otok	5.468
Podbablje	4.709
Podgora	2.514
Podstrana	9.103
Postira	1.554
Prgomet	689

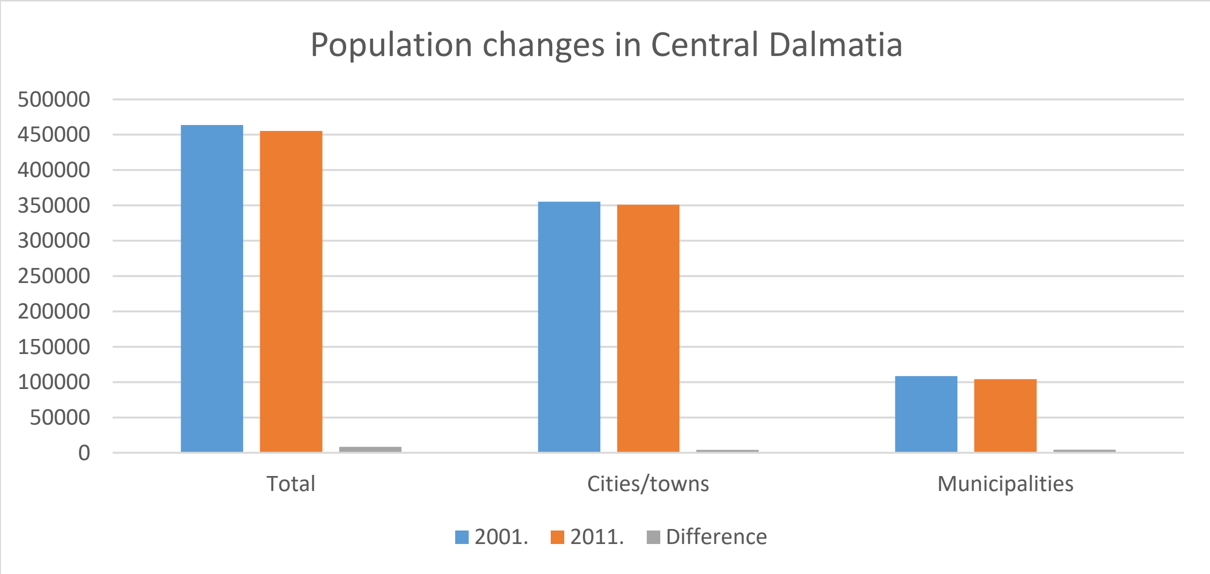
Primorski Dolac	773
Proložac	3.796
Pučišća	2.189
Runovići	2.442
Seget	4.863
Selca	1.804
Sućuraj	463
Sutivan	826
Šestanovac	1.917
Šolta	1.675
Tučepi	1.918
Zadvarje	289
Zagvozd	1.184
Zmijavci	2.080

Figure 18: Cities/towns and municipalities in Central Dalmatia[2]

4.1.1.1. Population trends

Out of total number of inhabitants in Central Dalmatia, in cities and towns live approximately 77.1% of inhabitants, while in municipalities lives approximately 22.9%.[2] In the year 2011, average number of inhabitants per 1 city was 1994 inhabitants, while the average number of inhabitants per 1 municipality was 543 inhabitants.

STATISTIC: Population changes until 1.1. 2015.[46]



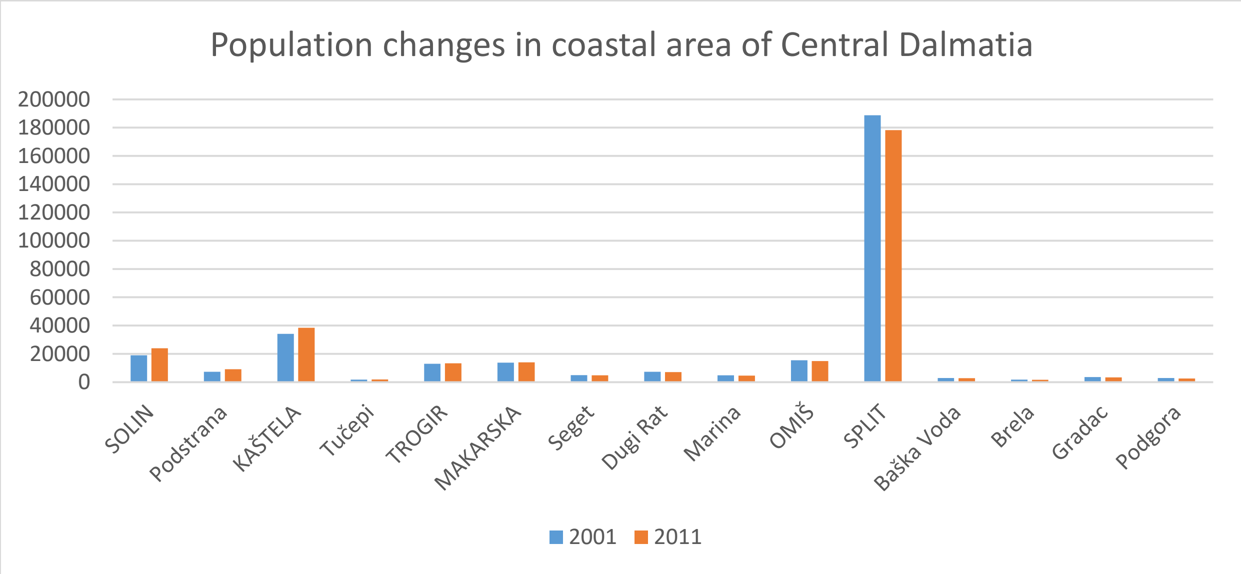
The decrease in the total number of inhabitants in the Central Dalmatia from the year 2001 to the year 2011 has occurred in cities (-1.16%), as well as in municipalities, which is even more evident (-3.97%). Altogether, the decrease for whole Central Dalmatia was1.82%.[6]

Decrease in number of inhabitants is also visible in most of the towns/cities and municipalities for both coastal and hinterlands area as well as islands.

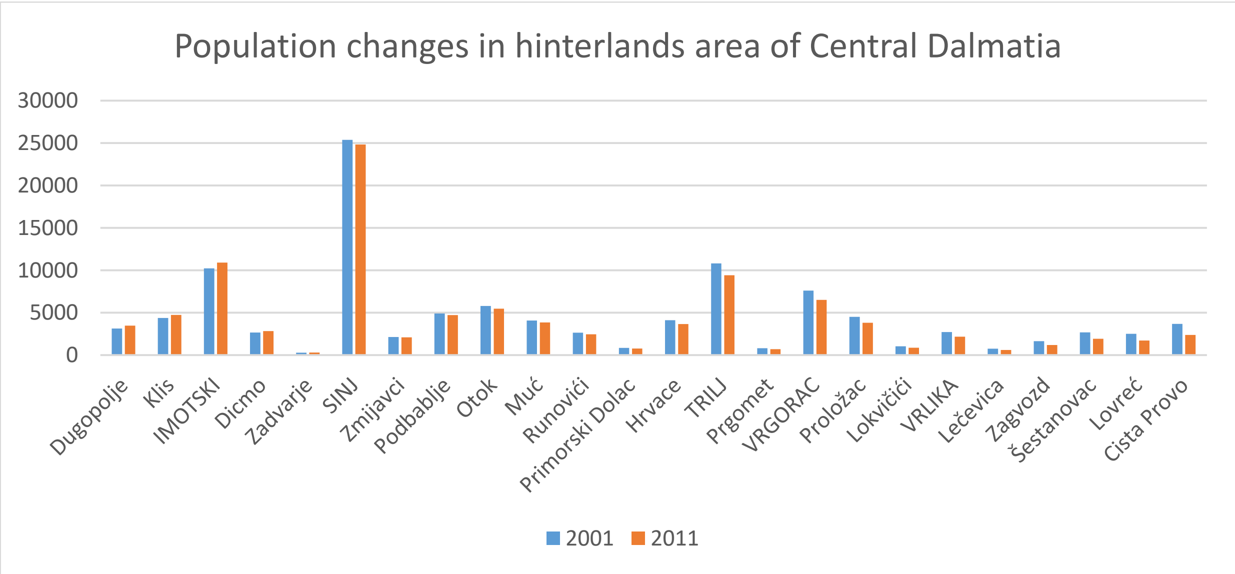
Most of the islands (except island Čiovo) are places with low number of inhabitants (Brač 35.4 inhabitants per km^2, Hvar 34.3 inhabitants per km^2, Vis 34.3 inhabitants per km^2,Šolta 28.4 inhabitants per km^2, Drvenik Mali 27.9 inhabitants per km^2, Drvenik Veli 11.6 inhabitants per km^2. Island Čiovo (connected to the mainland with a bridge) has 208.2 inhabitants per km^2.[6]

[46] Što pokazuju prvi rezultati popisa stanovništva 2011. godine za stanovništvo Splitsko-dalmatinske županije?

STATISTIC: Population changes in coastal area[5]

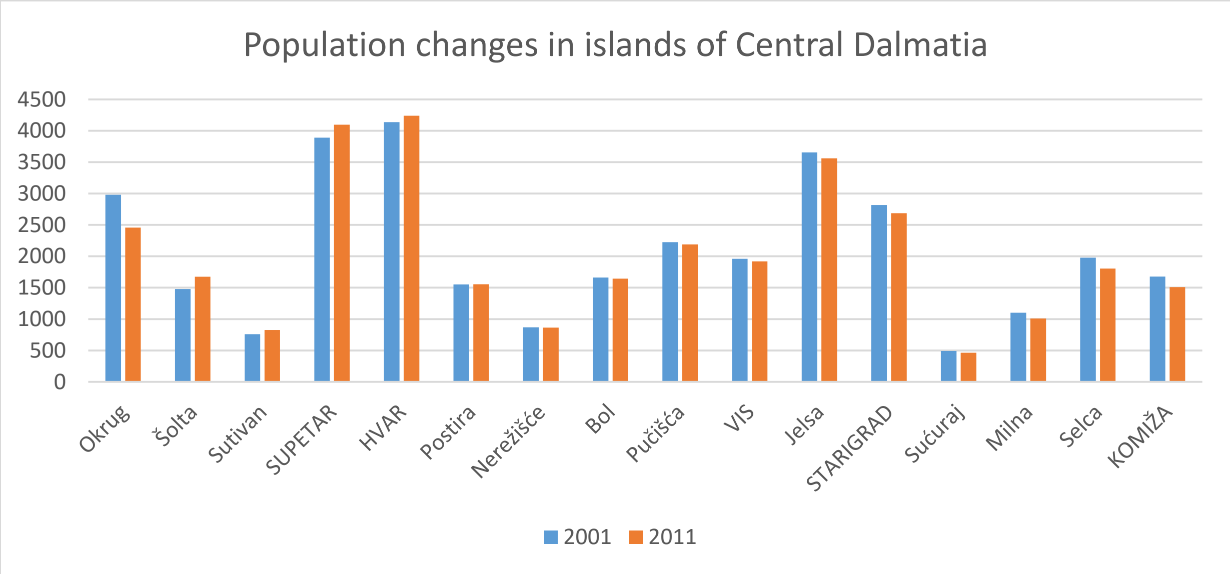


STATISTIC: Population changes in hinterlands area[5]



Increase in the number of inhabitants in Central Dalmatia was noticed in: Solin, Kaštela, Imotski, Supetar, Hvar, Trogir and Makarska.

STATISTIC: Population changes in islands[5]



4.1.1.2. Wind Risk/Vulnerability of the population

Although the local population is well adapted to this local meteorological phenomenon, injuries and damage due to flying objects blown away by wind may occur. In the periods of extremely strong bora, children and elders should stay at home for safety reasons. Workers cannot come to work. Furthermore a reduction in the number of travelers through the town does occur.

4.1.2. Infrastructure

According to Croatian bureau of statistics[3], Central Dalmatia in the year 2009 covered 2659km of roads, out of which 864km state roads, 854 municipal roads and 941km local roads. Road density in Central Dalmatia is 586 m/km^2.[47]

Highway Zagreb-Split-Dubrovnik is part of the road route between the continental part of Croatia and Dalmatia, and is under construction since the year 2002. Connection roads to the highway in Central Dalmatia are the following: Prgomet – Trogir, Dugopolje – Split, Dubci – Gornja Brela – Zadvarje – Šestanovac – Cista Provo – Aržano – Kamensko, Baško Polje – Bast – tunnel Biokovo – Zagvozd – Kamenmost – Imotski – Vinjani Donji.

Domestic water supply in the Central Dalmatia is sufficient. It consists of three regional systems: Split-Solin-Kaštela-Trogir, Omiš-Brač-Hvar-Šolta-Vis, regional system Makarska, then two grouped water supply systems for Sinj and Imotski. Furthermore, there are smaller water supply systems: for Vrgorac, Vrlika, Marina, Vis, Žrnovnica, Sitno Donje, Studenci and Podšpilje.

[47] Razvojna strategija Splitsko-dalmatinske županije 2011.-2013.

Split, Solin, Kaštela and Trogir are supplied by water from the river Jadro. Sinj and Trilj from river source Kosinac and Ruda, Imotski from river source Opačac, Vrlika from river source Cetina.

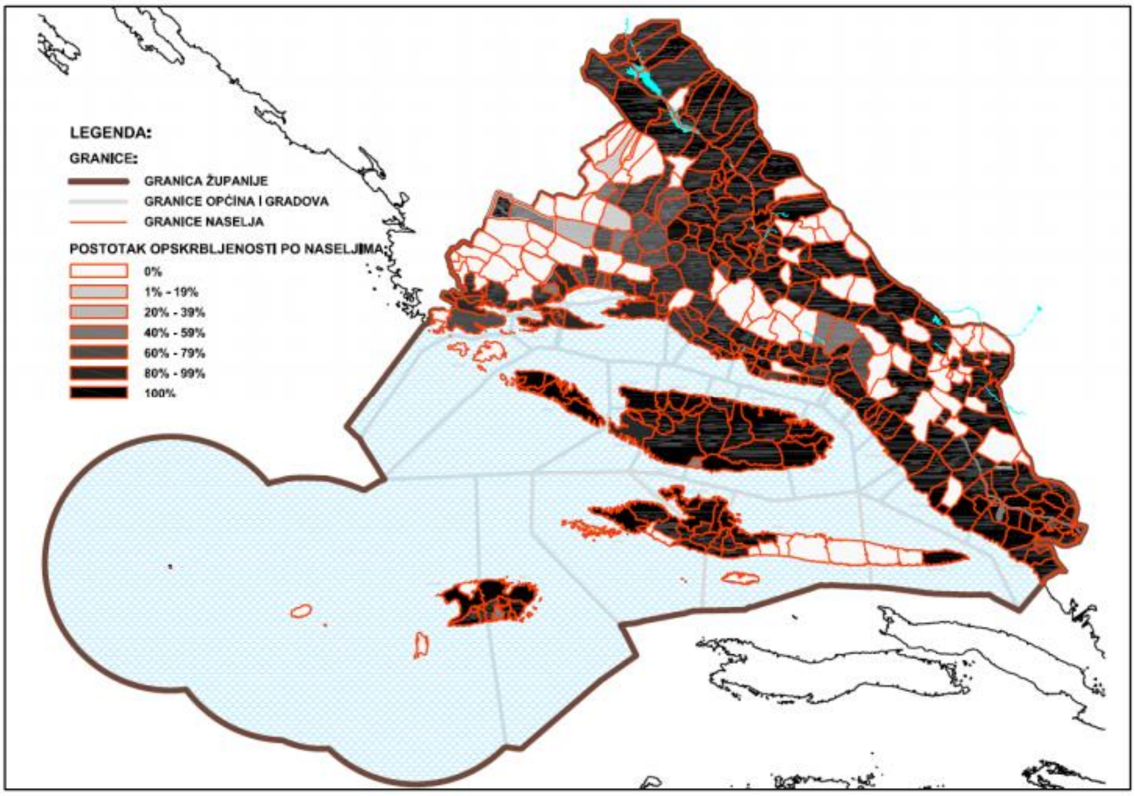


Figure 19: : Water supply coverage in Central Dalmatia[48]

In Central Dalmatia, wastewater gathering is rather well organized (with 33 national systems).

[48] Vodoopskrbni plan Splitsko-dalmatinske županije

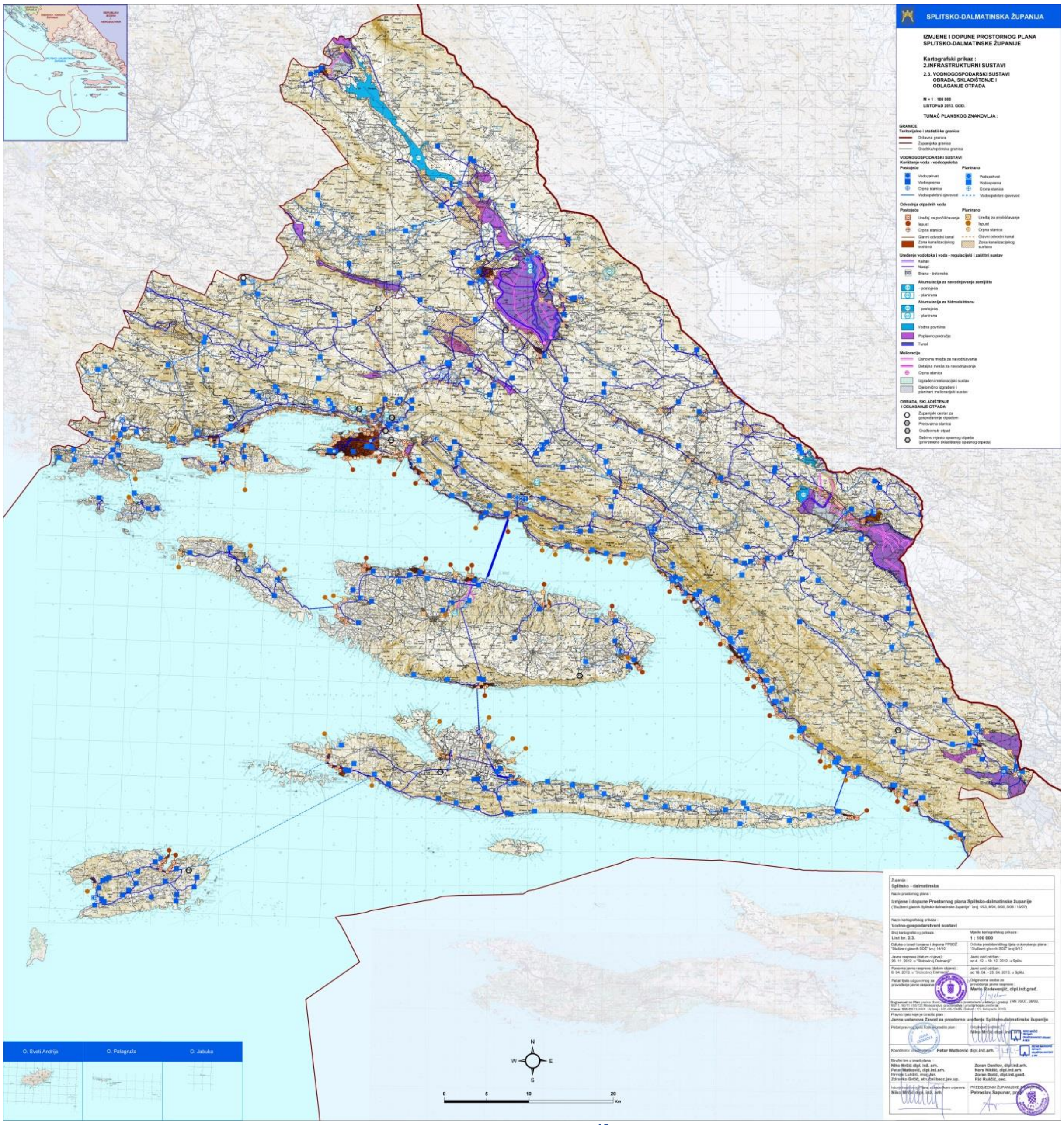


Figure 20: Water supply coverage in Central Dalmatia[49]

49 www.dalmacija.hr

4.1.2.1. Infrastructure trends

Although the water supply network in Central Dalmatia covers most of the region, there are some flaws[50]. Unfortunately, 10% of the Central Dalmatia is not yet connected to any kind of water supply. Also, due to the age of the water supply network, quality of pipes is questionable. Also, there are numerous water supply companies, as well as several water supply networks which function on their own and are not mutually connected.

Biggest problem is that four biggest cities in the Central Dalmatia are supplied from the same river (Jadro).

Wastewater gathering systems for cities Split, Solin, Kaštela. Trogir and municipalities Seget, Okrug, Dugopolje, Klis and Čiovo is being reconstructed through eco project »implementation of the Integrated Kaštela bay protection project«.

4.1.2.2. Wind Risk/Vulnerability of the infrastructure

Strong wind easily tears down the electricity and telephone cables. Lack of electrical power affects also the supply of drinkable water.

4.1.3. Transport

As previously stated, Central Dalmatia in the year 2009 covered 2659km of roads, out of which 864km state roads, 854 municipal roads and 941km local roads. Road density in Central Dalmatia is 586 m/km^2.[51] In Central Dalmatia there is 232940 registered drivers, 211987 vehicles. Altogether, there is 0.466 vehicles per person, what is higher than the national average being 0.459.[52]

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[50] Vodoopskrbni plan Splitsko-dalmatinske županije
[51] Razvojna strategija Splitsko-dalmatinske županije 2011.-2013.
[52] Strategija prometnog razvoja Republike Hrvatske (2014.-2030.)

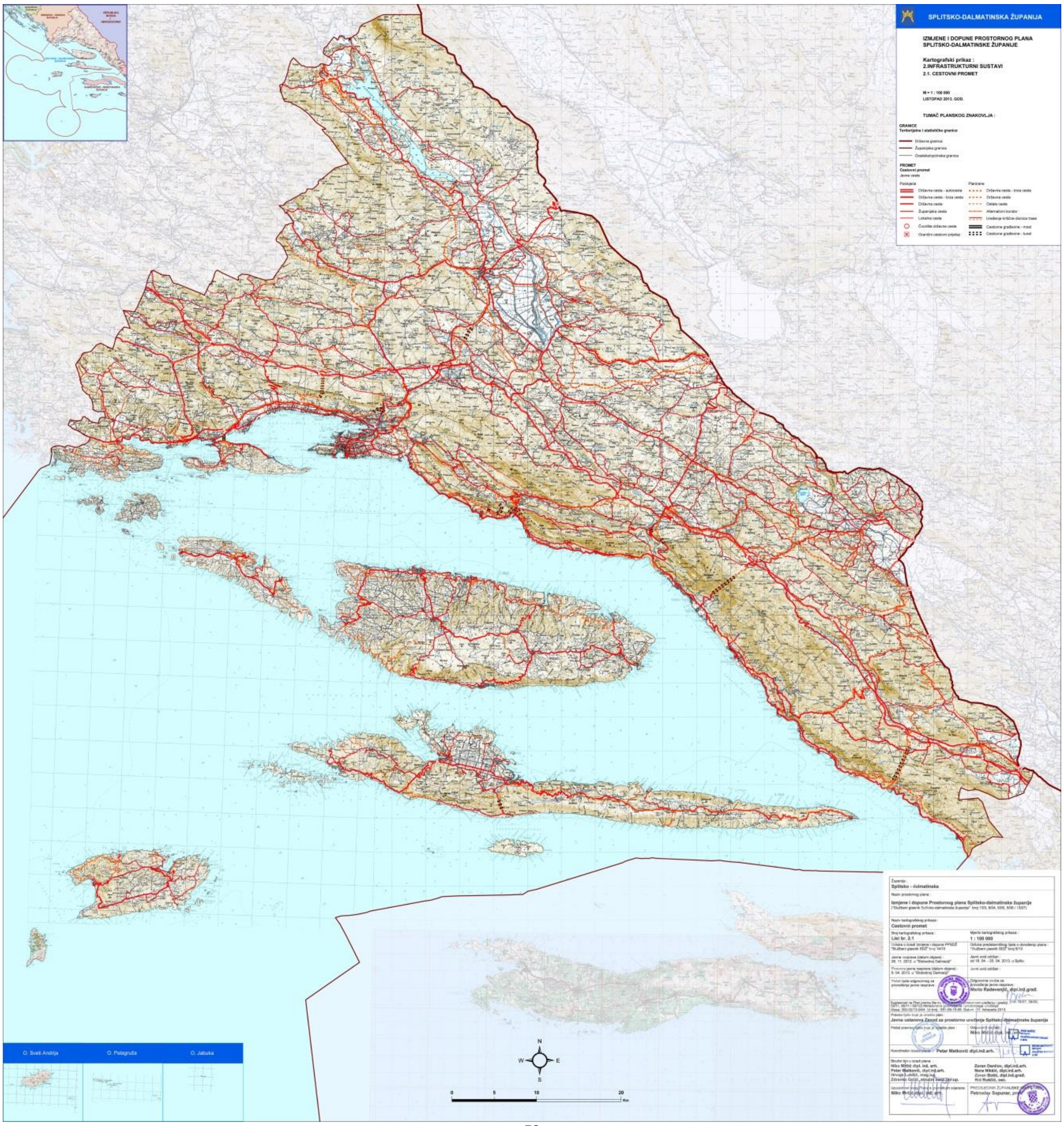


Figure 21: Road coverage in Central Dalmatia[53]

Central Dalmatia is connected to the national railroad through the line Split-Perković-Knin. The overall length of the railroad in Central Dalmatia is 52.8km with 14 stations and 3 junctions.

Naval transport is of great importance for Central Dalmatia, with Split as onw of the largest harbours in Croatia. Split harbour consists of two parts, passenger and cargo ports.

[53] www.dalmacija.hr

Figure 22: Coastal lines in Croatia[12]

4.1.3.1. Transport trends

Road infrastructure in Central Dalmatia is well covered, especially due to the A1 highway. However, it is expected that construction of several roads should be completed in the near future, such as D1 Solin-Klis, Vučevica-Kaštela, Stobreč-Dugi Rat, Dugi Rat-Omiš. During the tourist season, many of the roads are full with traffic, especially near Omiš and Trogir.

The main problem of the railroads in Central Dalmatia is the need for modernization, as well as the direct passing of the railroads through settlements.

4.1.3.2. Wind Risk/Vulnerability of the transport

Both Bora and Sirocco are serious problem for the naval transport in the Central Dalmatia, as well as for vehicles on the roads and railroads.

During high bora winds, ferries do not sail, what makes islands in the Central Dalmatia cut off from the mainland. This causes a major economic deficit to the entire region.

When bora blows over 130 km/h – most of the roads are closed for buses and trucks. This can also cause a major economic deficit to the entire region. In addition, Bora carries debris on roads and streets which also cause damage on other structures such as fences, traffic lights and signs etc.
The most famous phenomenon is that tunnel sv.Rok on the highway A1 is often closed due to the wind causing the travel delay for all travellers.

4.1.4. Buildings

In Central Dalmatia, there are 156080 households.

STATISTIC: Households in towns and municipalities in Central Dalmatia[4]

Towns/Cities	Households
Hvar	1531
Imotski	2709
Kaštela	12678
Komiža	628
Makarska	4918
Omiš	5009
Sinj	7692
Solin	7872
Split	62906
Stari Grad	1125
Supetar	1627
Trilj	2813
Trogir	4641
Vis	782
Vrgorac	2157
Vrlika	848
Municipalities	
Baška Voda	1015
Bol	591
Brela	594
Cista Provo	844
Dicmo	927
Dugi Rat	2272
Dugopolje	111
Gradac	1273
Hrvace	1185
Jelsa	1383
Klis	1610
Lećevica	247
Lokvičići	250
Lovreć	656
Marina	1779
Milna	470
Muć	1367
Nerežišća	334
Okrug	1419
Otok	1666
Podbablje	1302

Podgora	1000
Podstrana	2744
Postira	567
Prgomet	287
Primorski Dolac	267
Proložac	1180
Pučišća	762
Runovići	702
Seget	1683
Selca	715
Sućuraj	228
Sutivan	350
Šestanovac	738
Šolta	841
Tučepi	661
Zadvarje	107
Zagvozd	464
Zmijavci	553

4.1.4.1. Buildings trends

In areas with highly dispersed settlements, the development of local centers is encouraged in order to provide appropriate allocation of supply facilities, social care and other activities.

4.1.4.2. Bora Risk/Vulnerability of the buildings

In the periods of extremely strong bora public buildings, factories and even medical center are closed due to safety reasons. Therefore, school curriculum interferences, production interruptions etc. often occurs. Furthermore, smaller and bigger damage done on buildings due to strong Boras is inevitable. Most common damage due to strong Bora winds is lifting off roofs and roof tiles on new, improperly design and inadequately constructed buildings.

4.1.5. Forests

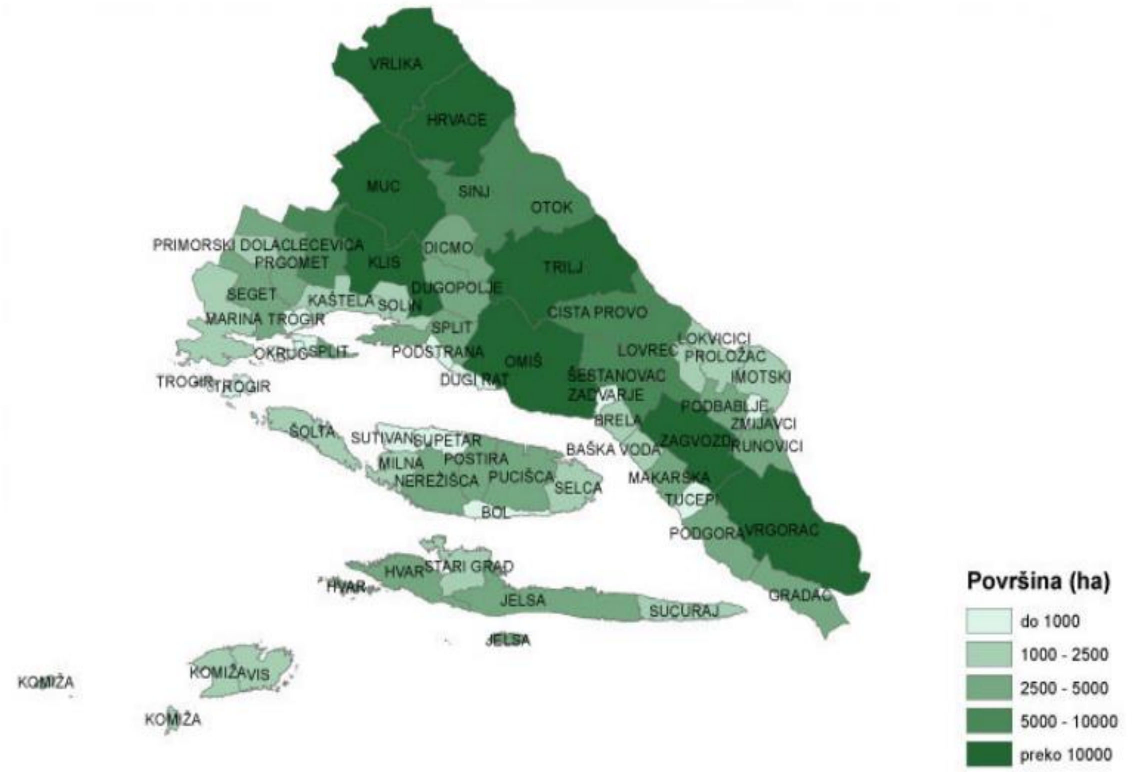


Figure 23: Forest coverage in Dalmatia

In Central Dalmatia, there is total area of 4523.64 km^2, where 49.4% is covered by forests, 48% is agricultural land, 2% is settlements and finally, only 0.6% water bodies.[2]

STATISTIC: Forest area in Central Dalmatia[2]

Towns/Cities	Forests (km^2)
Hvar	2870,24
Imotski	2087,28
Kaštela	2137,3
Komiža	2041,83
Makarska	2787,78
Omiš	16435,74
Sinj	9302,12
Solin	1980,82
Split	3080,62
Stari Grad	2354,93
Supetar	182,85
Trilj	13499,89
Trogir	358,11
Vis	1520,95
Vrgorac	20510,77

Vrlika	18828,08
Municipalities	2038,75
Baška Voda	967,22
Bol	2043,15
Brela	2043,15
Cista Provo	7882,78
Dicmo	4184,48
Dugi Rat	29,51
Dugopolje	3528,37
Gradac	4531,55
Hrvace	11622,35
Jelsa	4566,51
Klis	10782,05
Lećevica	6561,88
Lokvičići	2140,36
Lovreć	7595,54
Marina	2346,29
Milna	1029,66
Muć	16844,45
Nerežišća	3973,77
Okrug	13,39
Otok	6554,02
Podbablje	2715,6
Podgora	4211,38
Podstrana	11,96
Postira	2614,76
Prgomet	4569,66
Primorski Dolac	2087,87
Proložac	1921,17
Pučišća	4865,11
Runovići	3853,37
Seget	3884,52
Selca	1242,01
Sućuraj	2129,17
Sutivan	568,73
Šestanovac	5904,9
Šolta	1089,04
Tučepi	766,31
Zadvarje	938,18
Zagvozd	13766,42
Zmijavci	272,08

4.1.5.1. Forests trends

The total forest area in Central Dalmatia has increased by 31558ha from the year 2002 to year 2011.[54] According to [2], a further increase in forest areas is to be expected, as it is good for both tourism and quality of life.

4.1.5.2. Wind Risk/Vulnerability of forests

Strong wind can break or uproot trees. Damage most likely occurs in winter and spring, when bora shakes off the tree blossoms. Furthermore, local areas where Bora is at its highest, threes grow inclined with asymmetric crowns.[55]

[54] Prostorni plan Splitsko-dalmatinske županije
[55] http://wikinfo.org/w/Hrvatski/index.php/Ekologija_bure

4.2. Identification of trends in hazard aspects

Two local winds are most prominent – Sirocco (local name Jugo) and Bora (local name Bura). Sirocco is warm, damp and uniform wind originating from North Africa mostly associated to low atmospheric pressure and rainy weather. The typical synoptic situation regarding Sirocco wind is represented in **Error! Reference source not found.**2.

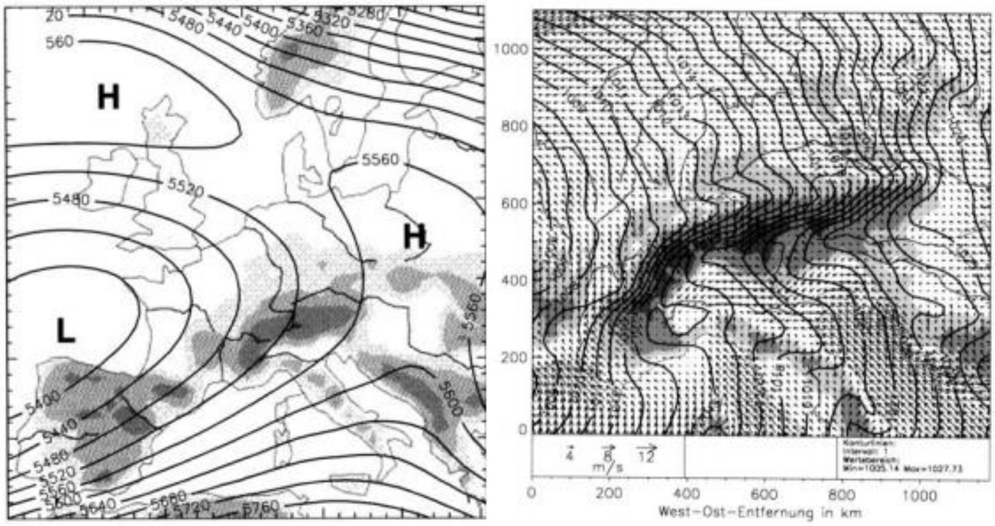


Figure 24: Mean geopotential height (m) isobaric surface 500 hPa (left) and mean atmospheric pressure on sea level (hPa) taken December 3rd-6th, 1987. (right) (taken from Heimann, 2001)

Bora is strong, gusty and cold wind usual genesis along seaside of Dinarids mountain range in accordance with wave brake theory and driven by intrusion of cold air from north or northeast. Both of them can reach high wind speeds but generally bora is considered more dangerous to constructions due to higher wind speed and stronger gusts. The typical synoptic situation regarding bora is represented in Figure 3

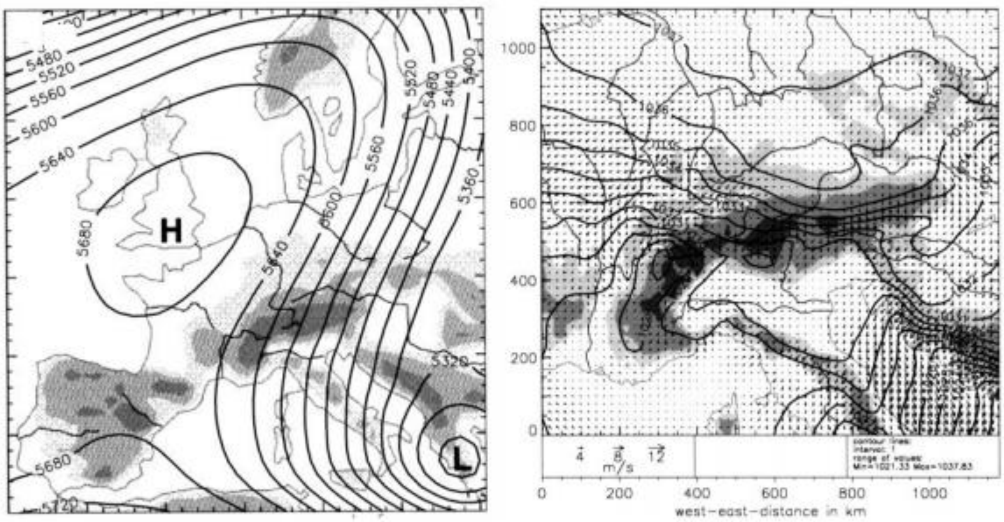


Figure 25: Mean geopotential height (m) isobaric surface 500 hPa (left) and mean atmospheric pressure on sea level (hPa) taken December 7th - 10th, 1987. (right) (taken from Heimann, 2001)

The unofficial highest wind speed recorded during bora wind is 85 m/s, recorded December 24th 2003. on A1 highway between St. Rok tunnel and Maslenica bridge. Unofficalty of record is due to lack of calibration of recording device. The official highest speed recorded is 69 m/s, recorded December 21st, 1998. at Maslenica bridge.

RISK TYPES, SHAPES AND LEVEL: strong wind, sometimes enhanced with rain or even hail can cause damages property, agriculture, forests, buildings and in transport. Strong wind can cause material damage in economy, endangers people lives and can even cause loss of lives. It is observed that frequent delay of transport is caused by wind. Roads or part of the roads are closed often in case of wind. Ferry lines are also sometimes canceled because of high waves caused by wind.

THE COURSE AND **POTENTIAL** EXTENT OF THE DISASTER: Coastal part of Croatia is mostly endangered by Bora and Sirocco. During spring and autumn Sirocco happens more often. During winter, Bora and Sirocco are more frequent. Bora is gusty and causes high waves.

NUMBER OF PEOPLE AND ANIMALS AT RISK: people and animals are not directly at risk, but with evolution of event they can become endangered.

THE EXTENT OF JEOPARDIZED PROPERTY AND CULTURAL HERITAGE: Area is rich with cultural heritage and archeological sites that can be endangered in case of extreme conditions.

POTENTIAL DISASTER CONSEQUENCES**:** Injuries or even humans and animals death, material damage to property and crops, interruption of electricity supply and telephone connections, traffic disruption…

PROBABILITY OF CHAIN-REACTION ACCIDENT**:** strong wind, in combination with hail and lightning can cause severe damage.

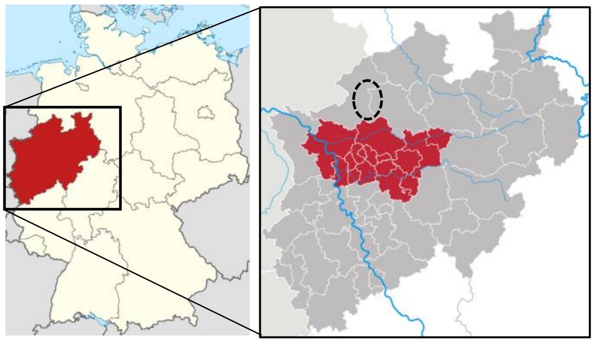
DISASTER PREDICTABILITY**:** meteorology service can predict occurrence of high wind with wind gusts, but not the extend of disaster.

5. Wind condition in Germany

5.1. Introduction of North-Rhine Westphalia and the City of Essen

North-Rhine Westphalia is one of the 16 federal states (German: *Bundesländer*) of Germany and is located in the middle-west of the country, sharing a border with The Netherlands and Belgium. North-Rhine Westphalia is with a population of about 17 million the federal state with the most inhabitants. In the western center of North-Rhine Westphalia the *Ruhrgebiet* (English: *Ruhr Area*), a post-industrial region in transition, is located. The Ruhr Area is Germany's largest agglomeration, consisting of 11 self-governed cities and 4 counties with smaller municipalities. About 5 of the 17 million inhabitants of North-Rhine Westphalia live in the Ruhr Area, most of them in the cities. (Cf. Website Wikipedia)

Figure 26: The Ruhr Area within the federal state of North-Rhine Westphalia, Germany



Source: Website Wikipedia, own additions.

One of the cities in the Ruhr Area is the case study city *Essen*. Essen is located in the southern Ruhr Area and in the center of North-Rhine Westphalia.
Essen consists of 50 districts (see figure 2), jointly making up an area of 210.4 square kilometers. In 2014 Essen had more than 580,000 inhabitants.

Figure 27: Districts of Case Study City Essen

Source: *own depiction.*

Figure 28: Essen on Google Maps

Source: Kartendaten © GeoBasis-DE/BKG (©2009) Google

The Bertelsmann Stiftung (English: *Bertelsmann Foundation*), a substantial German research foundation i.e. researching on demographic classifications and their projected changes, categorizes the city of Essen a city of *Demographic Type 7*, meaning 'urban centers with heterogeneous economic and social dynamic'. Many cities of the Ruhr Area are classified as Type 7. (Cf. Bertelsmann Stiftung 2012: 1, 11)

Main features of cities like Essen:

- They are large cities with a high population rate and also a high population density,
- they have many social welfare recipients (in average more than 10 % of the population) and simultaneously many highly qualified people (academics), due to the presence of universities or other research institutions,
- they have many single households,
- there is a high rate of unemployment and little spending capacity,
- there is a clear industrial character, facing transformation processes (structural change) from former heavy industry towards nowadays manufacturing industry and a more knowledge based and service orientated economy. (Cf. Bertelsmann Stiftung 2012: 1, 5f., 10f.)

All these characteristics hint at severe social and economic differences and problems within the polarizing cities of *Demographic Type 7*. Therefore, in order to assess the risk of Essen to high wind and high wind gusts, there needs to be a better understanding and knowledge of the local area. In the following first vulnerability and subsequently hazard parameters are outlined and assessed.

5.2. Vulnerability Parameters in Essen

5.2.1. Population

5.2.1.1. Current Total Population

In Essen the total number of inhabitants amounted 581,312 in the year 2014. However, there were distinct fluctuations in the number of inhabitants in the past three years: in 2012 the city accounted 576,109 inhabitants, which decreased until 2013 (557,802 inhabitants) and then increased in 2014 again. (Cf. Stadt Essen a 2015: 4)

The spatial distribution of Essen's inhabitants can be seen in figures 4 and 5. The six districts with the most inhabitants (e.g. more than 30,000 people in Frohnhausen) are all located around the city center of Essen, in the northern half of the city. Only few inhabitants live in the direct center, due to other predominant spatial functions as e.g. shopping, and also fewer in the southern half of the city.
Regarding the population density, this north-south divide becomes even more apparent. While the southern districts have a population density of less than 2,000 inhabitants per square kilometer, many northern districts have 4,000 to 6,000 inhabitants per square kilometer. With more than 8,000 (more than 10,000) inhabitants per square kilometer the central districts have the highest population density.

Figure 29: Total Inhabitants per District

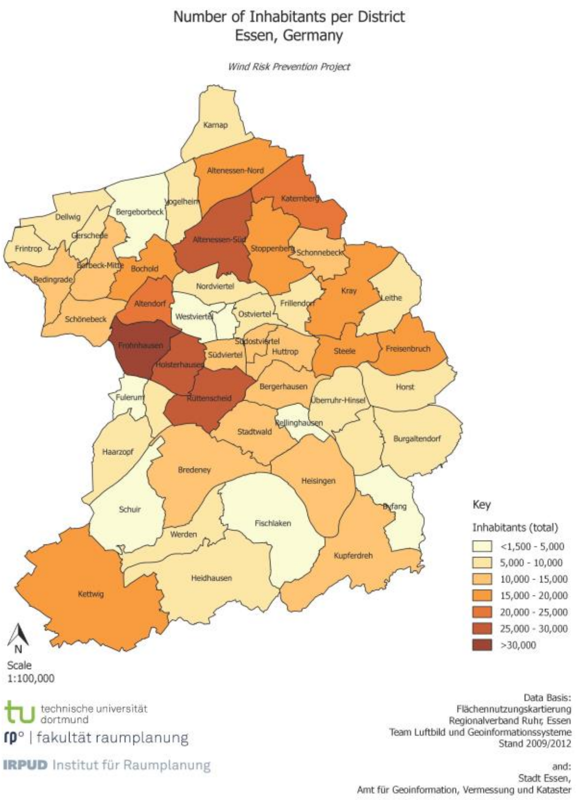
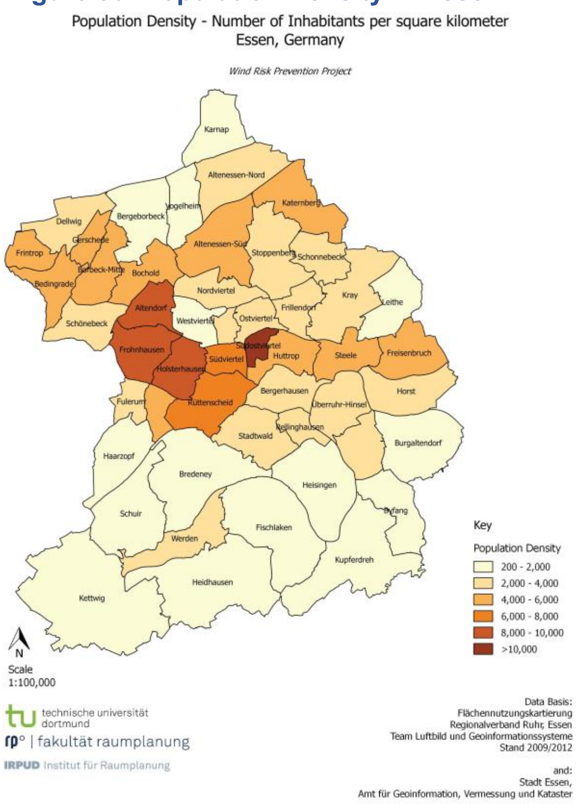


Figure 30: Population Density in Essen



Source: own depiction.

The structure of the current population can be seen in table 1. In 2014 the population group of persons below legal age (<18 years) covered 15.1 % of the total population of Essen. With 56.9 % of the population, the group of adults (18 till < 60 years) certainly was the major population group in Essen, whereas the group of seniors (>60 years) covered 28.0 % of the total population.

Table 5: Total population of Essen by age (2014)

age (years)	**inhabitants (total)**	**inhabitants (relative)** (%)	**name of population group**	**population group (relative)**, (%)
0-5	28,378	4.9	below legal age; (<18 years)	15.1
6-9	19,062	3.3		
10-14	24,048	4.2		
15-17	15,555	2.7		
18-24	47,325	8.2	adults; (18 till < 60 years)	56.9
25-29	40,622	7.0		
30-34	38,261	6.6		
35-39	34,057	5.9		
40-44	36,088	6.3		
45-49	45,818	7.9		
50-54	45,312	7.9		
55-59	40,570	7.0		
60-64	35,713	6.2	elderly; (> 60 years)	28.0
65-69	29,376	5.1		
70-74	30,804	5.3		
75-79	29,876	5.2		
80+	35,826	6.2		

Source: Stadt Essen b 2015: 4

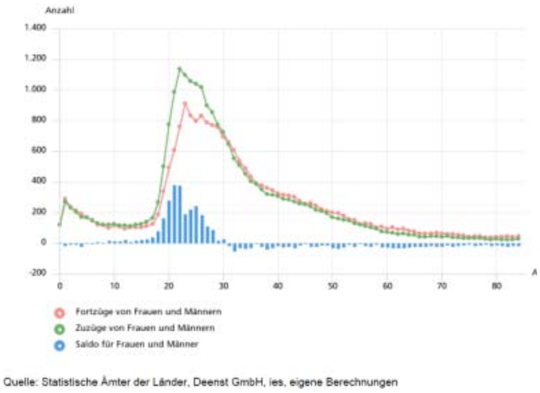
5.2.1.2. Current Migration

Although the cities in the Ruhr Area are of economic and scientific importance, the number of young, high educated inhabitants of Essen is relatively low and the average age is with 44.6 years (43 median) fairly high. The reason for the high mean and median population age is the low percentage of children and families, combined with a high percentage of elderly people.

The average age of the population is closely linked with the trends of migration and immigration. Regarding the migration rate, the number of immigrants and migrants strongly differs between the ages of the inhabitants of Essen. As can be seen in figure 6, there is a positive migration balance for young adults between the age of 18 and 28. For the age classes of 30+ and also children the migration balance is mainly negative, meaning there is more migration than immigration in the city.

This migration pattern is typical for cities like Essen, which usually feature a small percentage of under age population (and families) and have a low birthrate, which generally reflects the strongly urbanized character of cities. In Essen, however, this pattern is significantly distinct, as due to the structural change and the omission of jobs many adults migrate from the city. The main reason for the immigration of young people to Essen is the variety of educational training facilities, e.g. the four universities and colleges of the city. (Cf. Bertelsmann Stiftung 2012: 7f., 10f.; Bertelsmann Stiftung 2013: 4; Website Stadt Essen a 2015)

Figure 31: Migration rate by age, Essen

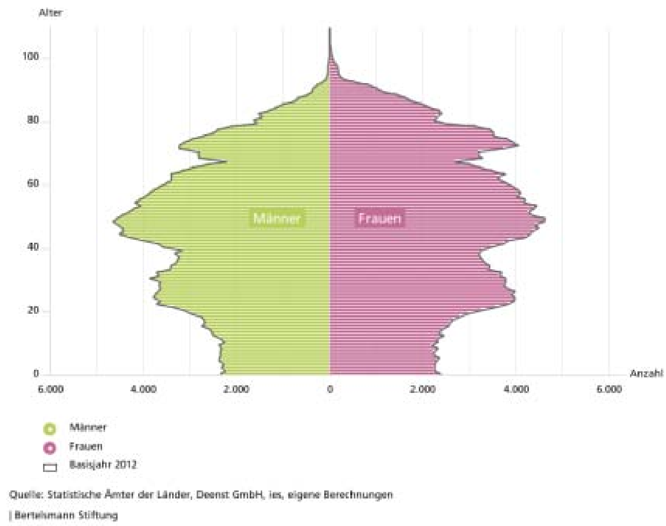


Source: Bertelsmann Stiftung 2013: 5

5.2.1.3. Current Demographic Characteristics

Population pyramids are an illustrative option to demonstrate the population structure of an area by containing the number of inhabitants per age. Figure 7 shows the population pyramid for the city of Essen. The colors separated male (green) and female (purple) inhabitants.
As can be seen, the 'pyramid' has an appearance that reminds of a fir tree, rather than of a pyramid. It has an obvious 'treetop', containing the number of very old people (> 90 years), various 'branches' in the age category of adults and seniors and a 'trunk', depicting the number of under-age persons.

Figure 32: Population Pyramid of Essen (2012)



Source: Bertelsmann Stiftung 2015

When interpreting the 'population fir tree' it can be stated, that the 'treetop' results from an increasing number of very old people, going up to over a hundred years. The very top of the 'treetop' is solely constituted by women, who in average have a higher life expectancy than men. The obviously smaller 'trunk' results from low birth rates, as they are typically for industrialized nations. In Essen the 'trunk' covers nearly two decades, symbolizing that for the last 20 years the number of inhabitants accounted about 4,000 children per year.

The most interesting parts of the 'population fir tree' are the branches because usually the indentations in the population can be read from them. Starting at the top, the first very clear indentation at a population age of about 70 years marks the population losses of the Second World War. Contrary to the branch peak above the indentation (marking the age group of births during the 'roaring twenties'), many people died during World War II and only little were born.
After the first big indentation, during the post-war era and the *Wirtschaftswunder* (English: *economic miracle*), birthrates rose – especially in the *Ruhrgebiet*, where many jobs were offered in the heavy industry sector. In the age group of today's people in their fifties (birth cohort 1960+), more than 8,000 people live in Essen.
The second big indentation results from a birth-influencing invention – the birth control pill. When making contraception that easily accessible, both from a financial and a dissemination point of view, the number of births drastically declined for about five years and never reached more than 8,000 again. The birth control pill influences the population pyramid until today because by now the second (way smaller) generation of women also uses contraceptives. Paired with a general decline in birth rate and increasing childbearing age, nowadays birthrates are less than half of what they used to be in the 1960's, which explains the 'trunk' of Essen's 'population fir tree'.

5.2.1.4. Population Trends

The cities of the Ruhr Area are predicted to have a median average age of 49 years by 2030, which is about 6 years higher than in 2012. For the city of Essen, the prognosis assumes an increase of about one to two years in average age. (Cf. Bertelsmann Stiftung 2012: 8f.)

In total the population of the city of Essen is going to decrease. Population losses of approximately 30,500 inhabitants are predicted by the city administration, which corresponds a population decrease of about 5 % in comparison to 2012. (Cf. Stadt Essen b 2015: 4) The Bertelsmann Stiftung estimates a less drastic but still clear population decline of 3.7 % until 2030 (cf. Bertelsmann Stiftung 2013: 4).

Table 6: Total population of Essen, 2012 – 2030

31.12.2012	31.12.2013	31.12.2014		*31.12.2030*
576,109	557,802	581,312		*545,630*

Source: Stadt Essen b 2015: 4

The estimated distribution of age groups in Essen for the year 2030 varies with different reference sources. Table 3 lists the results for three up to date studies. All references assume that in 2030 about 16 % of the population will be under-age. Similar are also the expected percentages for seniors (> 60 years) in 2030, while the rate of very old people (> 80 years) differs. However, major differences exist for the population group 'adults': While the Bertelsmann Stiftung projects that about half of the population of 2030 will be adults, the city administration and also the North-Rhine Westphalian Office for Statistics [IT.NRW] assume about 60 % of Essen's inhabitants to be adults.

Table 7: Estimated Population by population groups for Essen, 2030

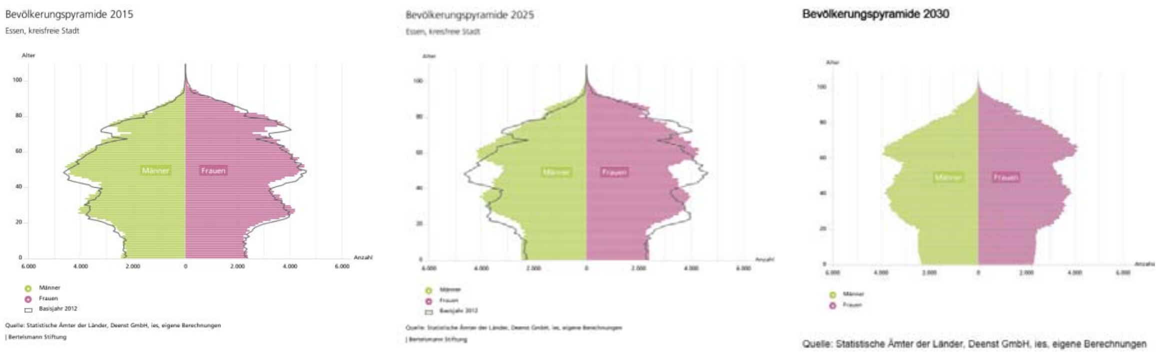
Population groups	Reference Sources		
	Bertelsmann Stiftung	Essen City Council	IT.NRW
Below legal age (<18)	15.9 %	15.3%	16.7%*
Adults (18 – 65)	48.4 %	61.3%	59.6%*
Seniors	25.5 %	23.4%	23.7%*
thereof over 80 years	*7.5 %*	*12.8%*	*…16.7%*

**) age groups vary slightly: 0-19 years; 19-65 years; > 65a years*

Source: Bertelsmann Stiftung 2013: 7f.; IT.NRW 2015: 31; Stadt Essen a 2015: 26ff.

Based on figure 7 in chapter 2.1.3 the following three population pyramids illustrate the development of the demographic characteristics sex and age. The grey line shows the population status of the year 2012 (see 2.1.3). It becomes apparent that the trunk of the tree grows taller, standing for a persistent small birthrate and i.e. few under-age inhabitants. The earlier termed 'branches' of the population tree merge increasingly and in total the tree grows, visualizing more very old people.

Figure 33: Population Pyramid for Essen, 2030



Source: Bertelsmann Stiftung 2013: 11, Website Bertelsmann Stiftung 2015

5.2.1.5. Storm Related Vulnerability of the Population

Extreme weather events like storms generally have a strong impact on the population (e.g. damages, interruption of production chains, losses of lives). Paired with the demographic change, challenges in adaptation are most likely going to increase.

In Germany a common saying is: 'we will become older, fewer and more colorful!' (cf. Bundesregierung 2012: 1). Regarding the storm related vulnerability of the population, especially the shift in age groups is understood as a major challenge. As there are going to be more elderly people that are by tendency restricted in their mobility and may not be able to care for themselves, an increase in (frequency and magnitude of) storm events also increases the vulnerability. Therein the restricted mobility of the elderly becomes more and more challenging both during the actual storm event as well as in the hours (or even days) after the event, in which the supply of health care articles and groceries may not be guaranteed.
It therefore can be stated that with an ongoing demographic change, the vulnerability of the population towards storms increases and that there is a need for specialized emergency concepts.

5.2.2. Transport

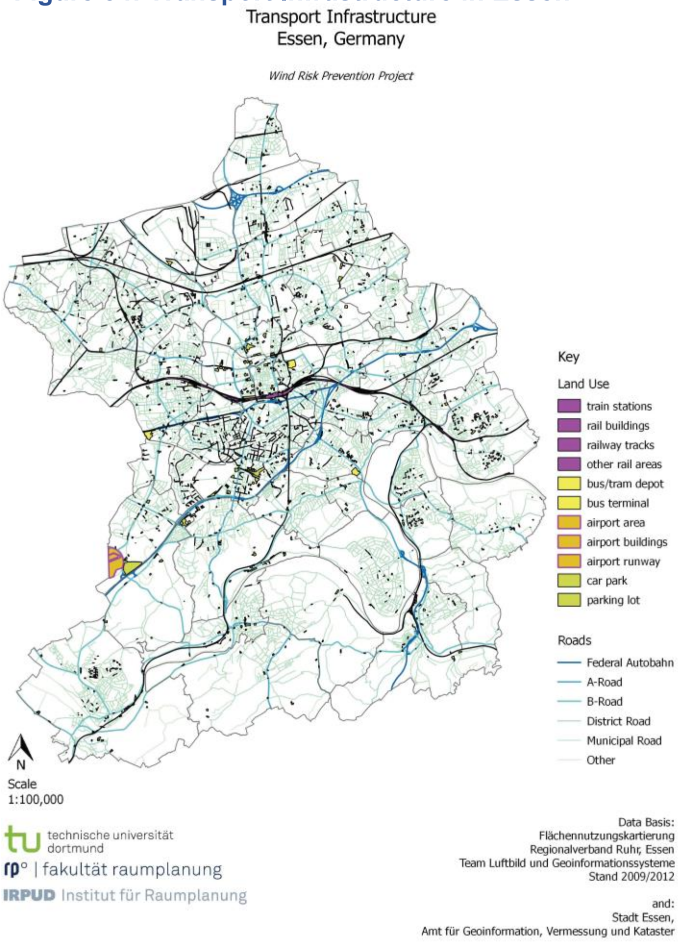
Essen is integrated into a dense network of highways and a-roads, connecting the Ruhr Area with all other parts of Germany and also many regions in Europe. Traffic-wise the city is of great importance having four different highways (A40, A42, A44, A52) and three a-roads (B224, B227, B231) that ensure both a north-south as well as east-west connection. In Essen there are many roads connecting its districts. In the south of Essen the density of roads is less high because there also are fewer settlements.

Furthermore the central train station of Essen ensures international transport connections and also secures well-connected regional and local public transport. The main station can be reached directly by all German cities above 250,000 inhabitants.

Every day more than 100 long-distance trains leave Essen. Beside the main station Essen has further regional train stations. The local traffic in Essen covers 90 % of the urbanization zone. (Cf. Stadt Essen 2011: 27) Additionally three metro lines and eight tramways provide inner-city railway connections. There is also offered a bus line network with about 32 bus lines and 16 night bus lines. (Cf. Website evag 2015)

Also the connection of Essen to the Düsseldorf International Airport is very good, both by car and train. Last but not least the cities Essen and Mülheim share a regional airport and because of the Rhein-Herne-Kanal (a canal in the north of the city) also ship traffic is ensured. (Cf. Website metropoleruhr 2015)

Figure 34: Transport Infrastructure in Essen



Source: own depiction

The total length of all roads in Essen accounts up to more than 300 km. Highways make up 30.8 km, a-roads 24.6 km, b-roads 164.9 km and district roads 71.8 km (Cf. Landesdatenbank.NRW a 2015)

In 2015 313,472 vehicles were licensed in Essen. 274,031 of all licensed vehicles were cars, 14,971 were trucks and 22,749 were other vehicles. (Cf. Landesdatenbank.NRW b 2015) Caused by the location of Essen in the middle of the Ruhr Area and the existing strong economical linkages there is a high number of commuting traffic and economical traffic in the morning and in the afternoon. (Cf. Stadt Essen 2011: 25)

5.2.2.1. Transport trends

The focus on the future development of the roads in Essen lies on the maintenance and the strengthening of the roads' quality. Additionally there is the plan to construct a better north-south connection by constructing missing parts of the highway A52. Furthermore it is planned to implement redevelopment and extension of the highway A40 to improve the traffic situation. (Cf. Stadt Essen 2011: 25)

5.2.2.2. Storm Related Vulnerability of the Transport System

Generally speaking the vulnerability of the transport system in its physical dimension is dependent on how dense and broad it is, as well as on how important it is for a city and transport connections (systemic dimension).

As in Essen the transport system is of high importance for local transport and regional connections, the vulnerability towards natural hazards is also high. Damages to the system, both direct and indirect, can have serious systemic consequences. When summer storm *Ela* occurred, the city was off public and private transportation for several days. In consequence inhabitants were not able to get to their work places, tourists were not able to reach the main train station and also business transport could not take place. Indirect costs like these are hardly quantifiable. Still the *Deutsche Bahn* (German Rail) estimates the costs due to damages on their tracks, overhead wires, etc. € 20 million, while the costs due to the malfunction of the system are estimated € 35 million. (Cf. Bundestag 2014)

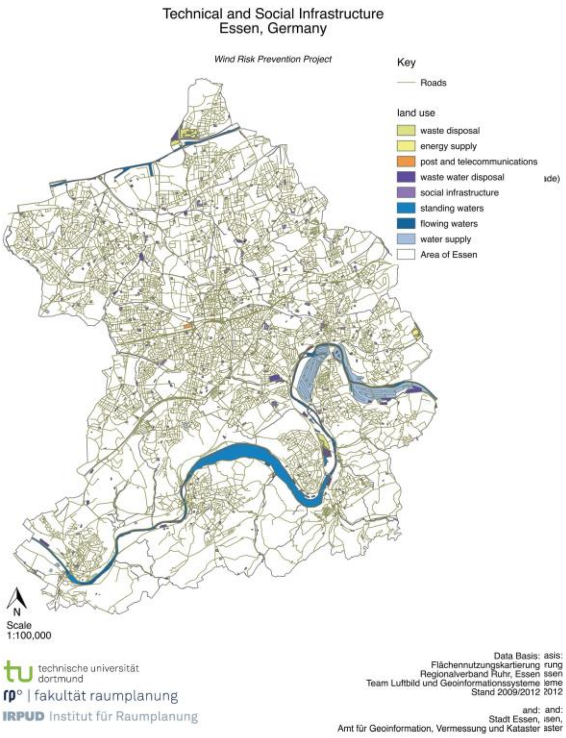
Furthermore summer storm *Ela* impressively revealed that many inner city roads are of extremely high importance for the disaster preparedness and immediate response. Especially those roads major to emergency units (e.g. roads from and to hospitals, the fire brigade, etc.) are extremely vulnerable towards storms, as damages to those have severe consequences for the disaster management and therefore the safety of the population.

5.2.3. Infrastructure

Throughout the City of Essen several technical and social infrastructures are distributed. Technical infrastructure herein refers to e.g. energy supply infrastructure, water supply and water disposal infrastructure, waste disposal infrastructure and telecommunication. Social infrastructure refers to buildings and institutions of the commonwealth, e.g. schools and universities, hospitals and other critical infrastructures, retirement homes and kindergardens, etc.

Regarding the social infrastructure there are three universities in Essen with more than 43,000 students. The majority of these students (more than 41,000) studies at the University Duisburg Essen. Besides the universities Essen has 20 business and technical colleges with more than 21,000 students. Furthermore there are 161 schools with more than 60,000 pupils. (Cf. Website Stadt Essen b 2015)
The critical infrastructures like fire brigades (professional and voluntarily) and hospitals are distributed over the whole area of the city, as figure 10 shows. In total there are 11 hospitals in the City of Essen. (Cf. Website Stadt Essen c 2015, Website Feuerwehr Essen 2015)

Figure 35 and 36: Technical and Social Infrastructures and Emergency Services in Essen



Source: own depictions.

Regarding the technical infrastructure of Essen, there are 42 waste treatment plants, managing more than 1,000,000 tons of disposed mass of garbage every year.

In 2010 the average water consumption per day and inhabitant accounted 155.6 liters. The waste water is treated in four waste water treatment plans throughout the city and transported in a sewer system with a length of 1,658 km. (Cf. Website Landesdatenbank.NRW c, d, e 2015)

5.2.3.1. Storm Related Vulnerability of the Infrastructure System

The vulnerability of the technical and social infrastructure system is mainly determined by critical infrastructures. In general the more (technical and social) critical infrastructures there are, the higher the potential physical vulnerability of the city towards any natural hazard is. However, there is also a systemic dimension: the more social infrastructure is served by a particular element of the technical infrastructure (e.g. power supply) the greater the systemic importance and consequently the vulnerability of this infrastructure element.

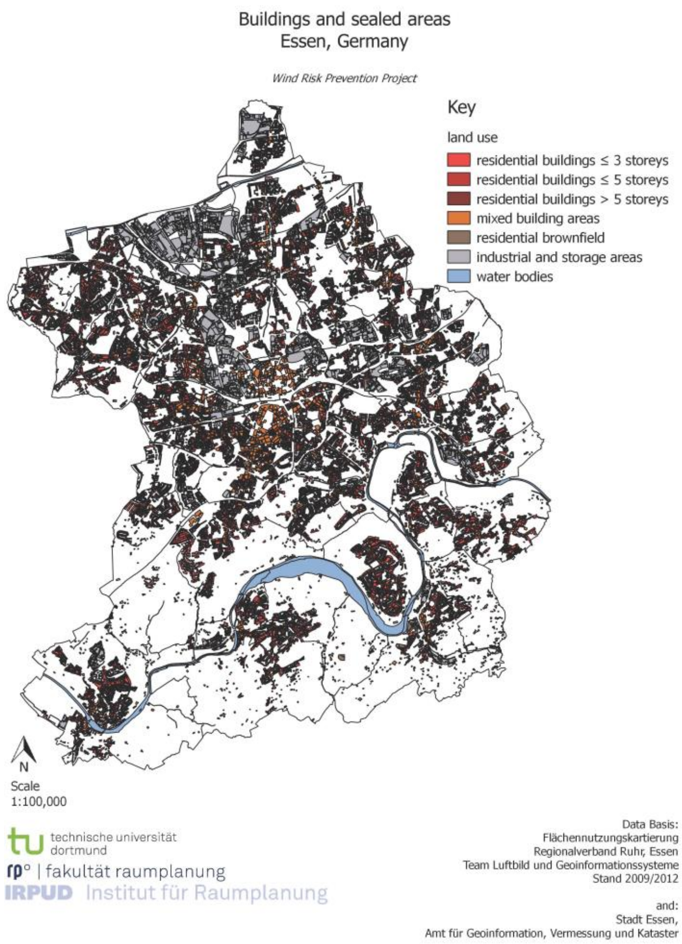
Summer storm *Ela* showed that it is of very high importance that the emergency response units like the fire brigade can securely operate. Also important is that technical infrastructure systems are secured in their operational capacity. An example can be taken from the waste water management: As summerly convective weather extremes often go along with heavy precipitation and strong winds, leaves from the trees congest manholes so that it might come to inundations in the city. Also the sewage system needs to be capable of handling great amounts of precipitation in a short span of time.

5.2.4. Buildings

The distribution of buildings in the City of Essen is quite distinctive, as figure 12 shows. First of all it can be seen that in the northern half of the city the building density is much higher than in the southern half.
Furthermore the southern settlements mainly consist of residential buildings while in the city center especially mixed buildings are predominant. North of the city center, one distinct axis of industrial and storage areas can be seen.
By the end of 2014 the City of Essen had 89,501 residential or mixed buildings with all in all 324,268 apartments. The living space per person accounted 40.8 square meters. (Cf. Website Stadt Essen d 2015)

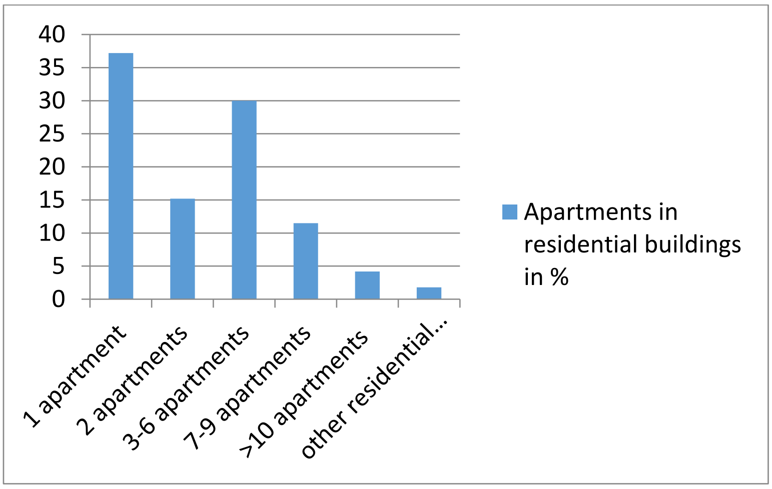
As can be seen in figure 13, most residential buildings in Essen consist of residential buildings with one apartment, i.e. single-family houses. Second come buildings with three to six apartments, allocated in three of more storeys. Buildings with more than 10 apartments or other buildings with housing space are less typical.

Figure 37: Buildings in Essen



Source: own depiction

Figure 38: Number of Apartments in Residential Buildings in Essen

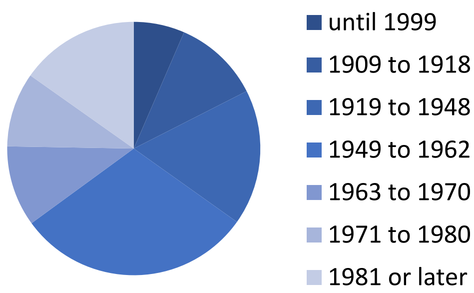


Source: Stadt Essen 2014: 41.

About thirty percent of the residential buildings in the City of Essen were built between 1949 and 1962. Even though during World War II many houses were destroyed there is still a high amount of buildings from earlier ages. Nowadays in the amount of buildings built after 1981 is 15.2 %. (Cf. Website Stadt Essen d 2015)

Table 8: Percentage of Residential Buildings in Essen (31.12.2014)

Year	Percentage
until 1908	6.5 %
1909-1918	11.0 %
1919 to 1948	17.3 %
1949 to 1962	30,1 %
1963 to 1970	10,3 %
1971 to 1980	9,5 %
1981 or later	15,2 %

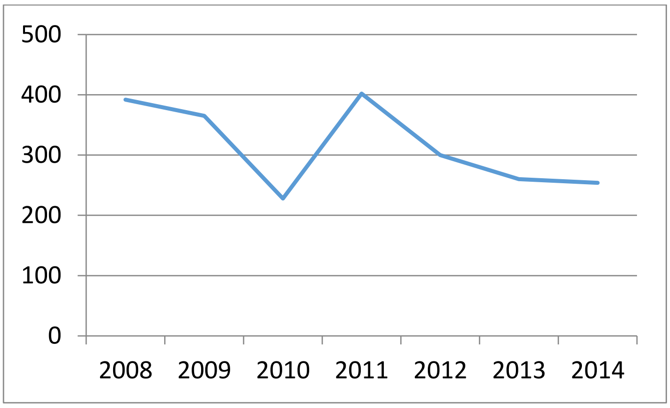


Sources: Website Stadt Essen d 2015

5.2.4.1. Buildings trends

In the last years the trend of building new houses decreased, as figure 14 depicts. (Cf. Stadt Essen 2014: 86) In the year 2014 367 planning permissions were given. 254 of the permissions were for new buildings, 113 were for modifications of the buildings. (Cf. Website Stadt Essen d 2015)

Figure 39: Number of Building Permissions in Essen since 2008



Source: Stadt Essen 2014: 86.

The regional plan for the Ruhr Area states that within the next ten to 15 years Essen is allowed to realize 5,000 new residential units. This strategy also includes the demolition of decrepit existing buildings and their substitution with new building on the same spot. With this strategy the land consumption shall be reduced.

One major trend for the building sector is that even though the population of Essen is shrinking, the number of households stays the same. The reason for this is a strong segregation of the society and the increase in single households. Furthermore the City of Essen identified a strong demand for single-family houses in the south of Essen as well as a demand for new apartments with a greater amount of square meters living space. (Cf. Stadt Essen 2011: 21)

5.2.4.2. Storm Related Vulnerability of Buildings

The storm related vulnerability of buildings depends on their function and the number of people potentially affected. Buildings that can be counted as critical infrastructure are, because of their important function for either the commonwealth or emergency response, highly vulnerable (see also chapter 2.3). But also residential buildings with many inhabitants or business buildings with many employees are vulnerable as people might get hurt, e.g. by trees falling into the buildings.

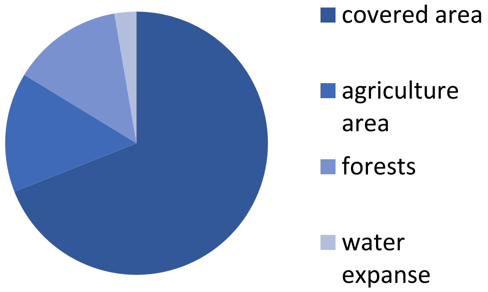
Nevertheless, due to Eurocode 1 buildings in Germany and all over Europe are built following a storm resistant building standard. According to Eurocode 1 (DIN 1055-4 for Germany) there are four wind zones in Germany, ranking from zone one (inland regions with low velocity pressure on buildings) to zone four (mainly coast regions and islands with high velocity pressure on building). The exact wind zones and maximum velocity pressures can be found in Chapter C.3 – Assessing the risk of areas to wind gusts in combination with snow and sleet.
The City of Essen is associated with wind zone 1 (inland). Buildings in this wind zone are therefore built to withstand roof velocity pressures of 0.5 kN/m^2 if they are less than 10 meters high, 0.65 kN/m^2 up to 18 meters height and 0.75 kN/m^2 for buildings up to 25 meters height.

In case of a storm with velocity pressures higher than set in Eurocode 1, damages may be expected.

5.2.5. Forests

In Essen the predominant land use categories are housing and infrastructure, leading to a high percentage pf 69.0 % ground-covered area. Agricultural areas cover 14.7 % of Essen's area and 2.7 % are water bodies. The forest area in Essen amounts 13.6 %. Furthermore Essen has 11 nature protection areas which cover 1.6 % of its area. (Cf. Stadt Essen 2014: 17; Website Naturschutzinformationen 2015).

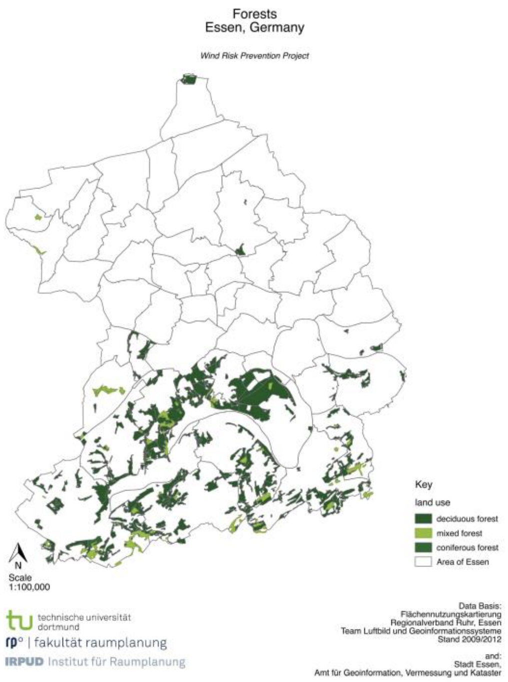
Figure 40: Land Uses in the City of Essen

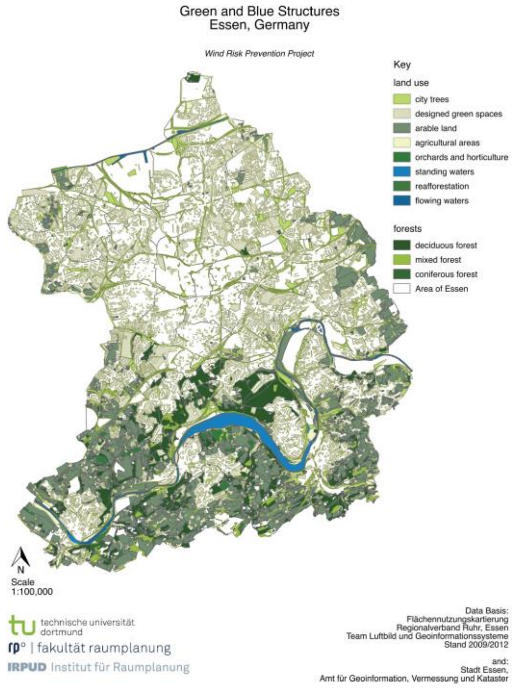


Source: Stadt Essen 2014: 17

Forests are mainly located in the southern half of the city, as can be seen in figures 16 and 17. Large parts of the forest consist of deciduous trees. Nevertheless there also are areas with solely coniferous trees or a mixture of both tree species.

Figures 41 and 42: Forest Areas and Green and Blue Structures in the City of Essen





Source: own depictions.

In 2014 the total area of forest amounted 2,853.97 ha in Essen. Compared to the year 2002 the forest area increased from 12.3 % to 14.6 %. (Cf. Stadt Essen 2014: 16, 17)

The property situation of the forest areas in Essen is as follows: 42.5 % of the forest areas belong to the municipality. (Cf. Stadt Essen 2014: 20). In these areas coniferous trees are predominant with a ratio of 97.3 % to 2.7 %. (Cf. Website Stadt Essen e 2015)
It is estimated that in total Essen has about 2,600,000 trees. 2,200,000 of these trees are in forests, 50,000 in the streets, 90,000 in private gardens and 120,000 trees in green areas and cemeteries. The other trees can be found on other land uses.

The growing conditions for city trees, trees in private gardens or in court yards differ from their natural surroundings. These trees adapted to their built environment but are often restricted in their vegetaion e.g. in their root growth. (Cf. Website Stadt Essen f 2015)

5.2.5.1. Forest Trends

The long-term vision for Essen's forests is that these are secured and further developed as recreational forests close to nature. All forests shall furthermore fulfill the standards for the Forest Stewardship Council (FSC)[56] and be cultivated and developed. (Website Stadt Essen g 2015)

[56] Following the guiding principle of the FSC®-Forest Stewardship Council® (Lizenz Code FSC®-C014716), the forest of the city of Essen shall be cultivated as close-to-nature recreational and permanent forests.

5.2.5.2. Storm Related Vulnerability of Forests

As summer storm *Ela* showed, especially trees in the city are vulnerable towards summer storms. City trees are often deciduous trees and due to their leaves provide a great windage during the summertime. In case branches break or trees even fall the damages arising are on the one hand direct to the trees but in the case of city trees often on the other hand also indirect to assets and infrastructures.

Forests of course are also vulnerable towards storms, even though the windage mainly relates to the front trees and not so much to those in the middle of the forest. Therefore forests have a natural defense system. Nevertheless in cases of strong winds forests sometimes need to be closed for the public because of the danger of branches or trees falling. In these cases the recreational character gets lost for the time of the inhibition.

5.3. Hazard Parameters in North-Rhine Westphalia and Essen

In the past and present Germany had to face several strong winter storms. To only name those with hurricane strength there were storms *Daria*, *Vivian* and *Wiebke* in 1990, *Coranna*, *Verena* and *Lore* from 1992 till 1994, *Lothar* in 1999 and most recent storm *Kyrill* in January 2007 (cf. DWD 2015). Large damages are associated with winter storms; especially the most recent storm *Kyrill*. (Cf. Fink et al. 2007: 405)

In 2014 a so far untypical storm phenomenon swept over large parts of Western Germany – the summerly thunderstorm *Ela* (named by the German Meteorological Service). *Ela* was similar to supercells that periodically occur in North America. Unlike the well investigated and predictable winter storms, summer storm *Ela* hit Germany unarmed and caused massive losses to lives and assets, especially in the Wind Risk case study city Essen.

5.3.1. Hazard Parameters

5.3.1.1. Classification of Storms in Germany

The Beaufort Scale
The German Meteorological Service classifies winds according to the Beaufort Scale, invented by Sir Francis Beaufort in 1806. Table 5 depicts an overview of Beaufort classes 8 to 12 (storm to hurricane classes) and their corresponding wind velocities measured in kilometers per hour.

Table 9: Beaufort Scale as used by the German Meteorological Service

	Wind speed*) *) Measurement of wind gusts, 10m off the ground over open terrain	
Designation	**Beaufort Scale (Bft.)**	**km/h**
Stormy wind	8 Bft.	60-7 km/h
Storm	9 Bft.	75-85 km/h
Severe storm	10 Bft.	90-100 km/h
Hurricane-force storm	11 Bft.	105-115 km/h
Hurricane	12 Bft.	≥ 120 km/h

Source: DWD 2012: 8, own translation.

5.3.1.2. Differentiation between Winter and Summer Storms

In meteorology there is a general differentiation in storms occurring during the meteorological winter half year (winter storms; October – March) and storms occurring during the summer haft year (summer storms; April – September).
In Germany especially winter storms are of high relevance as they occur quite often (see introduction) and usually lead to large damages. Nevertheless, summer storm *Ela* impressively showed that also summer storms can occur anytime and anywhere in the country and that the resulting damages are also very high. Therefore the following table presents the differences and similarities between winter storms and summer storms.

Table 10: Characterization of Winter Storms vs. Summer Storms

	Winter Storms Oct - Mar	**Summer Storms** Apr - Sep
Character	mainly depressions: • events of several hours, even days • great geographic extent • gathering over several days • precisely, early predictable storm path	mainly convective events: • events of minutes, hours • small geographic extent • gathering within hours • no predictable storm paths
Examples[57]	Storm *Kyrill,* 2007 at DUS	Storm *Ela,* 2014 at DUS
Magnitude	Peak wind gust: • 144 km/h 10-minutes middle wind: • ca. 7-8 Bft. Area affected: • wide parts of Northern Europe	Peak wind gust: • 140 km/h 10-minutes middle wind: • ca. 3-4 Bft. Area affected: • local parts of Belgium, The Netherlands, France and Germany (esp. North-Rhine Westphalia)
Most Affected Area	Forests (10 % of the forest areas were destroyed in the Ruhr Area)	Urban Areas (20,000 city trees were destroyed)
Damage Costs	Property Damage Federal Republic of Germany: • € 2.0 bil.	Property Damage Federal Republic of Germany: • € 650 mio. Municipal Damages: • € 300 mio. Damages for the German Rail (*Deutsche Bahn*): • € 20 mio. direct damages, • € 36 mio. Indirect economic losses
Major Responsibility	➢ **Sectoral Planning: forestry**	➢ **Comprehensive Spatial Planning**

Sources: Deutsche Rückversicherung 2015: 21; DWD 2014: 7; Bundestag 2014; Website GDV 2007

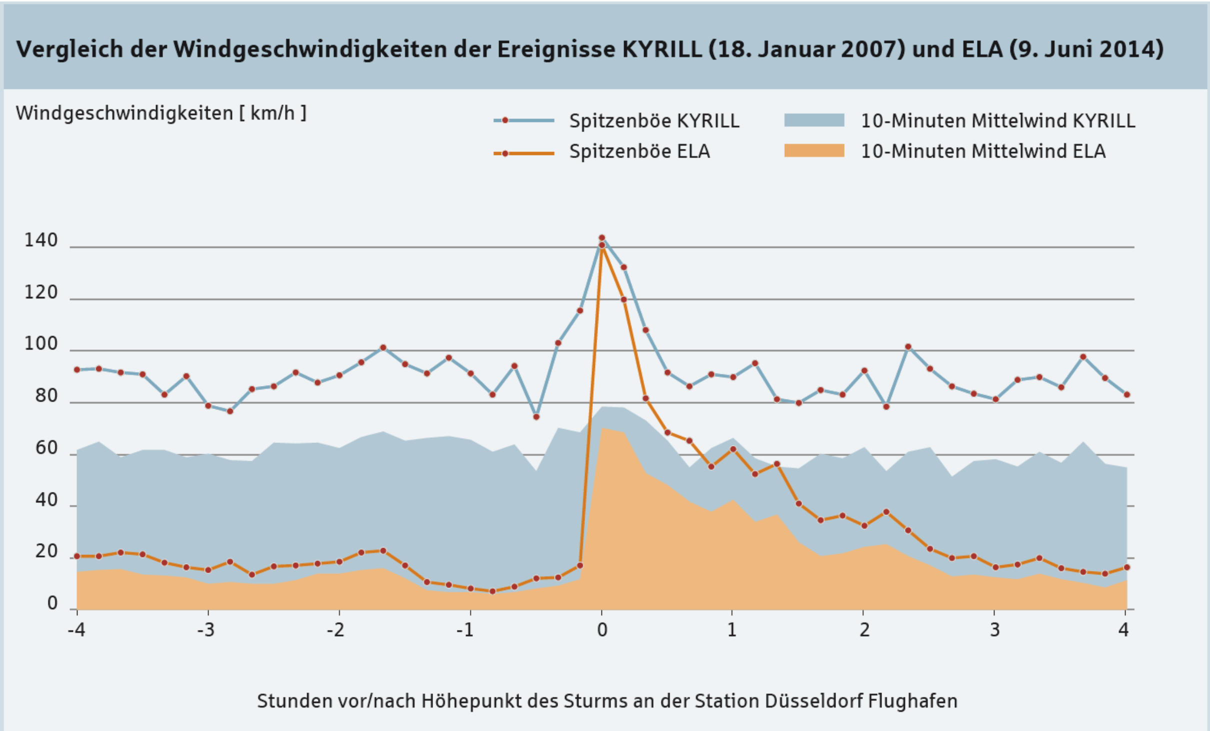
Generally speaking, the intensity (wind speed) of a storm is more important for the amount of damages than its duration. Winds that endure only for a short time but with a very high wind speed can lead to high damages and that is why wind gusts – the extremes of the wind speed distribution – are crucial for the arising damages. (Cf. GFZ, DWD 2014: 9) This phenomenon can again be seen when comparing winter storm *Kyrill* to summer storm *Ela*.

As figure 18 shows, winter storm *Kyrill* had strong wind gusts of between 80-100 km/h (Beaufort classes 9 and 10 – storm, severe storm) for several hours, peaking in a wind gust of about 140 km/h (Beaufort class 12 – hurricane). The middle winds (the 10-minutes-average) of *Kyrill* amounted around 60 km/h (Beaufort class 8 – stormy winds).
Ela on the other hand had quite low 10-minutes middle winds of largely less than 20 km/h (Beaufort class 4 – moderate winds) and the wind gusts did not differ from these values for

[57] Both measurements were taken at the weather station of the German Meteorological Service at Düsseldorf International Airport (DUS).

hours. Then, suddenly within ten minutes, the peak wind gust went from 20 km/h up to about 140 km/h (hurricane force). Within only three hours both middle winds and wind gusts returned to moderate winds of around Beaufort class 4. (Cf. Deutsche Rückversicherung 2015: 21)

Figure 43: Comparison of Wind Speeds of Events *Kyrill* and *Ela*



Source: Deutsche Rückversicherung 2015: 21.

The following description focusses on summer storm *Ela* as it is a new, so far mainly uninvestigated hazard.

5.3.1.3. Hazard Description of Summer Storm Ela

Magnitude of the Event

In the evening of June 9th 2014 (Whit Monday) there was an unusually intense thunderstorm complex moving across North-Rhine Westphalia. During Saturday June 7th and most of Sunday June 8th of Whit weekend 2014 the Ruhr Area was meteorologically determined by a large high-pressure area ('Wolfgang'), extending from the western Mediterranean Sea to Middle and Eastern Europe. The high-pressure area lead to hot temperatures of more than 30°C in large parts of Germany and created both the first heat wave of the year as well as the hottest day of 2014. Because of 'Wolfgang' the Whit weekend of year 2014 also was the hottest one since weather recordings. (Cf. Deutsche Rückversicherung 2015: 16)

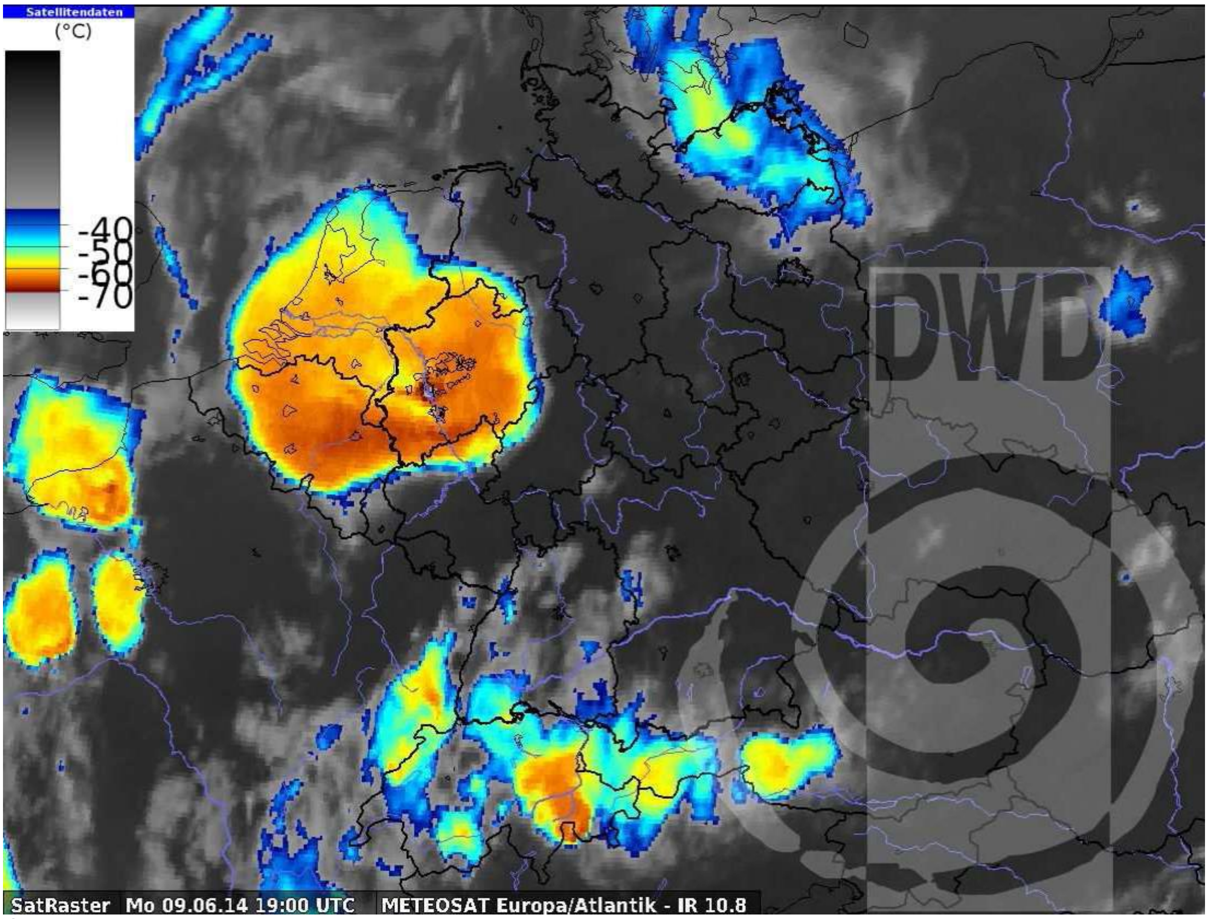
At the same time the low-pressure area 'Ela' was located at the west coast of Ireland. Already on Sunday low-pressure area 'Ela' started to infiltrate the hot, humid and labile air masses in North-Rhine Westphalia, smoothening the way to heavy thunderstorms. (Cf. Deutsche Rückversicherung 2015: 16; DWD 2015: 3f.)

Meteorologically thunderstorms are characterized as following: first there is a very warm or even hot preliminary phase with a high humidity at the near-ground level. As the air temperature descents between ground and tropopause, distinct instability (lability) arises. If then a cold front approaches, the near-ground air gets elevated and due to a minimum ground pressure, broad prefrontal convergence lines format. Along with the elevations goes an increase in wind speed, increasing with increasing height. (Cf. DWD 2015: 2)

In the case of summer storm *Ela,* several multi-cell thunderstorm clusters arose along the first convergence line since June 8th 2014. These were accompanied especially by hail, causing the first damages of the weekend. (Cf. Deutsche Rückversicherung 2015: 16, 20) On Whit Monday a mesoscale convective complex (MCC) developed above France. MCCs are characterized as the strongest thunderstorm complexes possible, as they are the most widespread and durable thunderstorm complexes possible. (Cf. DWD 2015: 4, 11)

Figure 19 illustrates the temperatures measured at the top of the clouds of the MCC of *Ela* at 9pm MESZ on June 9th 2014. It can be seen that despite the in general warm near-ground temperatures the clouds have a temperature of up to -70°C, visualizing the immense convective potential. (Cf. DWD 2015: 11f.)

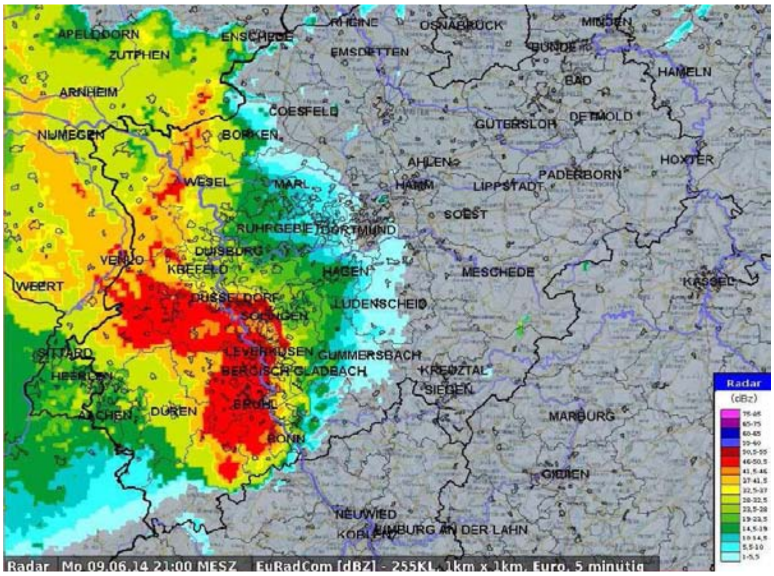
Figure 44: The Mesoscale Convective Complex of *Ela* above North-Rhine Westphalia



Source: DWD 2015: 12

Figure 20 shows that within the MCC a distinct S-form of precipitation arose. This precipitation structure is called “bow echo” and indicates furthermore an intense gust front. The radar picture contains the precipitation scan reflectivity (dBZ), distinctly showing the highest values in the City of Düsseldorf. But as the MCC moved further north-east-wards, it hit the City of Essen. In both cities the measured peak wind gusts had hurricane force (12 Beaufort). At 9pm about 360 lightning strikes per minute were measured[58]. (Cf. DWD 2015: 13, 17, 20)

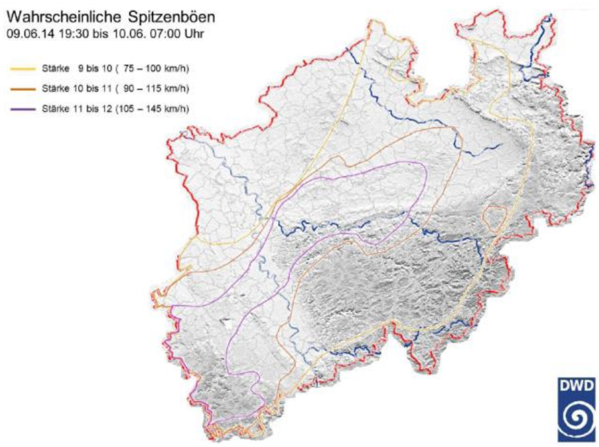
Figure 45: Bow Echo within the MCC, June 9th 2014



Source: DWD 2015: 13

The German Meteorological Service used data from radar, wind and lightning measurements in order to estimate the probable peak wind gusts for whole North-Rhine Westphalia. Within the purple framed area (± 10 km) wind gusts of hurricane strength were reached (see figure 21). (Cf. DWD 2015: 23)

Figure 46: Probable Peak Wind Gusts during *Ela*



Source: DWD 2015: 23

[58] All over Germany there were 61,000 lightning strikes recorded on June 9th. (Cf. Deutsche Rückversicherung 2015: 21)

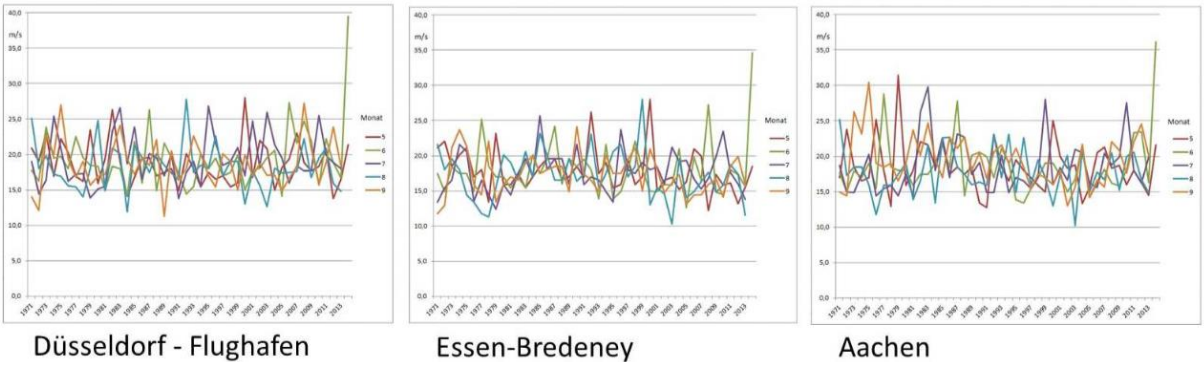
It can generally be stated that orography and topography are only of little importance when measuring wind speeds of thunderstorms. Factors to consider are that valleys, if oriented parallel with the wind direction may accelerate wind speeds and that of course hill summits are more exposed to wind as they are high off mean sea level (MSL). When discussing thunderstorms on a small scale, street canyons built in wind direction may generally increase wind speeds and the edge of a forest as well as buildings at the edge of urban are more exposed to wind. (Cf. DWD 2015: 23)

Frequency of the Event

The German Meteorological Service states that every 2 to 3 years North-Rhine Westphalia is hit by a thunderstorm complex. Problematic is that usually the complexes were geographically less broad and therefore occur in differing regions.
Also there usually are variations in the concomitants of the thunderstorms. Sometimes they come along with heavy precipitation, sometimes with strong wind gusts, sometimes with hail.

Summer storm *Ela* was a new dimension[59] of a thunderstorm. Geographically *Ela* was broader than any thunderstorm before and therefore large areas of North-Rhine Westphalia were affected simultaneously. As an MCC it also was more intense and long-lasting than any event before. Furthermore all concomitants (heavy precipitation, strong wind gusts and hail) came together, further increasing the damages. The historically outstanding intensity of *Ela* can also be seen in Figure 22.

Figure 47: Peak Wind Gusts (May - Sep) since 1971 at three stations in North-Rhine Westphalia



Source: DWD 2015: 25

5.3.1.3.1. Damages caused by Summer Storm *Ela*

The *Gesamtverband der Deutschen Versicherungswirtschaft e.V.* (*The German Insurance Association;* GDV*)* recorded 350,000 damages caused by summer storm *Ela* (cf. GDV 2015: 28). In total there were six fatalities and 30 seriously and 37 slightly injured persons caused by summer storm *Ela* in Germany (cf. Deutsche Rückversicherung 2015: 23).

Very interesting to notice was that most damages were associable with the high wind speeds of the extreme event, as the *Deutsche Rückversicherung* (*German Reinsurance Company*) states (cf. Deutsche Rückversicherung 2015: 21).

[59] at least since 1971 (further historical analyses are under preparation)

The thunderstorm with its 300 km high storm cloud reached Düsseldorf at about 9 pm and at about that time reached its peak wind speed. Düsseldorf, the state capital of North-Rhine Westphalia with about 600,000 inhabitants was hit hard by the storm. About 30,000 trees were uprooted and again about the same severely damaged. The falling trees and branches caused indirect damages to houses, roads, technical infrastructure, parking cars and other city components. Furthermore direct damages arose when roof tiles got unroofed by the hurricane force wind speeds.

Figure 48: Picture of Uprooted Trees in Düsseldorf

Source: GDV 2015: 29

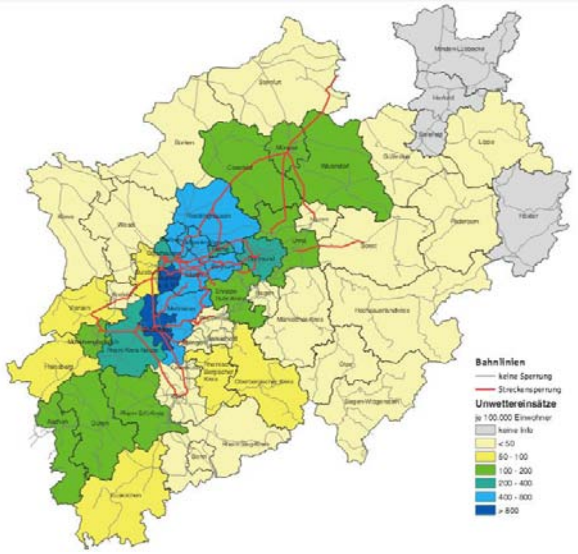
At DUS (Düsseldorf International Airport) take-off and landing were stopped from 9 pm to 10 pm and the German Rail precautionary ceased all rail traffic in North-Rhine Westphalia.

In the cities of the Ruhr Area furthermore heavy precipitation caused massive damages as it locally came to inundations. The reasons for the inundations were both the liters of rain pouring from the sky within few minutes as well as the problem that falling leaves congested the manholes. (Cf. Deutsche Rückversicherung 2015: 21f.)

The severe damages became even more visible the next morning, when road and rail traffic were extremely restricted and thousands of people were not able to get to their work places. Especially the German Rail had serious problems in overcoming the damages as one third of the whole rail network was unusable. All in all the police in North-Rhine Westphalia had more than 5,000 weather related operations in the night of June 9th/10th. (Cf. Deutsche Rückversicherung 2015: 22)

The GDV recorded a damage amount of € 650 million for Germany. Thereof € 400 million were related to property insurances and € 250 million to vehicle insurances. Summer storm *Ela* was ranked second most expensive storm in the last 15 years. The total damages in Middle Europe by *Ela* were estimated € 2.1 billion. (Cf. Deutsche Rückversicherung 2015: 23; GDV 2015: 3.) The storm path as well as the path of damages is visualized in figure 24. It can be seen that most rail tracks needed to be closed in the Ruhr Area and that especially in Düsseldorf and the central Ruhr Area up to more than 800 emergency operations were conducted per 100,000 inhabitants.

Figure 49: Closure of rail tracks and operations of emergency units in North-Rhine Westphalia



Source: Deutsche Rückversicherung 2015: 23

5.3.1.3.2. Trends in Summer Storms

As *Ela* was the first MCC recorded in North-Rhine Westphalia it is impossible to project possible future changes or tendencies. Nevertheless, it has to be assumed that due to global climate change air temperature in general will increase and that also temperature extremes (heat days) will increase in their number of occurrence. And as warmer air contains more steam and therefore is more energized, the probability of occurrence for extreme thunderstorm complexes like MCC rises. (Cf. DWD 2015: 25)

Basing on the analysis of historical data at six weather stations the German Meteorological Service states the following return periods for different summer storm events (see table 7).

Table 11: Return Periods of Summer Storms of Different Intensities

Intensity of Summer Storms	Probable Return Period
10 Beaufort	7-10 years
11 Beaufort	about 34 years[60]
12 Beaufort	≥ 44 years

Source: DWD 2012: 25.

[60] A summer storm with 11 Beaufort was only measured once at one weather station (Aachen). This weather station is located in a vally, oriented along the main wind direction (south-west to north-east). It may therefore be concluded that the orography of the region potentially increases the wind speed and that this recording was highly unusual. (Cf. DWD 2015: 25)

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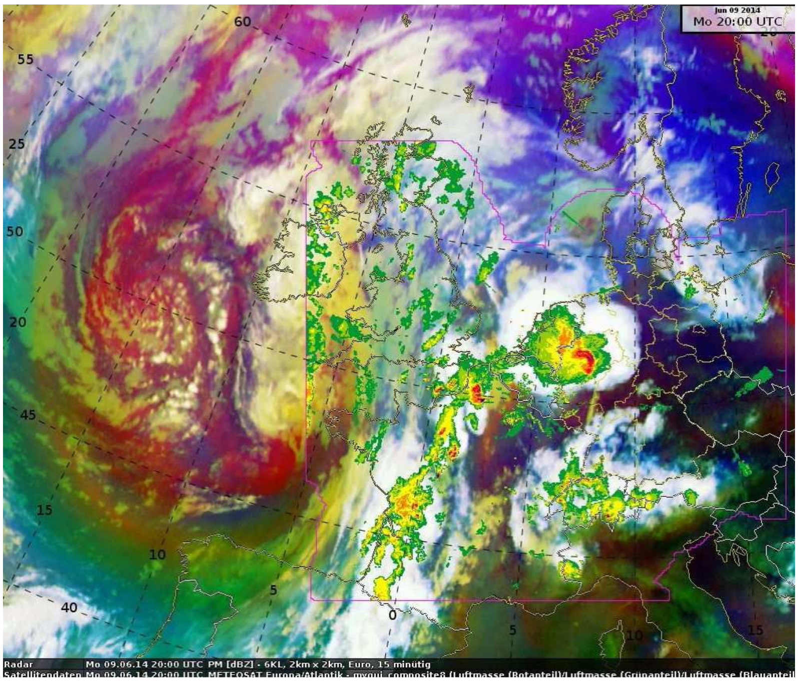
Summer storm *Ela* therefore was an extreme event with a relatively low probability of occurrence. Despite the calculated return periods as presented in table 7 the German Meteorological Service assumes that *Ela* had an intensity of a return period of far more than 50 years. (Cf. DWD 2015: 25) Nevertheless statements on the future situations cannot be made and climate change might drastically lower the potential return period of such an extreme event.

A research study of the German Meteorological Service in cooperation with the Federal Office of Civil Protection and Disaster Assistance (BBK, *Bundesamt für Bevölkerungsschutz und Katastrophenhilfe*) on regional climate projections and changes in hazard extremes states for the variable wind speed that - relatively speaking - events will occur more often the more extreme they are. Despite some periodical fluctuations a nearly linear increase in the probability of occurrence of extreme wind speeds is projected. (Cf. DWD/BBK/THW/UBA 2012: 65)
The most significant trends were projected in winter storms so that it is stated that between 2070 and 2090 the number of winter storms will be doubled in comparison to the reference period 1961-1990. (Cf. DWD/BBK/THW/UBA 2012: 70)

5.3.1.3.3. Appraisal and Conclusion on Summer Storms

Summer storm *Ela* was the second costliest summer storms in Germany in the last 15 years. (Cf. GDV 2015: 3) From Sunday, June 8th until Tuesday, June 11th 2014 there were several local thunderstorms, accompanied by heavy precipitation, hail and lightning. The most intense phase was on June 9th when several thunderstorms merged into one MCC. This MCC is today titled as *Ela* and is estimated to have a return period of more than 44 years. (Cf. DWD 2015: 3, 26) Figure 25 again depicts the dimensions of MCC *Ela.*

Figure 50 Satellite Picture and Radar Composite of June 9th 2014, 10pm MESZ



Source: DWD 2015: 5

In total there were six fatalities and 30 seriously and 37 slightly injured persons caused by summer storm *Ela* in Germany. Thousands of trees were either damaged or uprooted and many houses and cars were damaged. In some parts of the country there were blackouts as trees fell into power supply lines. In the Ruhr Area and especially the cities Düsseldorf and Essen public (and private) transportation collapsed for a couple of days as trees were blocking roads and teared down contact wires. Also flights needed to be cancelled at Düsseldorf International Airport and at several smaller airports. In total the property damages associated with *Ela* estimated € 650 million and municipalities reported further damages of €302. (Cf. Deutsche Rückversicherung 2015: 23; DWD 2015: 2; DWD 2014: 7f.)

If summer storm *Ela* had not occurred on a bank holiday (Whit weekend) for which people were prepared to be supplied with groceries for several days, there might have been more severe secondary consequences, e.g. bottlenecks in grocery supply.

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Foto: Šterman Mirko

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Task C – Risk/Vulnerability assessment

Action C.3: Assessing the risk of areas to wind gusts in combination with snow and sleet

For the Wind Risk prevention project

University of Ljubljana
Technical University of Dortmund
University of Split
Municipality of Ajdovščina

European Civil Protection

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Chapter C.3 - Assessing the risk of areas to wind gusts in combination with snow and sleet

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1. Introduction

This report aims to describe an assessment of the risk/vulnerability to high wind and high wind gusts in combination with snow and sleet for Germany (North-Rhine Westphalia area and the City of Essen) and Slovenia (Ajdovščina Municipality and City of Ljubljana). Since there is no occurrence of snow and sleet in Croatia (Central Dalmatia area), this report only focusses on two of three partner countries.

The extensive assessment of risk of areas to high winds in combination with snow and sleet is based on acquired existing data and reports from local, regional and national agencies and responsible institutions. The vulnerability towards snow, sleet and winds is assessed in five major aspects: population, infrastructure, transport, buildings and forests. The main focus is on damage to infrastructure and therefore communication, transport and power shortage as well as to forests and buildings. Consequently, the effect of high winds in combination with snow and sleet to population is also assessed.

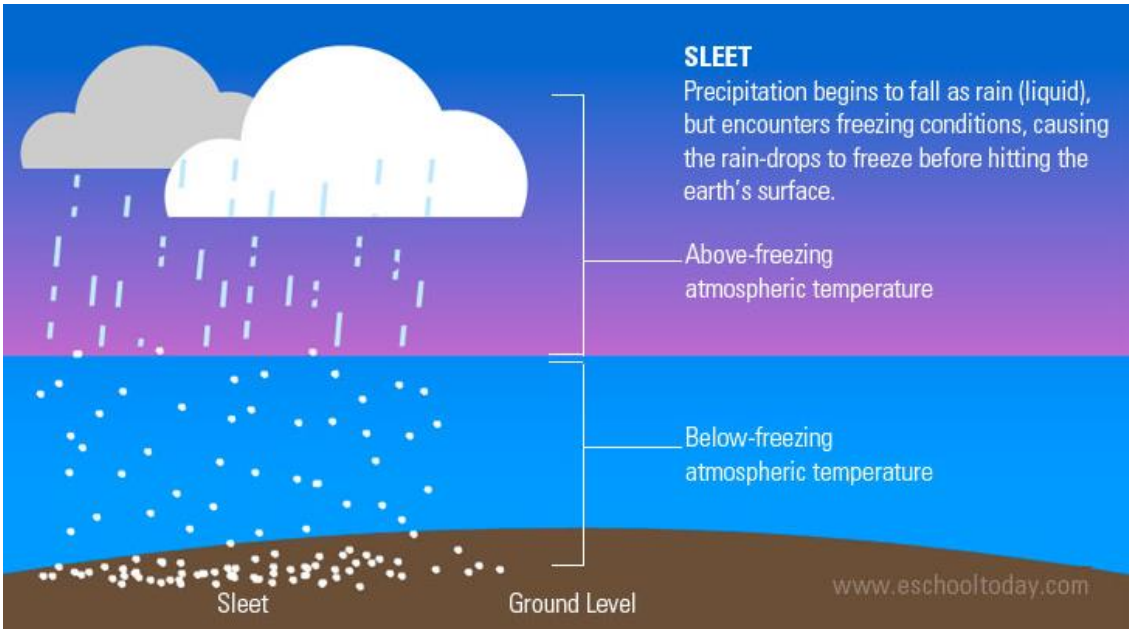
For better understanding, the formation of snow and sleet is presented first followed by gathered historical data and description of the vulnerability to high wind in combination with snow and sleet. The information about sleet, snow and wind are gathered in table.

1.1. The formation of sleet

Sleet is a smooth, transparent and homogeneous ice coating that forms either on ground or on other objects. It occurs when it rains at temperatures below freezing or when the precipitation in liquid form falls on subcooled ground. At such a temperature it usually snows, but in some weather conditions the snow or the mixture of snow and rain become liquid. Sleet is often associated with the approach of a warm front, when subfreezing air (temperatures at or below freezing) is trapped in the lowest levels of the atmosphere while warm air advects in aloft. As it accumulates a lot of cold air in the lowlands during a clear and calm winter nights, the warm air can hardly move it by the absence of stronger winds. The exchange of cold air with warmer is even more difficult in mountainous areas, where the cold air lake stay at farthest.

Next, a cold air flow in lower layers and warmer and moist air flow in higher layers of the atmosphere may also cause the phenomenon of sleet. This phenomenon is characterized by formation of secondary cyclone over the southern side of the Alps, which occur when atmospherics passing over Alps to the east. This is typical when from above the Mediterranean area over Slovenia at higher altitudes flowing moist subtropical air, and cold eastern air to the ground layer. Although in such weather conditions the temperature in the valleys remains several degrees below freezing, the zero isotherms in warmer layers maybe on altitude of the highest Alpine peaks (see Figure 1).

Figure 1: The formation of sleet



Source: e-school today

Because freezing rain does not hit the ground as an ice pellet but still as a rain droplet, it conforms to the shape of the ground, or object such as a tree branch or car. Surfaces coated with sleet are very slick and their weight often causes damages to plants, trees, buildings, and powerlines (Freezing Rain, 2015). When the freezing rain is light and not prolonged, the sleet formed is thin and it usually causes only minor damage as for example relieving trees of their dead branches etc. (CFS, 2011). On contrary, the large accumulation of freezing rain causes the most dangerous damages to nature and infrastructure facilities (Oblack, 2009).

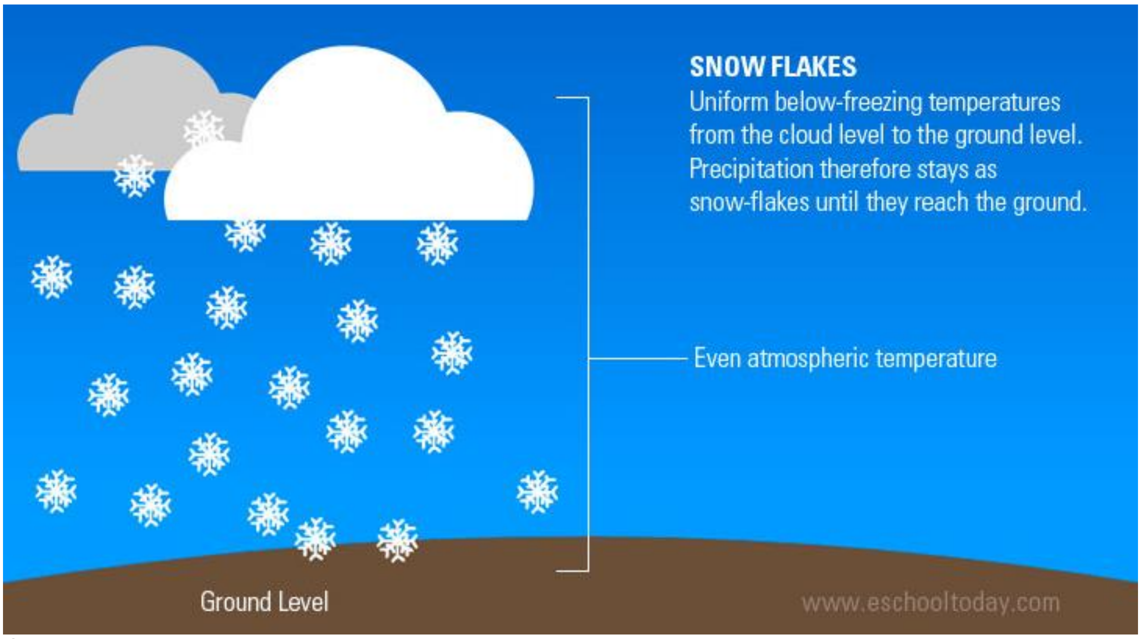
When the sleet layer exceeds approximately 6 mm, the tree branches coated in sleet can break off and fall onto power lines. The presence of windy conditions always exacerbates the damage. Power lines coated with sleet become extremely heavy, causing support poles, insulators and lines to break.

1.2. The formation of snow

Snow is precipitation in the form of flakes of crystalline water ice that falls from clouds (Snow, 2015). Whether winter storms produce snow correlates heavily on temperature, but not necessarily the temperature we feel on the ground. Snow forms when the atmospheric temperature is at or below freezing (0 degrees Celsius) and there is a minimum amount of moisture in the air. If the ground temperature is at or below freezing, the snow will reach the ground. However, the snow can still reach the ground when the ground temperature is above freezing if the conditions are just right. In this case, snowflakes will start to melt as they reach this higher temperature layer. The melting creates evaporative cooling which cools the air immediately around the snowflake. This cooling retards melting. As a general rule, though, snow will not form if the ground temperature is at least 5 degrees Celsius (National Snow and Ice Data Center, 2016). The formation of snow is schematically presented in

Figure 2.

Figure 2: The formation of snow



Source: e-school today

Once on the ground, snow can be categorized as powdery when light and fluffy, fresh when recent but heavier, granular when it begins the cycle of melting and refreezing, and eventually ice once it comes down, after multiple melting and refreezing cycles, into a dense mass called snow pack (Snow, 2015). There exist difference between heavy, wet snow and powdery snow. The cause for these differences is the surface temperature. When surface temperatures are just above freezing, snow can melt slightly, adding more moisture and creating heavy, wet snow. When surface temperatures are below freezing, we get powdery snow. Powdery snow contains less water, on average 10 cm of dry snow will melt to only 1 cm of water. Wet snow, however, can equal up to 2 cm of water for every 10 cm of snow. The wet snow is also more likely to accumulate an ice layer than powdery snow (AccuWeather, 2013).

2. Assessing the risk of Slovenia to wind gusts in combination with snow and sleet

Slovenia comprises a small, but, with regard to weather, a very diverse area. The climatic variability at short distances is a result of Slovenia being situated at the contact point of the mountain, continental and Mediterranean climate. Therefore, the weather forecast is frequently aggregated. The consequence of simultaneous influence of weather systems and orography may cause extreme weather events. Their consequences in the natural or urban environment are ranked among the natural disasters. One of them is the phenomenon of sleet (Sinjur et al., 2010). It is even worse, when phenomenon of sleet occurs in combination with snow and wind gust. Next, some short description of sleet and snow is presented.

The thickness of sleet layer and incidence of sleet are dependent on many factors which are usually interrelated and interacted. These factors are: trees species and size as well shape of treetops, the thickness of tree trunk, wood stock, treetop asymmetry and tree inclination, forest management, human actions, altitude, high wind speed and wind gusts, soil moisture, the influence of micro relief and micro location, geological structure, terrain slope, etc. Therefore, the thickness of sleet and the caused damages may vary already at a shorter distance (ACPDR, 2015).

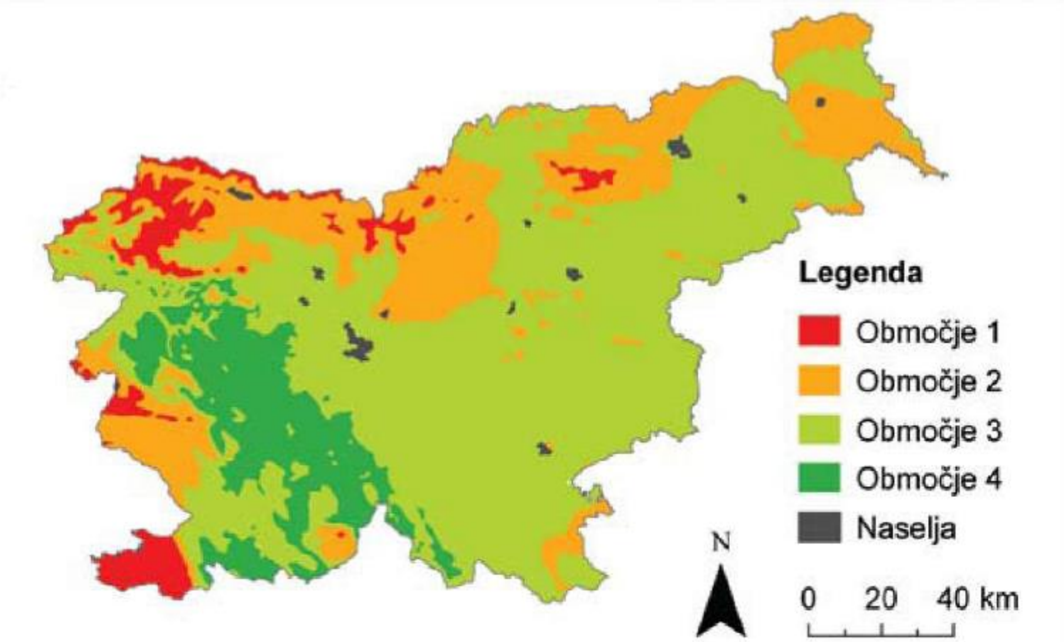
There are several impact factors influencing snow and snow cover in Slovenia. Due to lower temperatures in higher layers of the atmosphere, the snowfalls are more frequent than in lower layers. For the same reason, the snow melts slowly in higher altitudes. The shape of the terrain also affects the air temperature. In shady basins and valleys, where is not windily, the snow may persist much longer than on sunny slopes and ridges. The orientation and terrain types provide the spatial distribution of orographic precipitation over the Slovenia. At the windward side of the orographic precipitation usually falls more precipitation and also more snow than at the leeward side. The probability of snowdrifts occurrence is dependent on orientation and type of relief. At the exposed locations where high winds are very common (in the mountains), the snow conditions may change considerably at very short distances change. Somewhere the snow is blown away but in other places the snowdrifts are formed and snow can keep there for a long time.

The height of fresh snow and snow cover are meteorological variables measured at the meteorological stations daily at 7 am. The measurement represents the height of freshly fallen snow and snow cover in the last 24 hours. In Slovenia are only two avalanching stations, the Kredarica and Vogel, where the type of snow is also recorded (ARSO, 2016). According to this, the powdery snow and heavy snow are not extra labelled.

2.1. The incidence and consequences of sleet and snow – historical data

Slovenia is one of the countries that belong to sleety areas in Europe. In Slovenia, the sleet appears in the cold half of the year. The medium strong sleet occurs every few years while strong sleet, which causes high economic damage, occurs approximately every ten years. The greatest damage is caused to trees as well as to electrical and telephone communication lines. The sleet is characteristic above all for the southwestern part of Slovenia, along dinar barrier, either on the mainland or coastal side. The most commonly areas in Slovenia affected by sleet are Brkini, the area around Senožeče with Vremščica, the foothills and slopes of Snežnik, Javorniki, Nanos, Trnovo forest and Čičarija (ARSO, 2002). In Figure 3 the map of areas threatened by sleet during time period 1961-2006 is shown and the short explanation of zones as well.

Figure 3: Map of areas threatened by sleet in time period 1961-2006.



Zone 1: The area where sleet does not occur or occurs rarely in thin layers so it does not cause considerable damage
Zone 2: The area where sleet usually occurs, but very rarely causes minor damage (once every 10 years)
Zone 3: The area where sleet appears frequently and on 3 years average causes damage
Zone 4: The area where sleet causes damage and occurs on 1 to 2 years average relatively often with even greater damage

Source: Slovenian Environmental Agency, 2006

For the purposes of this report, we asked Slovenian Environmental Agency for the historical data of sleet. They are gathered in Table 1. Besides time period and affected area, the damages to forest are also presented. The notable events with high damages are in bold type.

Table 1: Damage due to sleet in Slovenia

Time period (month, year)	**Area**	**Damage to forest [m3/area]**	**Note**
1896*	Zgornja Pivka, Knežak		
December 1899	Zgornja Pivka, Vremska dolina		
1900**	Pivka		
1933	Brkini, Košana		Majority damage in altitudes between 500 and 700 m
January 1952	Vremščica, Brkini		
March 1952	Gorenji Kras		
December 1953	Idrijsko hribovje	153.000	Majority damage in altitudes between 500

			and 800 m
1958	Litijsko hribovje	1.150	
1958	Haloze, Boč, Tisovec	7.000	Majority damage in altitudes between 500 and 600 m
1960	Rudnica, Sotelsko, Haloze	7.930	Majority damage in altitudes between 400 and 500 m
November 1963	Area of Logatec	7.000	
1966	Area of Vrhnika and Škofljica		Sleet and snow damage
November 1968	Idrijsko hribovje, Trnovski gozd, Krekovše	75.080	Majority damage in altitudes between 600 and 800 m
January 1972	Kras in the edge of Divača, Trstelj	40.000	Majority damage in altitudes between 400 and 550 m
1973		106.000	
March 1975	Idrijsko hribovje	20.000	
November 1975	Idrijsko hribovje, Trnovski gozd, Hrušica, Snežnik, area of Kranj	378.860	Majority damage in altitudes between 800 and 1200 m
February 1976	Area of Razdrto		
November 1980	**Brkini, Čičarija, area of Idrija and other areas in Slovenia**	**673.644**	**Majority damage in altitudes between 500 and 800 m, inside the country in altitudes between 400 and 700 m**
November 1984	Idrijsko and Cerkljansko hribovje, the area of forestry organization of Ljubljana	More than 100.000	Majority damage in altitudes between 700 and 1000 m
November 1985	**Idrijsko and Cerkljansko hribovje, the area of forestry organization of Kranj and other areas in Slovenija**	**More than 500.000**	**Majority damage in altitudes between 700 and 1000 m**
At the beginning of January 1996	**The central Slovenia, Štajerska, Notranjska**	**680.700, 87.440 ha of damaged area, that is 8.1% of all forest area In Slovenia**	**Majority damage in altitudes between 400 and 900 m; sleet and snow damage**
At the end of January 1996	**Kras, Goriška Brda, Kambreško, Banjščice, Trnovski gozd, Brkini**		**Majority damage in altitudes between 400 and 900 m**
December 1996, January 1997	**whole country**	**867.400, 81.8100 ha of damaged area,**	**sleet and snow damage**

		that is 7.5% of all forest area In Slovenia	
February 2009	Bloke, Brkini		
January 2010	**Brkini, in places of Postojna and Brežice**	**Affected area 5150 ha from that 3720 ha of froests, damaged 850 m3 or 3 % in Brkini**	**Majority damage in altitudes between 600 and 750 m**
February 2014	whole country except Vipava valley, Brkini, Kras, coastal area and Prekmurje	9.386.776, 601.900 ha or 50 % of all forest area In Slovenia	Majority damage in altitudes between 300 and 1100 m
December 2014	**Trnovski gozd, Banjščice**		**Sleet damage only on electric installation**

Source: Slovenian Environment Agency, 2016; Summarized after Administration for Civil Protection and Disaster Relief, 2015

The Environmental Agency, likewise, gave us some comment on these data in Table 1. The meteorologists record the occurrence of sleet as a description of the phenomenon. The observer at climate station records the day when sleet either occurs or not. The observer has also possibility to note anything more, for example, the thickness of the ice. Because this is not obligated, the observer usually does not record it. The database is fulfilled only with written record about phenomenon of sleet. It has to be noted, that data are quite subjective and highly dependent on the observer as well. Moreover, if there exist snow cover, the phenomenon of sleet is not recorded (Bertalanič, 2016).

Among the listed events (see Table 1), the most critical events were chosen. The description of events was taken from news media. By gathering other meteorological data from Slovenian Environmental Agency, such as average wind speed, wind gust and precipitation (rain/snow) during sleety event, we came across some difficulties. Firstly, the varying weather conditions over some area cause different values of average wind speed at short distance. Therefore we took data from the nearest meteorological station comprising as much data as possible. Secondly, the lack of some finer data, e.g. wind gust per half an hour on major meteorological stations, represented another difficulty.

In the last 40 years, five intense sleet occurrences took place in southwestern part of Slovenia: the most damage occurred in November 1980, November 1985, somewhat less on the New Year 1996/97, next in January 2010 and recently in February 2014.

November 1980

The most famous historical sleet damage with great extent occurred in November 1980 in Brkini. In the forests and orchards it was sleet cuirass thickness of up to 70 mm. Breaking trees and power lines (see Figure 4) were additionally subjected to high winds. On the 30th of November the average wind speed over Ilirska Bistrica reached 22.6 m/s (81 km/h). It took nearly 5 years to clear the damages on 13.000 ha of land done by 400 workers of Slovenian forest organization (Perko and Pogačnik, 1996). Due to damage it was cut down about 674.000 m3 of wood stock. In Figure 4, the sleet damage on electricity lattice steel tower in Brkini at the end of November 1980 (Sinjur, 2010).

Figure 4: Sleet damage on electricity lattice steel tower in Brkini at the end of November 1980

Source: Archive of Slovenian Forestry Institut

November 1985

In November 1985 sleet damage affected approximately 21.000 ha of area belong to forestry sector Kranj. It was damaged nearly 500.000m^3 of wood stock (Forestry organization Kranj, 1990). For determination of wind speed we took daily data from meteorological station Javorje above Poljane. The high wind occurred on 10th of November with average speed of 10.3 m/s (37 km/h). On that day, the temperature fell from 10.8 to 2.8 degrees Celsius in 24 hours. At the same time the average wind speed in Ljubljana was 3.2 m/s and the average temperature fell from 14.2 to 3.5 degrees Celsius in 24 hours. At that day it started raining and snowing. It fell between 10 and 15 cm of snow.

In the winter of 1995/1996

By the end of year 1995 and beginning of year 1996 sleet damage in combination with snowfall damage affected up to 8 % of overall Slovenian country (approximately 87.000 ha of forests). Majority was affected forestry sectors of Ljubljana, Kranj, Celje and Maribor. It was injured approximately 680.000 m^3 of wood stock, split to deciduous trees injured by sleet damage and to younger coniferous trees injured by heavy snowfall (Slovenian Forestry Institute, 1996). For analysing this event we took meteorological variables in time period from 15.12.1995 to 15.1.1996 in Ljubljana station. In Ljubljana City it fell between 20 and 30 cm of snow. The type of snow is unknown. The maximal average wind speed in that time period was 4.6 m/s, and maximal value of wind gusts was 13.1 m/s.

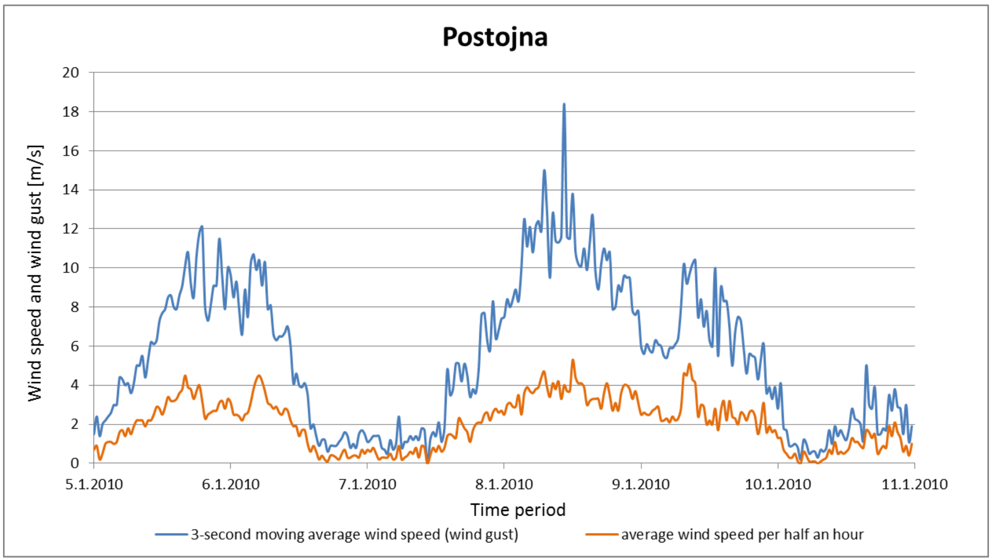
In the winter of 1996/1997

In the winter of 1996/1997 a major damage was caused to forest, transport and infrastructure as well. The sleet broke branches, fall trees. The power supplies and telecommunication network was damaged almost everywhere in the country. The transmission lines, which connect central Slovenia with the rest of the network, were mainly damaged. The situation become even worse, when it started to snow and blow bora wind, which caused additional damages to different aspects cross the country. At the same time it fell over 20 cm of snow (unknown type) and the wind had a speed of 17 m/s (8 Beaufort). The average cut-down in forests was amounted to an 867.400 m^3 of wood stock over the 81.810 ha (ACPDR, 2014). All damage started by sleet damage at December 24th and continued by snowfall damage till the end of January 1997. In January 1st started snowing in Ljubljana. It fell 30 cm of fresh snow in 24h. There is now known data which type of snow fell. The average wind speed at that time was up to 2 m/s. Mostly were affected forestry sectors of Kranj, Ljubljana, Kočevje and Novo mesto as well as areas with altitude between 400 m and 900 m. (Sinjur, 2010).

January 2010

In 2010, a big sleet occurred on January 8th and 9th in Brkini on the altitudes between 600 and 750 m. The sleet also appeared in the forest management region Postojna in the area under Mašun, in the Postonjska vrata surroundings and in higher situated locations of the forest management Brežice (Sinjur, 2010). For analysing this event we took meteorological variables from Postojna station between January 5th and 11th. In Figs. 5 and 6 the average wind speed and 3-second moving average wind per half an hour are presented.

Figure 5: Average wind speed and 3-second moving average wind per half an hour in Postojna in January 2010



Source: Slovenian Environmental Agency

It is clearly visible that average wind speed started increasing during sleety event as well as wind gusts. The maximal value of average wind speed was 5.3 m/s and wind gusts were up to 18 m/s. The thickness of sleet reached 10 cm on the altitude between 600 m and 700 m, and 20 to 30 mm on altitude above 700m. It was affected around 850 m^3 wood stock (3 %).

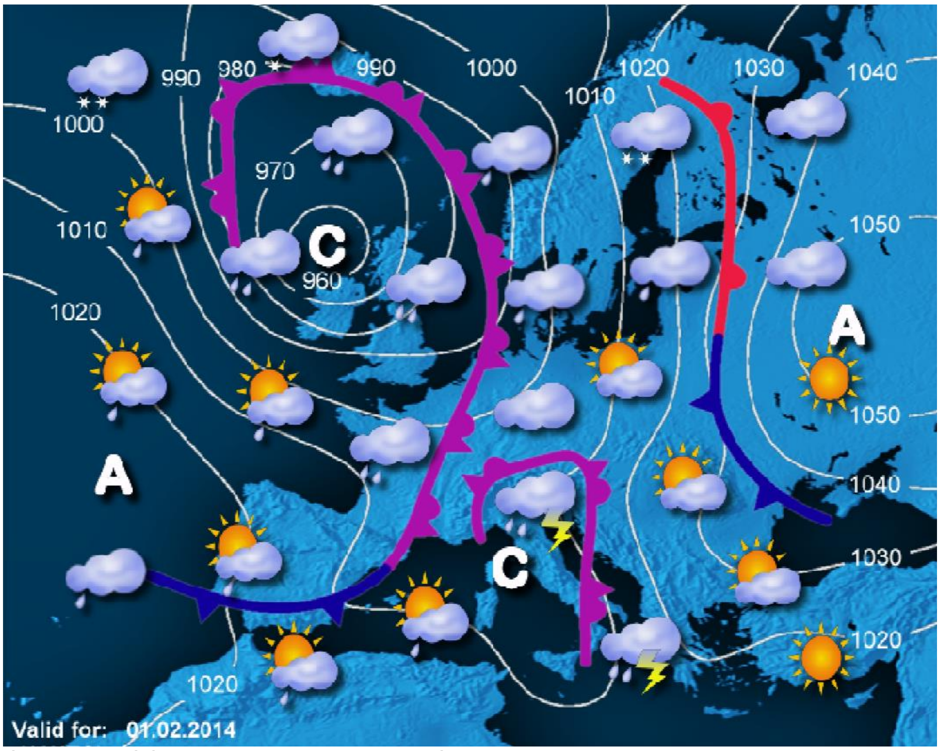
February 2014

In February 2014 the worst sleety event in living memory occurred in a great part of the country. The extended description of this event is presented additionally.

2.2. Weather situation in the end of January 2014

In the end of January 2014, the weather situation in the area above Europe was characterized by high contrast between deep cyclonic area above the eastern Atlantic and partly over the Mediterranean, and expressive anticyclone with the center above Russia (see Figure 6). The difference in air pressure between both formations was occasionally more than 100 hPa. The Slovenia was in large part in the area of contact between anticyclone and cyclone, where the frontal zone was renewed constantly. In frontal zone, the cold air of polar origin in a thin boundary layer of the atmosphere and a strong flow of warm and moist air at altitudes above North Africa and the Mediterranean were composed. In February during 30th and 5th intense precipitation occurred in large areas of Slovenia, widely combined with high southwestern wind speed and wind gusts of intensity category 8 Beaufort, which is nearly 70 km/h. This kind of synoptic situation constitutes a recipe for abundant rainfall, snowfall and sleet formation on the southern edge of the Alps.

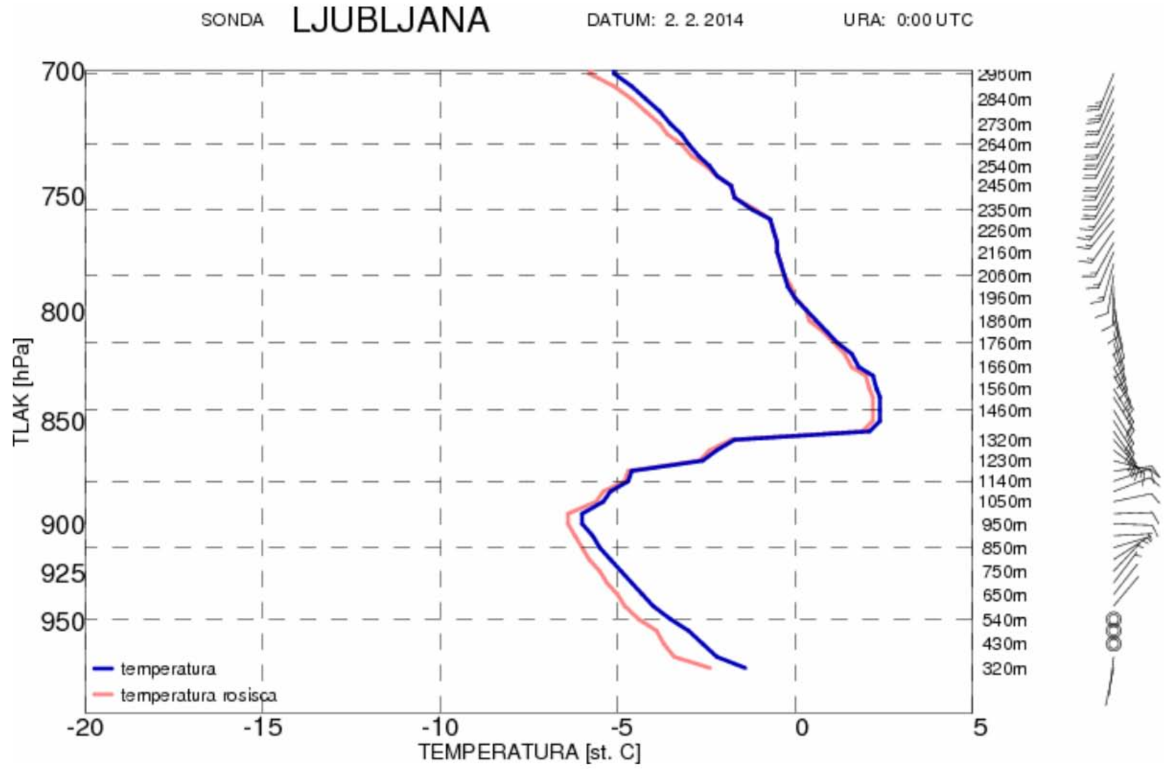
Figure 6: Surface pressure chart over Europe in February 1st



Source: ARSO, National Meteorological Services, 2014

In February 4th the anticyclone above Southeast Europe started to weaken as well as the difference in air pressure between the Adriatic Sea and Balkans, likewise the temperature inversion over Slovenian area. The influence of the extensive Atlantic cyclone started to strengthen, and in the some ground layers of the atmosphere the southwestern wind was blown. Consequently, it lifted temperatures above freezing point. In February 6th the wind weakened. The strong southwest wind was blown through lowland and stopped the period of raw weather. In Figure 7 the vertical radiosonde above Ljubljana in January 30th in 2014 is shown. The temperature between 1.300 and 1.900 m was positive, however, the temperature inversion was 9 degrees Celsius in 400 m of altitude difference.

Figure 7: Vertical radiosonde above Ljubljana in January 30th. Temperature inversion.

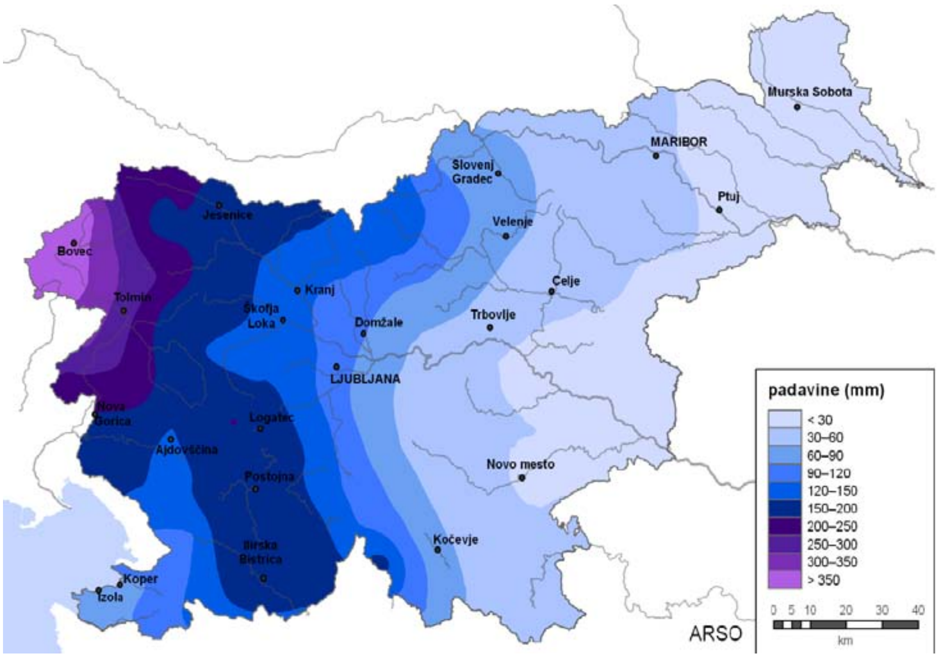


Source: ARSO, National Meteorological Services, 2014

At the contact of cold and warm air masses near the ground - mostly at foothills area of High Karst – the repeatedly exchange of cold and warm air masses was happened. It was stated that the exchange of air masses was happened about six times, however, the temperature difference was in the range from 6 to 8 degrees Celsius (Vertačnik et al., 2015). In the south of air pressure masses contact it was abundant rainy weather. In Figure 8 the assessment of precipitation cross Slovenia between January 29th and February 6th is shown.

Because of the inflow of warm air in a layer between 1.000 and 2.000 meters, the temperature was often above the freezing point in the layer between 1.200 and 1.900 meters. The snowfalls that fell through a layer of positive temperatures were in the aforementioned wedge of warm air flux where were melted, consequently, it was raining in the lower parts. In the cooler boundary layer the raindrops were super-cooled, however, their temperature fell below freezing. Where the raindrops stayed in liquid form all the way to the cold ground and the temperature was below freezing at ground level as well, the touch of a sub-cooled surface caused sleet of them. This condition was fulfilled almost everywhere in the interior of Slovenia, except in the higher altitudes of Coast region (ARSO, 2014; ACPDR, 2014).

Figure 8: The assessment of precipitation between January 29th and February 6th



Source: ARSO, National Meteorological Services, 2014

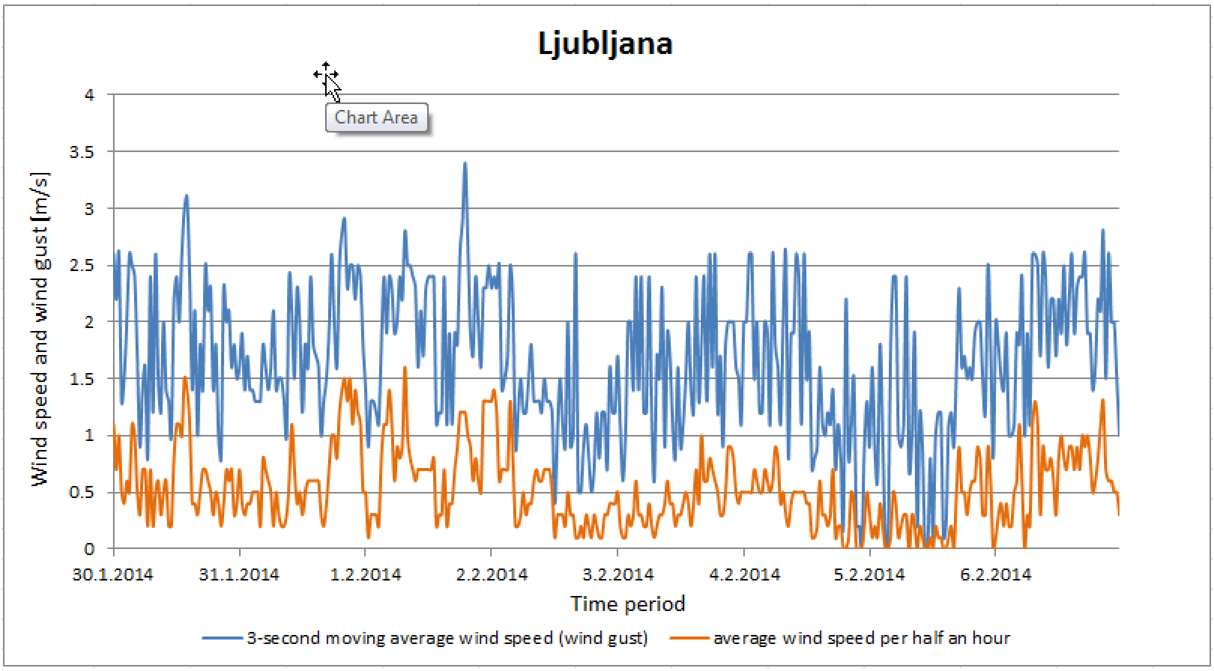
2.3. Weather variables in Ljubljana, Ajdovščina and Postojna

In order to obtain variability of parameters such as average wind speed, wind gust, precipitation and temperature, the meteorological data for Ljubljana, Postojna and Ajdovščina are presented next.

Ljubljana

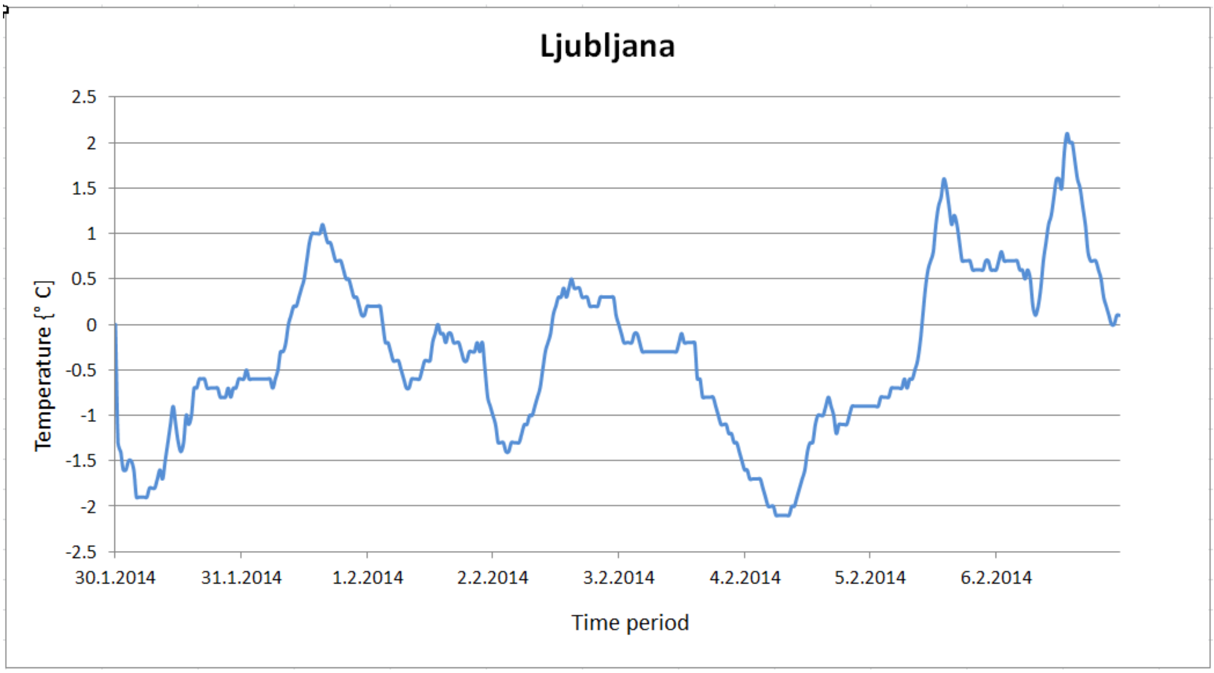
In Figure 9 the average wind speed per half an hour and wind gust for Ljubljana is presented. The maximal value of average wind speed per half an hour was 1.60 m/s and the maximal wind gust reached speed of 3.4 m/s. In January 31st it started snowing in northwestern part of Slovenia, where fall between 70 and 100 cm of snow. Next day it was raining in most of the country and the rain pass into snow. At that time the temperature in Ljubljana fell from 1 to -1.5 degree Celsius and caused the right conditions for phenomenon of sleet (see Figure 10 and Figure 11). The sleet started occurring in January 31st in the afternoon and the next two days. In February 3rd it stopped snowing and in the next three days the sleet thawed. The thickness of sleet was around 20-30 mm

Figure 9: Average wind speed per half an hour and 3-second moving average wind sped in Ljubljana for time period between January 30th and February 6th in 2014



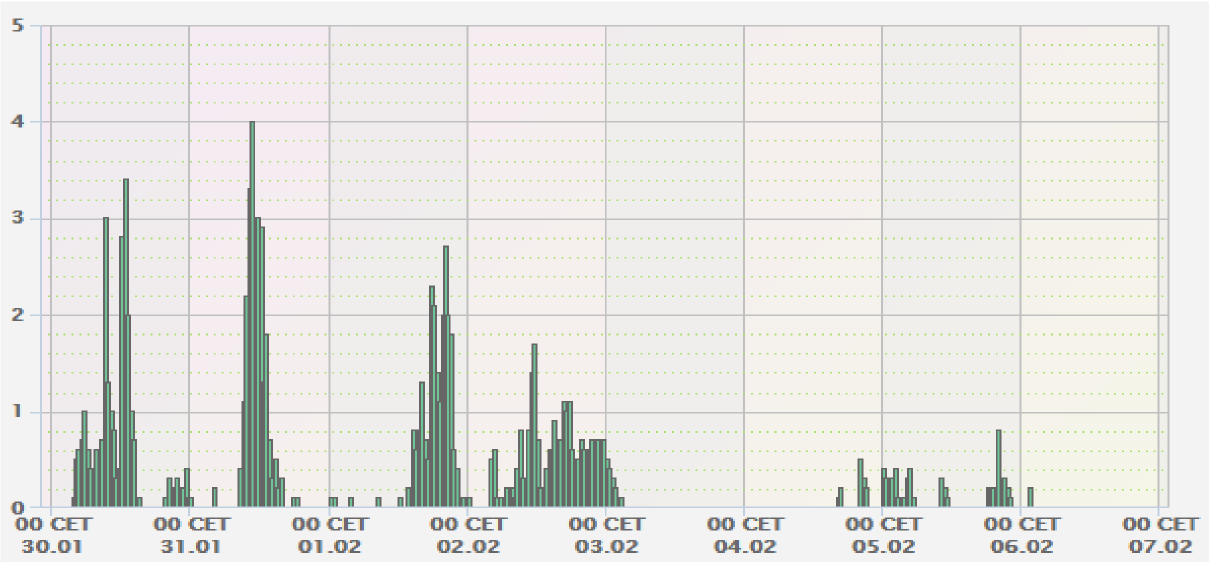
Source: ARSO, National Meteorological Services, 2016

Figure 10: Temperature per half an hour in Ljubljana for time period between January 30th and February 6th in 2014



Source: ARSO, National Meteorological Services, 2016

Figure 11: Average amount of precipitation in Ljubljana for time period between January 30th and February 6th in 2014



Source: ARSO, National Meteorological Services, 2016

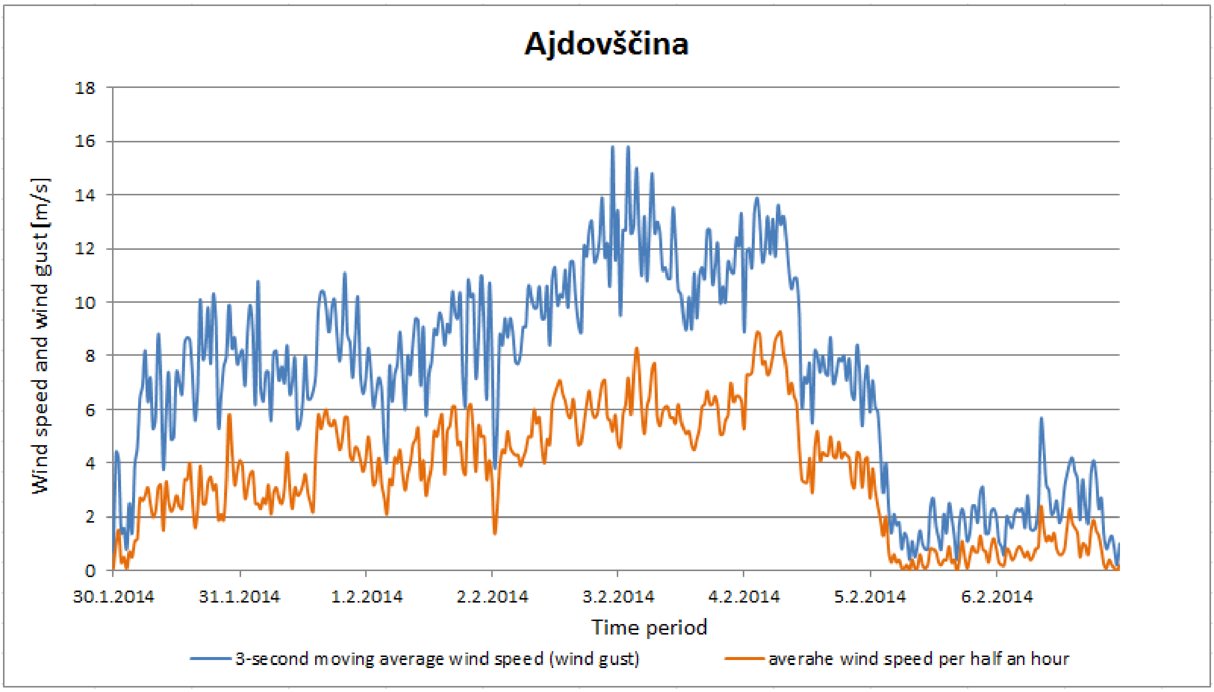
Ajdovščina municipality

In

Figure 12 the average wind speed per half an hour and wind gust for Ajdovščina municipality is presented. It is clearly to see, that bora wind started slowly increasing from 4 to 8 m/s and the wind gust reached maximal value of 16 m/s in February 3rd (see

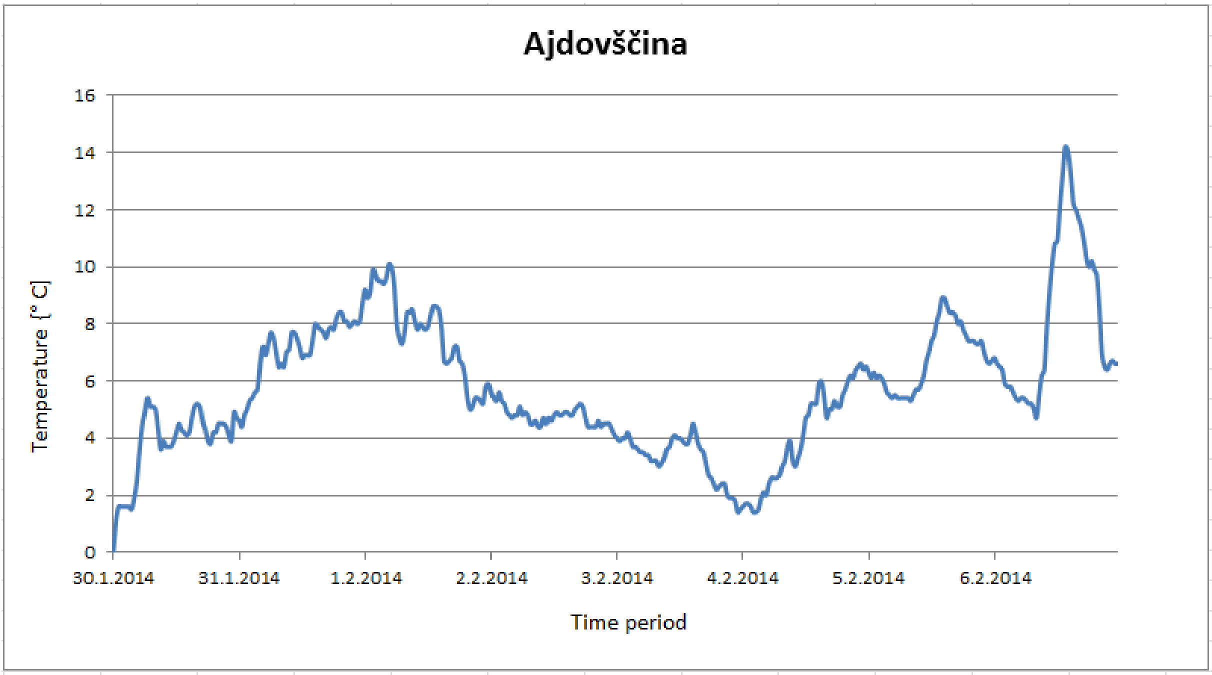
Figure 12). On the contrary, the temperature fell from 10 to below 2 degree Celsius in two days (see Figure 13). The sleet started occurring on January 31st in the afternoon and the next three days. In February 4rd it started blowing and in the next three days the sleet thawed. The thickness of sleet was between 20-30 mm. The precipitations are presented in Figure 14. It is found out that there exist possibility of correlation between bora wind and phenomenon of sleet.

Figure 12: Average wind speed per half an hour and 3-second moving average wind sped in Ajdovščina for time period between January 30th and February 6th in 2014



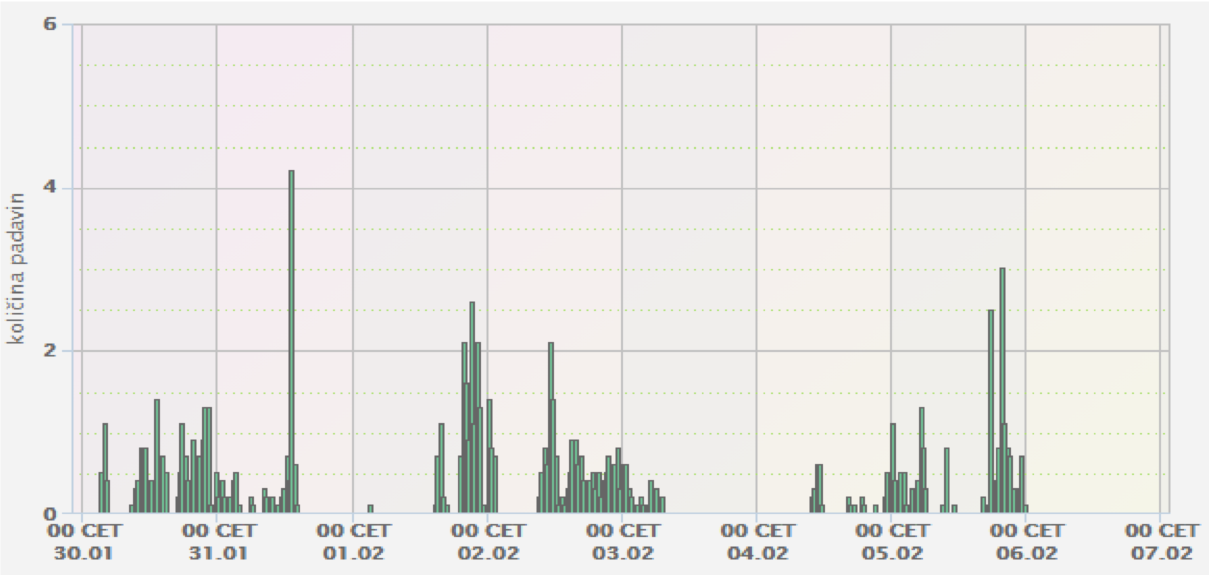
Source: ARSO, National Meteorological Services, 2016

Figure 13: Temperature per half an hour in Ajdovščina for time period between January 30th and February 6th in 2014



Source: ARSO, National Meteorological Services, 2016

Figure 14: Average amount of precipitation in Ajdovščina for time period between January 30th and February 6th in 2014

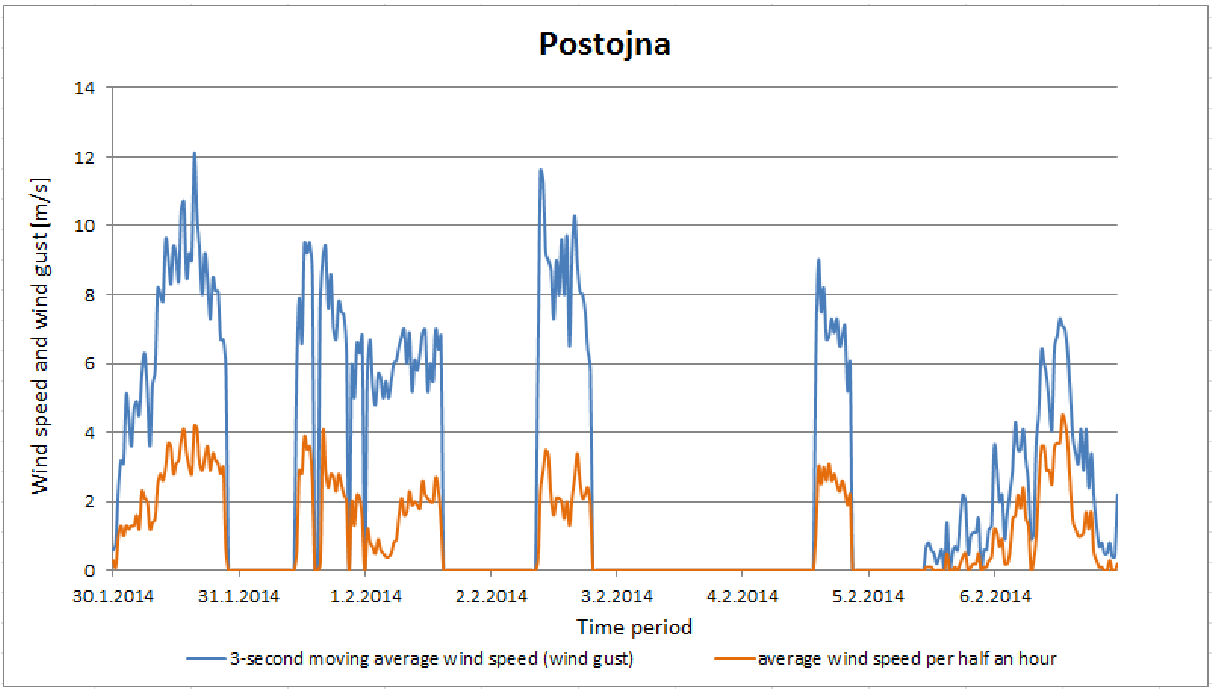


Source: ARSO, National Meteorological Services, 2016

Postojna

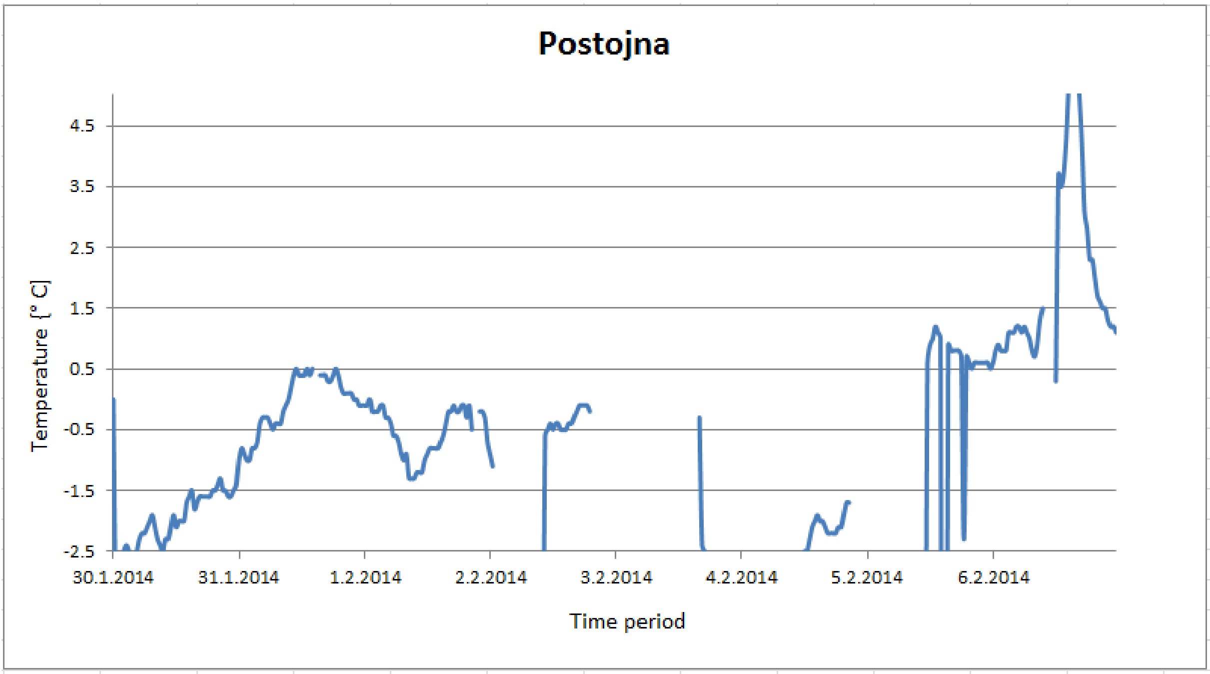
In Figure 15 the average wind speed per half an hour and wind gust for Postojna station is presented. Firstly, there is a lot of missing data due to electricity blackout. In spite of that, we notice that average wind speed per half an hour was varying around 3 m/s and the maximal wind gust reached value of 12 m/s at the time before phenomenon of sleet. In Figure 16 the temperature is presented but it is very difficult to comment on it due to a lot of missing data.

Figure 15: Average wind speed per half an hour and 3-second moving average wind sped in Postojna for time period between January 30th and February 6th in 2014



Source: ARSO, National Meteorological Services, 2016

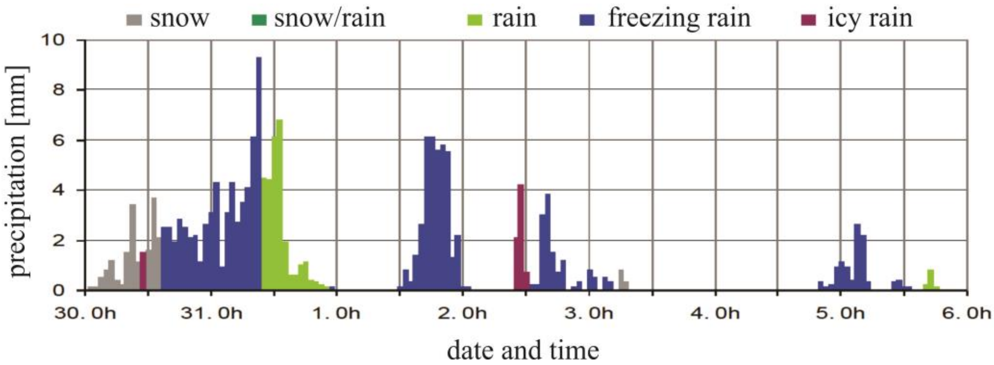
Figure 16: Temperature per half an hour in Postojna for time period between January 30th and February 6th in 2014



Source: ARSO, National Meteorological Services, 2016

On contrary, we found a descriptive graph for precipitations that fell in Postojna station (Vertačnik et al., 2015). They are presented in Figure 17. We also got some comment on it from Slovenian Environmental Agency (Bertalanič, 2016), who commented that '[p]henomenon of sleet was formed by rain with snow (denoted as snow/rain in Figure 17) and freezing rain even more. The snow, rain and icy rain (all denoted in Figure 17) did not formed sleet. Moreover, in case if on January 31st around noon would not being raining (rain, characterized by bright green in Figure 17), it would be even more sleet. Some sleet was melted, namely by rain. Finally, the data of precipitation type in the hours of each day are not digitalized and were analyzed separately from meteorological diaries of more stations.' The thickness of sleet in Postojna area was between 50 and 90 mm.

Figure 17: Average amount of precipitation in Postojna for time period between January 30th and February 6th in 2014



Source: Vertačnik et al., 2014; ARSO, National Meteorological Services, 2016

For better understanding of phenomenon of sleet, we gathered some available data of historical events. Most of them were acquired by Slovenian Environment Agency, but some of the data were collected from unofficial sources such as news media or witness account. Therefore, in Table 2 the days with sleet of historical as well as recent events are gathered.

Table 2: Days with sleet

SLEET							
Date of occurrence	Effected area [km2]	Area location (region)	Start of sleet fall (time)	End of sleet fall (time)	Sleet thaw (date & time)	Temperature	Amount of sleet [mm]
30.11.1980	130	Brkini	1am				70
10.11.1985	210	Kranj, Poljane				from 10.8 to 2.8 °C	
24.12.1997	818	Kranj, Kočevje	24.12.19976am	25.12.1997 6am			
8-9. 1. 2010	51.5	Brkini					10-30
31.1.2014		Ljubljana	31.1.2014;1-5 am	3.2.2014; 1-3 am	4.2.2014 6-8 am	from -1 to 1 °C	20-30
31.1.2014		Postojna	31.1.2014;1-5 am	3.2.2014; 1-3 am	5.2.2014 6-8 am	from -0.5 to 0.5 °C	50-90

Source: Slovenian Environment Agency, 2016; unofficial sources

It is clearly visible that we have some missing data, because it was very difficult to define start and end of sleet and its thaw. In single event, the amount of sleet was between 10 and 90 mm and temperatures around 0 °C. The wind speed properly was not so high, but in combination with sleet caused a great damage to infrastructure, forests, transport, buildings and to population as well.

2.4. Vulnerability Parameters – Damages to population, transport, infrastructure, buildings and forests

2.4.1. Population

The sleet damage caused a lot of problems to the population. About 153.400 of the households did not have electricity for at least one day and about 23.270 of the households had to live without electricity for more than two days. The Civil Protection of the Republic of Slovenia in cooperation with the electricity distributors had made a plan of priority electricity supply. Consequently, the electrical generators, which were connected to the operators of public telecommunications services, were assured by Civil Protection (ACPDR, 2014).

The great part of the population was not able to get to their workplaces due to collapse of many lattice towers and trees. Kindergartens and schools in the area of Pivka and Postojna and some other parts of the country were closed for one day, while students remained stranded overnight at a local school at Vojsko before access was unblocked in two days.

Emergence wards in hospital, as a secondary factor, had also seen a huge surge in emergency cases. Hundreds of patient with injuries received emergency care at the two main hospitals, namely, in Ljubljana and Maribor. There were also some injuries of electricians, firefighters and civil rescue teams who helped to unblock roads and provided emergency relief. Due to consumption increase of electrical generators and its irregular use, there were also some poisoning by carbon monoxide.

2.4.2. Transport

General Description

Slovenia has almost 39.000 kilometers of public roads. The Slovenian Infrastructure Agency (former Slovenian Roads Agency) manages main and regional roads and cycling routes, and some other roads (Ministry of Infrastructure, 2015).

Table 3: The roads network in Slovenia

Road category	Length in km	Operator
Motorways/Expressways	746	DARS d.d. Motorway Company in the Republic of Slovenia
Main roads	819	Slovenian Infrastructure Agency
Regional roads	5.117	Slovenian Infrastructure Agency
Local roads	13.598	Local communities
Public paths	18.626	Various operators

Source: Website Ministry of Infrastructure, 2015.

The public railway infrastructure is owned by the Republic of Slovenia. The operator of the public railway infrastructure is Slovenian Railways, as per the Railway Transport Act. The Slovenian Infrastructure Agency is responsible for the construction, upgrade, reconstruction and maintenance of public railway infrastructure, which comprises 1.209 kilometers of railway lines.

Table 4: The railways network in Slovenia

Railways	Line	Length in km
National line categories	Main lines	575.622
	Regional lines	633.462
Actual length of lines	Lines in total	1,209.084
Actual length of electrified lines	Single-track line	170.125
	Double-track line	330.299

Source: Website Ministry of Infrastructure, 2015.

The Slovenian railway network is presented in Figure 18.

Figure 18: Slovenian railway network

Source: Website Ministry of Infrastructure, 2015.

Vulnerability towards Snow, Sleet and Wind

The roads network and railway network are the main vulnerability parameter of transport. The most important part of this is the transport of population and cargo transport. Among the various environmental impacts to every kind of abovementioned network, the most critical phenomenon is strong wind with high wind gusts in combination with heavy snowfalls and sleet. Due to strong wind and high wind gusts, the roads in the Vipava valley are often closed. In other region, the transport network is affected by combination of strong wind and snowfalls and/or sleet.

During extensive sleety event, especially from February 2nd and 4th, a large number of national roads were closed due to fallen trees and electricity infrastructure. Because of sleet, mobility was strongly restricted. More than 1.000 trees were fallen on the motorways and expressways, and more than 1.000 trees in the area along both of them as well. It was damaged more than 40 kilometers of protective fencing and destroyed a number of signaling and safety devices. The municipal roads were suffered heavy damages (ACPDR, 2014).

Figure 19: Damage at installation of road signs

Source: Foto Izidor Šček

In most critical days, the electric traction was disabled in some electrified lines due to power failure. The worst situation was between Pivka and Borovnica where trains got stuck due to broken-down trees, demolition of masts and beams of overhead lines (ACPDR, 2014). Where it was possible, the electric trains were exchanged by diesel trains. Because of the worsening of situation, further falling of trees, demolition of devices and signaling, the trains with diesel traction had to finally stop. The railway stations of Postojna, Pivka and Prestranek and the other stations were fettered in sleet for several days. These railway stations were totally damaged. All cantilevers of the running network and a few columns were broken. The danger in the station area was accounted by broken and damaged vegetation (Slovenian Railways, 2015). The complete passenger traffic between Borovnica and Divača was moved to the bus lines for more than a year. The railway track at that segment was repaired recently in June 2015.

Figure 20: Sleet damage at railway station in Pivka

Source: Foto Paolo Visintini

To improve the standard of people living in the situations like this, the Ministry of infrastructure during this sleety event accepted decision of the priority of transport services in railway transport. In passenger transport basic mobility in peak time as well as the assurance of international connections were assured. In the cargo transport, the economy supply (oil products, coal, cereals, cars, spare parts, dangerous substances, etc.) was assured as well as delivery and removal of trains for the needs of the Port of Koper, and the transport of container trains and intermodal transport were assured (ACPDR, 2014).

2.4.3. Infrastructure

General Description

The energy supply infrastructure and communication infrastructure are the main vulnerability parameter of infrastructure. The most important components in the electric power system for electricity transmission are electrical overhead lines as well as telephone landlines and radio masts. Among the various environmental impacts to every kind of outdoors infrastructure, the most critical phenomenon is strong wind with high wind gusts in combination with heavy snowfalls and sleet. Regarding to climate changes, the new approaches in the design and dimensioning of overhead lines in the transmission network are also required (Rebolj, 2015).

Vulnerability towards Snow, Sleet and Wind

When the disaster due to atmospheric situation hit Slovenia in February 2014, transmission facilities (towers and conductors) were exposed to significantly thicker layers of sleet than anticipated in the planning phase. The sleet caused numerous defects in electrical distribution network. Many of the population were affected and stayed for several days without electricity.

The greatest damage was caused in Notranjska region, but the electricity network was damaged almost everywhere in the country. The transmission lines, which connect central Slovenia with the rest of the network, were mainly damaged. The connectivity of this part was weakened to such an extent that the basic supply of electricity to the greater part of central Slovenia was under question (ELES, 2014).

Table 21: The newly constructed transmission line (left) and the distribution network of Elektro Ljubljana (right)

Source: Websites of ELES (left) and Elektro Ljubljana (right).

The newly constructed 400 kV Beričevo-Krško transmission line provided continuous supply to the central Slovenia during the sleet, so it has to be noted that without this transmission line Ljubljana and its surroundings would have sustained large-scale blackout. This event more than just confirmed the fact, that the newly constructed transmission line is a great importance for a reliable and quality power in Slovenia; in addition to the already important role from the standpoint of increased possibilities of cross-border exchanges with foreign countries.

The disaster caused by sleet only in the area, which is administrated by Elektro Ljubljana, damaged 3000 wooden and 92 metal masts, 23 of them were on 110 kV voltage network and other in medium voltages network. It was damaged more than 4000 cantilevers and 6000 insulators. It was also affected 1800 km of medium voltages and 1200 km of low voltages. In Table 5 the number of customers without electricity all over Slovenia during disaster is presented.

Table 5: The number of customers without electricity during disaster in February 2014

Eletrical distribution network	**The number of customers without electricity**			
	3rd February	4th February	5th February	6th February
Elektro Maribor	47.000	6.500	1.915	908
Elektro Celje	30.000	4.200	1.500	613

Elektro Primorska	12.600	9.000	4.886	4.886
Elektro Gorenjska	3.800	300	3.862	3.862
Elektro Ljubljana	60.000	22.000	24.000	13.000
Total	153.400	42.000	36.163	23.269

Source: Administration of the Republic of Slovenia for Civil Protection and Disaster relief, 2014.

Figure 22: Collapse of electricity lattice steel tower in Logatec

Source: Foto Slovenian Press Agency

Figure 23: Amount of sleet on the conductor (left) and on the insulator (right)

Source: Rebolj, 2015

The damages of electrical transmission lines and telecommunications networks as well as aggravated or impossible accesses to them were the main cause of failure of the public mobile telephony in the extensive area. Besides, the cutout of fixed subscriber's IP cables, which were depended on electricity, caused that during the disaster a lot of people were left without telecommunications connections and without any possibility of an emergency call to 112. By the urgent assistance of forces for protection, rescue and aid were resolved up to restoration of emergency number 112 (Božičić, 2014).

As mentioned before, the assurance of electricity was the biggest problem, since the overhead power lines collapsed under the weight of wet snowfalls and sleet. The difficulties occur due to the lack of electrical generators. Therefore, the Civil Protection of the Republic of Slovenia in cooperation with the electricity distributors had made a plan of priority electricity supply. On the initiative of the Telekom Slovenija, who is the most accessible mobile service provider in Slovenia, the 36 telecommunications facilities were included at 3rd of February. In all telecommunications facilities operated by the Administration for Civil Protection and Disaster Relief and the Department of Informatics and Communications of Ministry of Defence, the supply of electrical generators, which were connected to the operators of public telecommunications services, was assured by Civil Protection. The helicopter transport of aggregates as well as fuel for aggregates was also assured to the aggravated places. The customers of Telekom Slovenia got reduced invoices for telecom services due to loss of cable network infrastructure caused by sleet. The value of reduced invoices was depended on time and type of services (Božičić, 2014).

Further, the problem occurred also in the optical communications that are performed on transmission lines mostly in lightning conductors (OPGW - Optical Power Ground Wire). In Slovenia, there are few thousands of kilometers of fiber optic connections in this technology. The main reasons were in the fiber-optic connections, which were not heated such as conductors and due to broken trees which fallen on transmission lines as well. A lot of fiber-optic connections in Slovenia are carried out by installations on train infrastructure, which was affected especially in the Notranjska area (Božičić, 2014).

Figure 24: Sleet damage at Postojna train station

Source: Foto Danilo Rozman

During the high snowfalls and sleet the mobile networks have an increase impact in communication. The speaking as well as a large part of the data transmission is moving to the mobile network. Therefore, the operation of mobile networks during natural disaster is even more important. The problem in operation occurred in more exterior points of mobile network during sleety event in February 2014, where it was provided alternative mode power supply, auxiliary systems and fast technician response.

2.4.4. Buildings

The phenomenon of sleet caused a lot of damages in forests, infrastructure and transport. In news media we find some reports of building damage during sleety event, however, as a consequences of fallen tree or fallen lattice steel power, which hit the roof of the building. However, luckily no major damages were recorded during sleety event. In Figure 25 and Figure 26, the consequences of fallen tree and lattice steel tower are shown.

Figure 25: The consequences of fallen tree in Cerknica

Source: Arcive Voluntary Fire Brigade Slivnica

Figure 26: The consequences of fallen electricity lattice steel tower

Source: Foto Nebojša Tejić

2.4.5. Forests

General Description

Slovenia belongs to the most forested countries in Europe. By the 1.184.526 ha of forests, the Slovenia is covered more than a half of its territory (forestation amounts to 58.4 %). Most Slovenian forests are located within the area of beech, fir-beech and beech-oak sites (70 %), which have a relatively high production capacity. The 71 % of forests in Slovenia are in private property and 29 % of forests are public (owned by the state or communes). Larger and undivided forest estates of state-owned forests enable good professional management (Website Slovenia Forest Service).

In addition to damage caused by insects (mainly by bark beetles), Slovenian forests have been lately (between January 30th and February 9th in 2014) endangered by snow, sleet and wind.

Vulnerability towards Snow, Sleet and Wind

The greatest damage to forests arose as early as in January 31st when at least 20.000 ha of forests were hit by snow, sleet and wind. The most severe regions were Notranjska, the southwest edge of Ljubljana Basin, Cerkljanska and Idrijska region (ACPDR, 2014). According to the Slovenian Forest Service the sleet damaged near 601.900 ha or 51 % of forest sites in various types of forests cross the country (ACPDR, 2015; Marinšek, 2015). Such natural disaster in Slovenian forests has not been observed.

Figure 27: Sleet damage to fruit trees

Source: Foto Slovenian Press Agency

It was damaged about 9.386,776 m^3 of wood mass and at least 660 ha of forest was completely damaged (ACPDR, 2014). Most damaged wood mass was in the regional unit GGO Ljubljana (about 2.4 million m^3), GGO Postojna (about 2.1 million m^3), GGO Tolmin (1.8 million m^3) and GGO Kranj (about 900,000 m^3). Among damaged trees, the third of all were coniferous tress (3.137,122 m^3) and the rest (6.178,403 m^3) were deciduous trees (Veselič et al., 2015; ACPDR, 2014). Some damages to forests are presented in

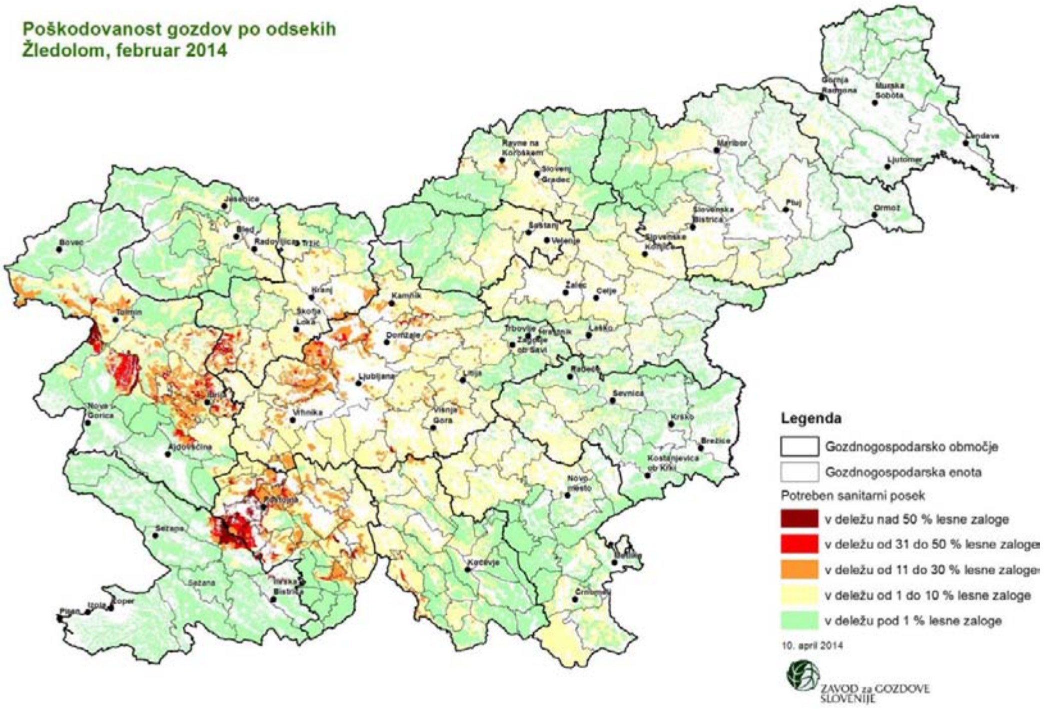
Figure 27 - Figure 28.

Figure 28: Damage to forest due to snow, sleet and wind

Source: Foto Gašper Stopar

In most of the country, the affected forests lie under 1.100 meters altitude (except in the lower parts of south-west Slovenia, to the east and the far north-east of the country, and in some places in the Spodnje Posavje) (ACPDR, 2014). The worst consequences were over the Notranjska region, particularly in the transition from sub-Mediterranean to the continental area on the southwestern edge of the Ljubljana Basin and the Cerkljansko-Idrijsko area where an altitude is between 300 and 900 meters (Veselič et al., 2015). In Figure 29 the damage to forests by segments is presented.

Figure 29: Damage to forests by segments



Source: Slovenia Forest Service, 2015

Over abovementioned areas the sleet damaged between 11 to 30 % of the forest stock (orange color) while over the most affected areas this value is risen up to 50 % or even more (red and bordo color). Over other areas the sleet damaged up to 10 % of forest stock or trees (yellow and green color). It was also blocked more than half of forest roads, however, 93 % of them were in the areas affected by sleet (6.300 km). Many of them represent the only connection between the individual farms and villages by public roads (ACPDR, 2014).

Although the forest has a lot of self-recovery capability, the consequences of sleet will be visible for a long time. The sanitation of forests will take place over several years. In 2014 it was cut 2.930,000 m^3 (3 %) of wood mass (Veselič et al., 2015), where the focus was on the large-scale of removal of damaged conifers. In the following years it can be expected the increase of insects (bark beetles) and frequent wind breakage in the reduced forests.

3. Assessing the risk of North-Rhine Westphalia and the City of Essen to wind gusts in combination with snow and sleet

For the case study area of North-Rhine Westphalia and the City of Essen a special approach was chosen in order to assess the risk to wind gusts in combination with snow and sleet. Instead of collecting historical data, one recent event, the so-called *Münsterländer Snow Chaos*, with heavy snowfall and wind gusts is analyzed. This was necessary, as Essen was never hit by a comparable event. The reference to the aforementioned event is justified by the fact that the City of Essen and the affected region are part of the same snow zone (see

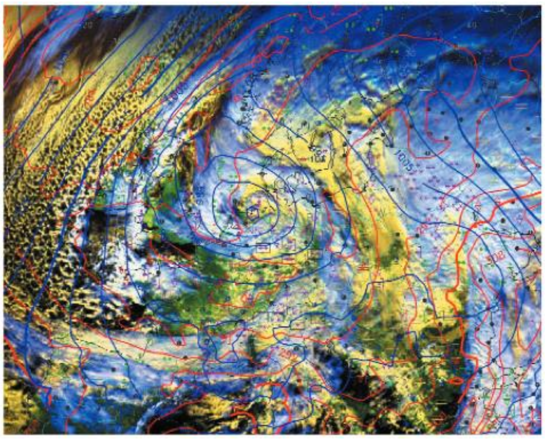
Figure 35). Subsequently the consequences of the *Münsterländer Snow Chaos* are qualitatively transferred to the City of Essen, assuming the same hazard magnitude but a different vulnerability. Therefore this assessment of risks regarding wind gusts in combination with snow and sleet has a qualitative scenario character.

This chapter is structured as follows: in the first subchapter the historical snow event is described and the affected area called *Münsterland* – a rural region of North-Rhine Westphalia – is introduced (see chapter 3.1). Furthermore hazard parameters are described in this subchapter. In the second subchapter the vulnerability of the *Münsterland* towards storm in combination with snow and sleet is analyzed in five vulnerability parameters: people, transport, infrastructure, buildings and forests (see chapter 3.2). The last subchapter transfers the findings of 3.1 and 3.2 to the City of Essen, assuming the consequences of the same hazardous event in the surroundings of the vulnerability of a densely populated urban area (see chapter 1.3).

3.1. Hazard Parameters – Meteorological Description of the *Münsterländer Snow Chaos*

During the 24th and 27th November 2005 intense and heavy snowfalls occurred in large areas of North -Rhine Westphalia, widely combined with wind gusts of intensity category 8 Beaufort (squalls, circa 65km/h). Especially in northern North Rhine Westphalia, in the *Münsterland*, the amount of fresh snow was 15 cm in 12 hours. The trigger for these intense and heavy snowfalls was the occlusion of a depression (“Thorsten”), which built up on the 23rd over the North Sea. Strongly intensified by wet air when arriving Western Europe, the depression rested at the Dutch shore for a period of four days (24th-27th November) and led to damages in wide areas of Western Europe. (Cf. Deutschländer, Wichura 2005: 163)

Figure 30: Satellite Image of Western Europe with ground pressure grid during depression “Thorsten”



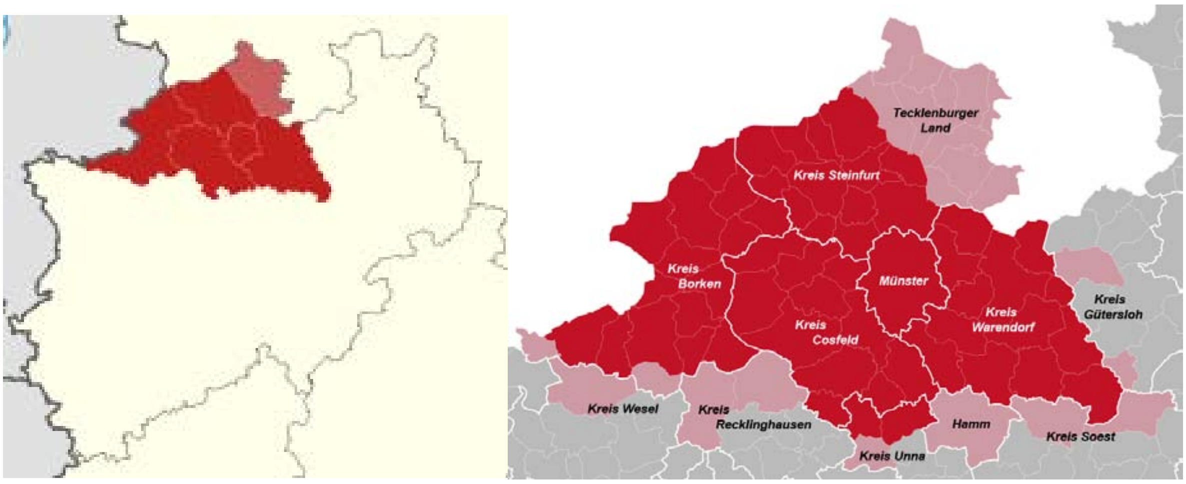
Source: Deutschländer, Wichura 2005: 163

The German Meteorological Service states that the snowfall in the *Münsterland* was unusually heavy, especially on the 25th November 2005. Solely regarding the amount of fresh snow, the probability of occurrence was estimated to about 40 till 70 years for an average of ten different weather stations in the *Münsterland*. (Cf. Deutschländer, Wichura 2005: 167)
In combination with the highly adverse temperature and gusty wind circumstances, the probability of occurrence most likely further decreases. Nevertheless, the *Münsterländer Snow Chaos* is a warning example, which could possibly occur anywhere in Western Germany, also in the densely populated, urbanized Ruhr Area Essen is part of.

The heavy snowfalls and strong wind gusts in November 2005 occurred in large areas of Western Europe and especially North-Rhine Westphalia. In the two northern counties of the *Münsterland* (*Kreis Steinfurt* and *Kreis Borken*) massive damages arose when about 50 electricity pylons (transmission towers) collapsed under the weight of snow and ice. These damages in the *Münsterland* gave the events its name – *Münsterländer Snow Chaos*. (Cf. Deutschländer, Wichura 2005: 163)

However, the North-Rhine Westphalian region *Münsterland* is rather a historical, political, societal and nature related distinction than an administrative one. Nevertheless, it consists of four counties (*Kreis Borken, Kreis Steinfurt, Kreis Coesfeld, Kreis Warendorf*) and the independent City of *Münster* (see Figure 31, dark red highlighting). In this chapter, the *Münsterland* is defined following these four counties around the City of *Münster*. In this area live 1.59 million of 17.5 million inhabitants of North-Rhine Westphalia. (Cf. Bezirksregierung Münster 2014: 1)

Figure 31: Map of North Rhine Westphalia's region *Münsterland*



Source: Website Wikipedia Münsterland

3.2. Vulnerability Parameters – Damages to population, transport, infrastructure, buildings and forests

3.2.1. Population

General Description

In 2005, the year of the *Münsterländer Snow Chaos*, the county *Borken* accounted about 370,000 inhabitants and the county *Steinfurt* about 444,000. (Cf. Website Regionalstatistik Genesis Online 2015). Accordingly about 800,000 people were exposed to the heavy snowfalls and gusty winds during the *Snow Chaos*. Table 6: Population by Age in Counties *Borken* and *Steinfurt* (2005)Table 6 shows the total and percentage population by age classes. It can be seen that in both districts more than half of the exposed population were adults (18 years till less than 60 years of age). By implication a little less than half of the population were either children (below legal age, <18 years) or elderly people (> 60 years). Assuming that especially younger and older people are more vulnerable as they might not be able to live autonomously, the vulnerability parameter population is quite afflicted.

Table 6: Population by Age in Counties *Borken* and *Steinfurt* (2005)

Age	County Borken			County Steinfurt		
	Total	%		Total	%	
<3 years	11,117	3.01	Below legal age (<18 years)	12,585	2.83	Below legal age (<18 years)
3 till under 6 years	12,425	3.37		14,532	3.27	
6 till <10 years	18,909	5.12		21,973	4.95	
10 till <15 years	25,423	6.89		28,874	6.50	
15 till <18 years	15,783	4.28	**22.66**	17,970	4.05	**21.60**
18 till <20 years	10,014	2.71	Adults (18 till <60 years)	11,740	2.64	Adults (18 till <60 years)
20 till <25 years	22,065	5.98		25,390	5.72	
25 till <30 years	20,525	5.56		23,228	5.23	
30 till <35 years	22,513	6.10		26,442	5.95	
35 till <40 years	31,609	8.56		38,036	8.56	
40 till <45 years	32,491	8.80		39,874	8.98	
45 till <50 years	27,622	7.48	**56.60**	33,682	7.58	**56.30**
50 till <55 years	23,011	6.23		27,999	6.30	
55 till <60 years	19,064	5.16		23,694	5.33	
60 till <65 years	16,182	4.38	Elderly (>60 years)	20,768	4.68	Elderly (>60 years)
65 till <75 years	36,114	9.78		45,420	10.22	
75 years or more	24,245	6.57	**20.74**	32,024	7.21	**22.11**
TOTAL	**369,112**	**100**		**444,231**	**100**	

Source: Regionalstatistik Genesis Online 2015

Vulnerability towards Snow, Sleet and Wind

The greatest damage to the population arose when about 50 electricity pylons (transmission towers) collapsed under the weight of snow and ice. The consequence was that about 98% of the households did not have electricity for at least one day and about 250,000 people had to live without electricity for up to four days. As indirect consequences of the blackout, electric heating, water boiling and cooking of hot meals was impossible. Less than 50 percent of the households were able to use other heating resources such as wood, gas or oil.

One housing area was evacuated due to the instability of a nearby electricity pylon. Most of the population had groceries stored at home for more than one day, as the *Snow Chaos* occurred on a weekend. Nevertheless a shortage of especially needed goods, such as candles, bread and batteries emerged. (Cf. Gardemann, Menski 2008: 1, 27, 43ff., 52)

Due to heavy snowfalls, mobility was strongly restricted. A lot of traffic accidents happened and only about half of the population was able to get to their workplaces. This might also be one reason why more than 95 percent of the affected population stayed in the Münsterland and only few moved to friends and relatives elsewhere. Even though many people commented in a survey that the possibility of grocery shopping was not endangered, especially elderly people needed to receive emergency care e.g. by the supply of food and blankets. (Cf. Gardemann, Menski 2008: 1, 27, 44, 61)

In some parts of the Münsterland disaster alert was exclaimed (cf. Deutschländer, Wichura 2005: 163). An action committee was set up and disaster management institutions were installed. In order to inform the population, e.g. about first aid care, loudspeaker vans patrolled through the housing areas. Nevertheless, due to the continuing heavy snowfalls some outer districts could not be reached with the loudspeaker vans and therefore stayed uninformed. (Cf. Gardemann, Menski 2008: 54, 70)

In general blackouts are also critical for secondary parameters, closely related to the vulnerability parameter population, such as the healthcare sector and the grocery, agriculture and farming sectors. E.g. nearly every medical and pharmaceutical facility is dependent on energy and although most have emergency generators, a long-lasting lack of energy supply can endanger the medical and pharmaceutical supply. The grocery sector is also highly dependent on energy supply and especially fresh food is less durable without cooling. This also applies for agriculture and farming, two predominant economic sectors in the *Münsterland.* Without energy supply e.g. milking or feeding machines cannot operate. (Cf. Bradke et al. 2011: 16ff.) However, luckily no major interferences were recorded in these sectors during the *Münsterländer Snow Chaos* in 2005.

3.2.2. Transport

General Description

The *Münsterland* is a rural region in North-Rhine Westphalia. The population density amounts 267.4 inhabitants per square kilometer, which is distinctly below the average of the federal state North-Rhine Westphalia (526.1 inhabitants/sqm), but quite a lot in comparison with other rural areas in German and abroad. The traffic area amounts 5.8% in the county *Borken* and 6.1% in *Steinfurt.* Both are again below North-Rhine Westphalian average (7.1%). (Cf. IT.NRW 2013)

The *Münsterland* has some transport axis (both road and rail) of regional, national and even European importance. One main north-south transport axis in the *Münsterland* connects the Ruhr Area with the North Sea coast and one of Germany's economic centers – the City of Hamburg. An east-west axis connects Amsterdam and Berlin. Furthermore, the regional airport *Münster-Osnabrück*, located in the county *Steinfurt*, secures national and international transport connections. (Cf. Bezirksregierung Münster 2014: 1)

Vulnerability towards Snow, Sleet and Wind

Likely consequences of heavy snowfalls in combination with gusty winds for the parameter transport are:

- failure of any electrically operating elements within the transport system, e.g. transport signals such as traffic lights,
- constraints in running transport vehicles (public and economic transport) and
- steering/organizing the transport systems.
- effects on agriculture (milk and egg production as well as pig fattening are depended from power supply)

Concernment rises as soon as more than one transport system is affected. If all transport systems collapse, locomotion is highly restricted or even impossible. (Cf. Bradke et al. 2011: 12)

During the *Münsterländer Snow Chaos*, especially the 25th November 2005, road and rail traffic were enormously restricted. Many traffic accidents occurred and lead to casualties and there were traffic congestions that impeded emergency services (cf. Engel et al. 2005: 1; Gardemann, Menski 2008: 26).

3.2.3. Infrastructure

General Description

The vulnerability parameter infrastructure comprises energy supply infrastructure and communication infrastructure. Both are not presentable as generally wished for in an exposition analysis because information on energy supply lines, electricity pylons, transformer stations as well as communication possibilities (internet, landline, mobile, postal, personal, etc.) are not publicly available. Therefore it can only be assumed that every kind of outdoors infrastructure (especially electrical overhead lines, telephone landlines and radio masts) is potentially exposed to heavy snowfalls in combination with strong wind gusts.

Vulnerability towards Snow, Sleet and Wind

During the *Münsterländer Snow Chaos* especially electricity pylons and electricity landlines were affected by the combination of heavy snowfalls and strong wind gusts. The reason was an unusual combination of wet snow, temperatures around freezing point and gusty winds. The heavy snowfalls led to a wet and therefore heavy aggregation of snow and ice on top of the landlines and electricity pylons, which raised the wind pressure. One possible explanation for the collapse of the pylons is that strong asymmetric forces in combination with old material led to the break down. (Cf. Engel et al. 2005: 1; Website Deutscher Wetterdienst 2015) Experts estimated from photographs that about 15mm icy snow deposited on the landlines, which gives a load of 51.1 N/m. This load is exceeding the given technical standard (DIN[1] measures for landlines), which amount to 14 N/m maximum (Cf. Deutschländer, Wichura 2005: 165)

[1] Standardized measure, determindes by the German Institute for Standardization (*Deutsches Institut für Normung, DIN)*

Figure 32: Collapse of electricity pylons during the *Münsterländer Snow Chaos*

Source: Website FOCUS 2015

Figure 33: Amount of icy snow on the landlines during the *Münsterländer Snow Chaos*

Source: Wichura 2015: 56

Because of the combination of heavy (wet) snowfalls and gusty winds about 50 electricity pylons collapsed in the counties *Borken* and *Steinfurt*. The collapses lead to a blackout in large areas of the *Münsterland* that lasted up to four days. (Cf. Deutschländer, Wichura 2005: 163)
As an intermediate action, emergency generators generated backup electricity. Subsequently to the event the complete energy supply was rebuilt. (Cf. Gardemann, Menski 2008: 26).

In general every long lasting blackout has massive impact on information technology and telecommunication. It is assumed that communication systems fail within a few days. Especially landline telephone connections are endangered, not at least because of the terminal devices in the households that are dependent on continuous energy supply. For the mobile telephone connection great instabilities occur when the base stations are without energy supply. Also too many users trying to dial in at the same time can overload the mobile network and lead to a breakdown.

Another aspect is that also public service broadcasting cannot be received in case of a blackout. Therefore the main information platform is the radio, which often can be used with batteries. (Cf. Bradtke et al. 2011: 9f.)

During the *Münsterländer Snow Chaos* more than 65% of the people affected had at least one possibility to communicate (either landline or mobile). Solely the Internet connection broke down completely but especially mobile and landline telephone connection remained possible. One major problem that arose from the breakdown of the Internet was that the major disaster information platform (*German Emergency Planning and Information System (deNIS)*), could neither be used by the population nor by the emergency response units.
As mentioned before, loudspeaker vans were used in order to inform the broad population about emergency stations and behavioral precaution measures. (Cf. Gardenmann, Menski 2008: 27, 46, 54, 70)

3.2.4. Buildings

General Description

In the *Münsterland* there are about 682,508 buildings (reference date 31.12.2011) with an average of 2.3 persons per apartment. Therewith 7.9% of all buildings in North-Rhine Westphalia are located in the *Münsterland.* The following table shows specific data for the counties *Borken* and *Steinfurt*. (Cf. Bezirksregierung Münsterland 2014: A62f.)

Table 7: Buildings in the counties *Borken* and *Steinfurt*

	Total Number of Buildings	Residential Buildings		Non-residential Buidlings	Persons per Apartment	Building Development 2008 – 2011
		Detached and Duplex Houses	Apartment Building			
Kreis Borken	148,264	Ca. 73%	Ca. 25%	Ca. 2%	2,5 (average)	+ 2.0%
Kreis Steinfurt	184,191	Ca. 72%	Ca. 26%	Ca. 2%	2,4 (average)	+ 1.9%

Source: Regierungsbezirk Münster 2014: A62f.

Since 1991 there is the European Norm DIN EN 1991-1 (also titled Eurocode 1), regulating the actions on structures by different loads, e.g. wind loads or snow loads.
In Germany DIN EN 1991-1 was elaborated into DIN 1055, regularly revised in cooperation with the German Meteorological Service. This norm is especially valuable for the vulnerability parameter buildings, as the norm specifies for each type of building how the roof has to be constructed in order to withstand a certain amount of wind snow and ice. In the following it is therefore used to describe the vulnerability of the *Münsterland* towards snow and wind loads.

Vulnerability towards Snow, Sleet and Wind

According to DIN 1055-4 there are four wind zones in Germany, ranking from zone one (inland regions with low velocity pressure on buildings) to zone four (mainly coast regions and islands with high velocity pressure on building). Table 8 contains the four German wind zones and their maximum velocity pressure in kN/m^2 for different building heights.

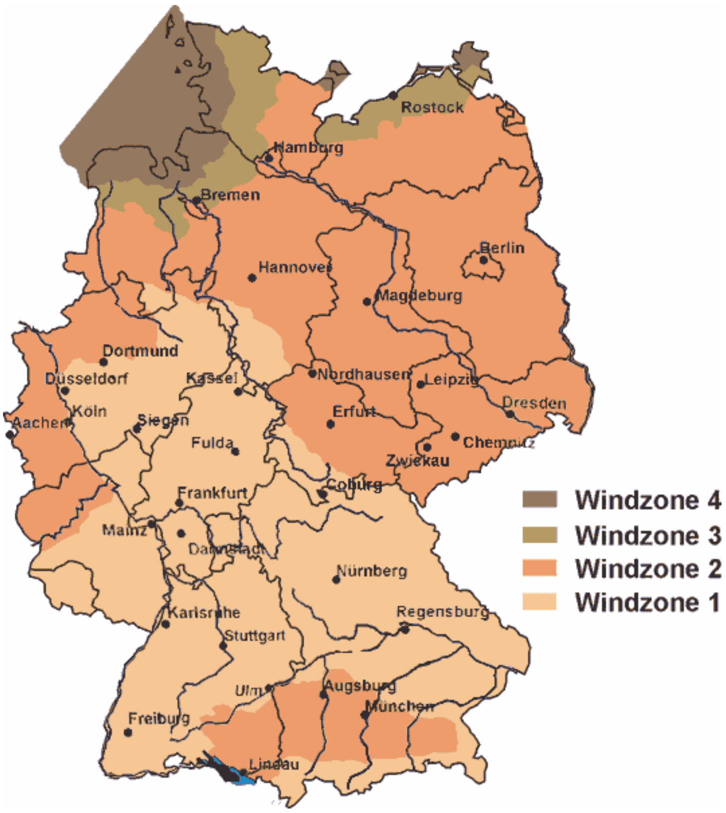
Table 8: Wind Zones according to Wind Load Norm (DIN 1055-4)

Wind Zones		Velocity Pressure in kN/m^2 at a building height *h** in the borders of:		
		$h \leq 10$m	10m < $h \leq$ 18m	18m < $h \leq$ 25m
1	Inland	0.5	0.65	0.75
2	Inland	0.65	0.8	0.9
	Coast/Shore and Islands in the Baltic Sea	0.85	1.	1.10
3	Inland	0.8	0.95	1.10
	Coast/Shore and Island in the Baltic Sear	1.05	1.20	1.30
4	Inland	0.95	1.15	1.30
	Coast/Shore of the North Sea and Baltic Sea and Island in the Baltic Sea	1.25	1.40	1.55
	Island in the North Sear	1.40	-	-

**h = height of the building*
Source: Eurocode 1: Einwirkungen auf Tragwerke – Teil a-4: Allgemeine Einwirkungen – Windlasten; Deutsche Fassung. EN 1991-1-4:2005 + A1: 2010 + AC:2010

These four wind zones apply to Germany as Figure 34 shows.

Figure 34: Wind Zones in Germany according to DIN 1055-4

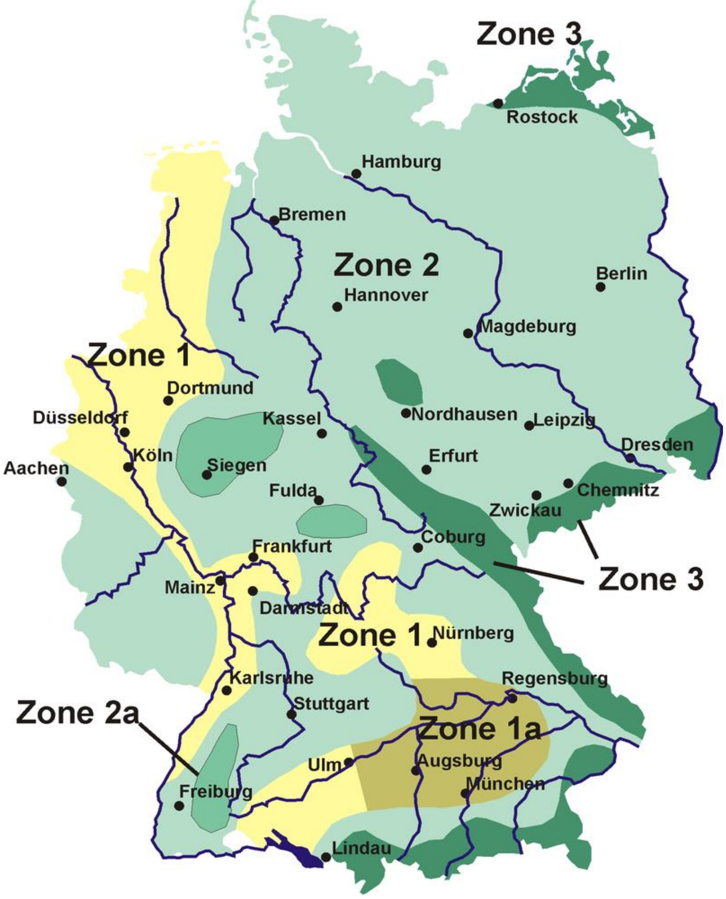


Source: Eurocode 1

As can be seen in figure 5, the *Münsterland* and the two highly affected counties *Borken* and *Steinfurt* associate with wind zone 2 (inland). Buildings in this wind zone are therefore built to withstand roof velocity pressures of 0.65 kN/m^2 if they are less than 10 meters high, 0.8 kN/m^2 up to 18 meters height and 0.9 kN/m^2 for buildings up to 25 meters height.

Eurocode 1 also contains snow zones, transferred to German DIN 1055-3. Basically the construction norms are oriented along the expectable amount of fresh snow (snow load in kg/m^2) in different regions for the probability of occurrence of once in 50 years. (Cf. Deutschländer, Wichura 2005: 164). Figure 35 shows the snow zones in Germany.

Figure 35: Snow Zones in Germany according to DIN 1055-3



Source: DIN EN 1991-1-1-3/NA: 2010-12

For the *Münsterland* the maximum amount of snow load is 50 kilograms per square meter roof. During the *Münsterländer Snow Chaos* snow loads of 30 till 50 kilograms per square meter were measured. (Cf. Deutschländer, Wichura 2005: 164)
The reason that no damages occurred to buildings most likely therefore is that the snow amount of the *Münsterländer Snow Chaos* were within the DIN norm 1055-3.

3.2.5. Forests

General Description

Forests make up 14.9% or 88,600 hectares of the total area of the *Münsterland*. More than 85% of the forests have private owners, only about 10% belong to either the federal state North-Rhine Westphalia or to the German Federal Republic. Two-thirds of the trees in the forests of the *Münsterland* are deciduous trees. With about one quarter of all trees, oak trees are the predominant species. (Cf. Website Forst und Holz NRW)

Vulnerability towards Snow, Sleet and Wind

In general trees are quite resistant to snow during the winter, as deciduous trees cast their leaves during autumn. Still very wet snow is heavier than dry snow and also the strong wind gusts facilitated that the snow attached to the trees.

Nevertheless, there was no remarkable damage to forests due to the *Münsterländer Snow Chaos*.

3.3. Vulnerability Scenario – Snow Chaos in the urban Ruhr Area

In the following the same hazardous event as for the *Münsterländer Snow Chaos* (see chapter 3.1) is applied to the vulnerability of the Ruhr Area, especially the City of Essen. This approach is appropriate because "[w]eather conditions, which lead to such heavy snow and ice deposition, are very rare in Germany. But, according to the DWD, they possibly can occur in any region in Germany" (Public Relations Department of the German Meteorological Service: 1; own translation).

Vulnerability of the Parameter Population towards Snow, Sleet and Wind

For estimating and comparing the vulnerability of the population, there are three basic but important indicators to analyze: the total number of inhabitants in the affected area, the population density and the age groups of the inhabitants.

In total the City of Essen has less inhabitants than the counties *Borken* and *Steinfurt* (about 581,000 in Essen; 800,000 in *Borken* + *Steinfurt*). Nevertheless it may not be concluded that in case of the same hazardous event occurring in the Ruhr Area less people would be affected. The reason is that during the *Münsterländer Snow Chaos* an area of 3,210 sqm (the area of the counties *Borken* and *Steinfurt*) was affected. However, Essen has an area of 210,4 sqm – so exactly 3,000 sqm less than *Borken* and *Steinfurt*. In fact, a more suitable comparison would be to contrast *Borken* and *Steinfurt* to the whole Ruhr Area (about 4,400 sqm). In this case more than 5 million inhabitants would be affected in case of the same event. (Cf. Website Wikipedia Ruhrgebiet)

The same fact becomes apparent when comparing the population density of the areas. While in the counties of the *Münsterland* the population density amounts 267.4 persons per square kilometer, the population density in Essen accounts for 2,762 persons per square kilometer, which is about 10 times more people per square kilometer.

- It can be concluded that up to 5 million people could possibly be affected if the *Münsterländer Snow Chaos* would occur in the densely populated Ruhr Area.

The third indicator when estimating the vulnerability of the population of Essen is a comparison of the age groups, when assuming that both young and old people are more dependent on help. Table 9 shows the percentage of persons below legal age, of adults and of elderly people.

Table 9: Comparison of Age Groups in *Borken* + *Steinfurt* and Essen

	Counties *Borken* and *Steinfurt* (average)	City of Essen
persons below legal age (<18 years) in %	**22.13**	**15.1**
adults (18 till <60 years) in %	**56.45**	**56.9**
elderly (>60 years) in %	**21.43**	**28.0**

Source: own depiction following Regionalstatistik Genesis Online 2015 and Stadt Essen 2015: 4.

- It can be seen that Essen has less under-age people but more elderly, so it may be concluded that the vulnerability regarding the population groups is quite similar between Essen and the counties of the *Münsterland*.

- Generally it needs to be stated that the vulnerability of the population also depends on their state of preparedness; if a snow chaos e.g. occurs on the weekend, people usually have enough groceries to cook food for a couple of days.

Vulnerability of the Parameter Transport towards Snow, Sleet and Wind

For estimating the vulnerability in the parameter transport it is important to examine the traffic area potentially affected and to investigate the presence and relevance of certain transport axis.

As outlined in chapter 1.2 the traffic area of the county *Borken* amounts 5.8% (82.24 sqm) and the one of *Steinfurt* 6.1% (109.31 sqm). Both percentages are below North-Rhine Westphalian average (7.1%). However, Essen as a strongly urbanized city has a high percentage of traffic area (13.9%) but in total ‘only’ covering 29,19 square kilometers. (Cf. IT.NRW 2013)

- As in Essen the total square kilometers of traffic area are distinctly lower than in the *Münsterland* it may be stated that direct damages to roads, railways and other traffic areas are therefore potentially lower.

Nevertheless also the relevance of the traffic area of a city needs to be estimated in order to give a final statement on its vulnerability.

Essen is integrated into a dense network of motorways and a-roads, connecting the Ruhr Area with all other parts of Germany and also many regions in Europe. Traffic-wise the city is of great importance having 4 different motorways (A40, A42, A44, A52) and 3 a-roads (B224, B227, B231) that ensure both a north-south as well as east-west connection. Furthermore the central train station of Essen ensures international transport connections and also secures well-connected regional and local public transport. The overhead contact lines of the railway system are quite vulnerable to snow and ice load. The same is a truth for the contact lines of many subway lines and trams that operative partly above the surface.
Also the connection of Essen to the Düsseldorf International Airport is very good, both by car and train. Last but not least the cities Essen and Mülheim share a regional airport and because of the Rhein-Herne-Kanal (a canal in the north of the city) also ship traffic is ensured. (Cf. Website metropoleruhr)

Figure 36: Transport Axis in Essen

** the grey circle roughly encircles the Ruhr Area*

Source: Website MyGeo, own addition

As outlined above, Essen is an important axis for public and private transport. Therefore the first statement can be complemented as follows:

- But as Essen's transport infrastructure is of greater relevance for the regional, national and international public and private transport, indirect damages (e.g. breakdown of the logistics system) can be assumed to be many times higher.

Generally it needs to be stated that the vulnerability of the transport system also depends on the users; if e.g. a snow chaos occurs on the weekend, people usually do not need to rely on public or private transport as most do not need to get to their work places.

Vulnerability of the Parameter Infrastructure towards Snow, Sleet and Wind

The estimation of the vulnerability of the parameter infrastructure is difficult as it can only generally be assumed that every kind of outdoors infrastructure is potentially exposed to snow, sleet and wind.

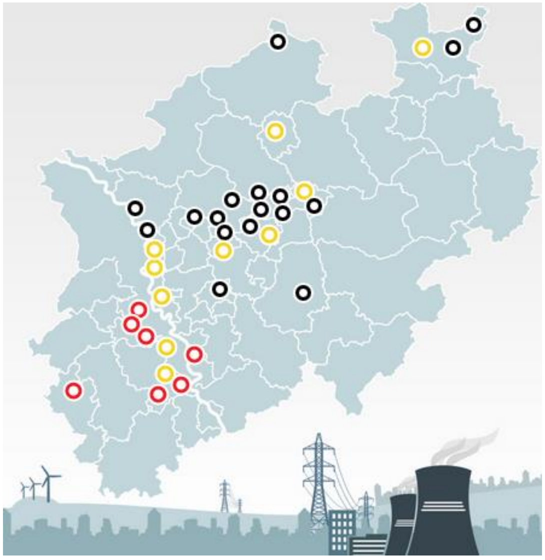
As constituted in chapter 3.2.3, both energy supply infrastructure and telecommunication infrastructure are investigated in this parameter.

Regarding the energy supply infrastructure it can be stated that there are less outdoors infrastructures (e.g. energy supply lines, electricity pylons, transformer stations) in Essen than in the *Münsterland*.

This circumstance on the one hand evolves from the city's integration into the Ruhr Area and a more regional energy generation and distribution. For example there is no power plant on the area of Essen but several in other cities around Essen (see Figure 37).

On the other hand the circumstance of less outdoors energy supply infrastructure bases on the high urbanization degree of Essen and the fact that energy supply lines are run underground (buried cables).

Figure 37: Power Plants in North-Rhine Westphalia



Source: Website derwesten 2015

Regarding communication infrastructures it may be an advantage that the population density in Essen is higher than in the *Münsterland* so that in a case of emergency inhabitants live closer together and at least a personal communication possibility is given, even if all electronic communication ways might break down.
In general it can be assumed that the vulnerability of communication infrastructure in Essen is similar to the vulnerability in the *Münsterland.*

- Therefore it is of prior necessity that there are disaster information platforms other than those in the Internet (e.g. *German Emergency Planning and Information System (deNIS)*). This is relevant for both the affected population as well as for the emergency response units.

Vulnerability of the Parameter Buildings towards Snow, Sleet and Wind

Going along with the strongly urbanized character of Essen there also are many buildings, each potentially vulnerable towards snow, sleet and storm. As outlined in chapter 3.2.4 the wind and snow zones of German DIN 1055 are a valuable basis for the assessment of the vulnerability.

While the counties *Borken* and *Steinfurt* in the *Münsterland* are in wind zone 2, the City of Essen is located in wind zone 1. In detail this means that roofs of buildings in Essen are required to withstand a velocity pressure of 0.5 kN/m^2 up to a height of 10 meters, a velocity pressure of 0.65 kN/m^2 up to a height of 18 meters and a velocity pressure of 0.75 kN/m^2 up to a height of 25 meters.

- Regarding the snow zones, Essen is, as well as *Borken* and *Steinfurt*, located in snow zone 1. If assuming the same hazardous event as in the *Münsterland* in 2005, the snow load therefore is within the buildings norms of Essen's buildings so that there are no damages expected.

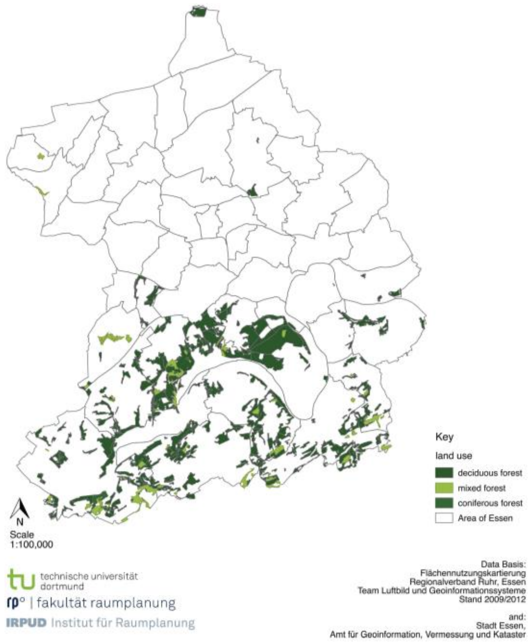
Vulnerability of the Parameter Forest towards Snow, Sleet and Wind

In average 21% of the Ruhr Area is covered with forest (cf. Website Wald Ruhrgebiet). This statement of course needs to be specified because the densely populated and sealed city centers need to be distinguished from the periphery.

In Essen (non-dissected) forests are almost exclusively located in the southern city districts, as Figure 38shows. Similar to the *Münsterland* also in the Ruhr Area the majority of trees are deciduous trees (73%) (cf. Website Wald Ruhrgebiet). This circumstance is an advantage regarding the vulnerability towards snow and sleet as the trees do not have leaves in the winter and therefore the snow load weighs less.

- Therefore the vulnerability of forests towards snow and sleet in combination with wind can be stated as low.

Figure 38: Forests in Essen



4. Conclusions

A detailed assessment of the risk/vulnerability to high wind and high wind gusts in combination with snow and sleet for Germany and Slovenia is presented. Since there is no occurrence of snow and sleet in Croatia (Central Dalmatia area), this report only focusses on two of three partner countries.

The extensive assessment of risk of areas to high winds in combination with snow and sleet is based on acquired existing data and reports from local, regional and national agencies and responsible institutions. The vulnerability towards snow, sleet and winds is assessed in five major aspects: population, infrastructure, transport, buildings and forests. The main focus is on damage to infrastructure and therefore communication, transport and power shortage as well as to forests and buildings. Consequently, the effect of high winds in combination with snow and sleet to population is also assessed.

The report comprises a description of two recent events that separately happened in Slovenia and Germany and their consequences. In February 2014 the worst sleety event in living memory occurred in a great part of the Slovenia. Therefore, the first case study was focused on Ajdovščina Municipality and City of Ljubljana and on the area in Postojna as well. It was damaged a lot infrastructure facilities, forests, and buildings; due to road closures, the mobility was strongly districted.

The second case study was North-Rhine Westphalia area in Germany. The event so-called *Münsterländer Snow Chaos*, with heavy snowfall and wind gusts happened in the end of November 2005 and caused a lot of damages to considered aspect. The same hazardous event as for the *Münsterländer Snow Chaos was* applied to the vulnerability of the Ruhr Area, especially the City of Essen.

The report also presents that it was really difficult to gathered data of sleet phenomenon, because taking some description of them is a decision of the observer. Therefore, it became apparent that there are no systematic measurements for sleet in both of Wind Risk Prevention Project partner countries. The Wind Risk Prevention Project therefore concludes that there is need for further research activities on sleet measurements. The partners suggest more accurate measurements of sleet and snow. The systematic measurements could improve the sleet zones in standard which would allow more accurate input data, particularly when designing overhead transmission lines.

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WIND RISK

Task C – Risk/Vulnerability assessment

Action C.5: Wind Risk legislation

For the Wind Risk prevention project

University of Ljubljana
Technical University of Dortmund
University of Split
Municipality of Ajdovščina

Chapter C.5 – Wind Risk Legislation

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1. Introduction

Wind Risk project deals with the protection of population, infrastructure, transit, buildings and forests in terms of wind hazard. The project aims are directed towards the proposition of new measures and innovative solutions for the minimization of damages related to the wind hazard.

Before assessment of legislation it is important to define terms used in this document: hazard, vulnerability, risk and disasters. According to the definition proposed by Thomas E. Downing, **hazard** is associated with potential threat to humans and their welfare. In the scope of wind risk project, wind hazard is used to express the possible harmful effect of wind to people, infrastructure, buildings and natural environment. Wind hazard can be classified as a natural hazard, and even more specifically atmospheric hazard. Natural hazards and natural disasters can be divided into several categories:

- Geologic hazards:
  - earthquakes
  - volcanic eruptions
  - tsunami
  - landslides
  - floods
  - subsidence
  - impacts with space objects
- Atmospheric hazards (mainly caused by processes operating in the atmosphere):
  - tropical cyclones
  - tornadoes
  - droughts
  - severe thunderstorms
  - lightning
- Other natural hazards (hazards that may occur naturally, but don't fall into either of the categories above):
  - insect infestations
  - disease epidemics
  - wildfires

Vulnerability is associated with potential damages and loss. Wind vulnerability describes possibility of negative consequences in case of high wind event due to the current state of affairs in the area. **Risk** is a term used for describing a combination of hazard and vulnerability, and depicts probability of high losses when hazardous event happens. Wind risk term depicts both – probability of meteorological hazard of high wind and vulnerability of the area where the hazard takes place. **Disaster** is used for describing realization of risk.

Figure 1. Basic definitions of hazard, vulnerability, risk and disaster

Hazard	**:**	**potential threat to humans and their welfare**
+		
vulnerability	**:**	**exposure and susceptibility to losses**
=		
risk	**:**	**probability of hazard occurrence**
disaster	**:**	**realization of a risk**

By following these definitions we can define **wind risk** as a probability of occurrence of atmospheric movement - wind - that will result in damages. According to this definition wind risk consists of two parts – one is the occurrence of high wind or hazard, and the other is vulnerability.

Hazard potential is influenced by meteorological conditions. Occurrence of wind is caused by complex atmospheric movements and cannot easily be influenced in a way to lower the probability of occurrence of high winds. Particularly all predictions of future climate change predict increase of wind speed and frequency in the future. Future wind conditions are discussed in previous wind risk project report (C1).

Vulnerability of area with respect to the wind hazard depends on many aspects of the area. Vulnerability can be discussed in term of vulnerability of people and living beings lives, vulnerability of natural environment (such as forests, beaches, landscapes...), vulnerability of buildings, infrastructure and properties that belong to people. Vulnerability of areas covered with wind risk project is discussed in project report C2.

The main method for dealing with wind risk is by reducing vulnerability of the area.

Legislation of wind risk mostly deals with prescribing implementation of preventive measures that should reduce vulnerability of high wind. These laws are prescribed for protection of people, nature and property in case of high wind. In this document we will review and cross compare the legislation of partner countries in terms of protection against high average wind and high wind gusts in the scope of protection of population, infrastructure, transit, buildings and forests.

A brief review of known practices in the rest of the world, other than European Union countries, will be assessed. All partner countries are members of European Union so, in the first part of the document, common European legislation will be presented. Following chapters will review national laws, national annexes and specifications.

The presentation of legislation will follow the structure of endangered aspects due to the high wind as accepted in other Wind Risk project reports. The structure of the presentation will consist of legislation aiming to protect:

- population,
- infrastructure,
- transport,
- buildings,
- forests.

All partner countries of the Wind risk project are members of European Union and all countries adopt the European legislation that can be extended with National Annexes.

For each of the endangered aspects (population, infrastructure, transit, buildings and forests) we will consider legislation of activities that are performed:

- before the wind – planning and alarming,
- during the wind – protection and rescuing,
- after the wind – restoration of damage.

2. Wind risk prevention measures

Wind and storms are threat to many areas, and most countries have adopted laws, policies and measures for mitigation of wind risk. The legislation of countries ranges from policies and procedures to detailed plans.

The measures for wind risk mitigation used are (windstorm impact reduction implementation plan USA):

- understanding, predicting and forecasting wind events;
- assessing the impact of wind hazard;
- reducing the impact of wind hazard;
- enhancing community resilience.

2.1. Understanding, predicting and forecasting wind events

Most important aspect of wind risk prevention is research of wind events. By understanding the cause and development of wind, more effective prediction system can be implemented. Many countries have a special agency responsible for measuring, forecasting and predicting wind (or other meteorological) hazards. These agencies have a responsibility of alarming responsible organizations, i.e. civil protection in case of the high wind.

Besides measurement and forecasting, research of causes, development and behaviour of wind is recognized as research area of many scientists from different areas (physics, computer science and engineering).

2.2. Assessing the impact of wind hazard

The impact of wind hazard should be done immediately after the event, or important data could be lost. Assessing the social and economic costs of the wind hazard is discussed in report C6. Assessing the damage on buildings and infrastructure is done by measurement using sophisticated equipment. Forest owners are responsible for assessing the damages in forests, but in the case of state owned forests the task is usually delegated to forest managing companies.

2.3. Reducing the impact of wind hazard

Reducing the impact of wind risk is done with warning systems, evacuation planning and building technology.

Warning systems rely on forecasting and predicting hazardous events. Evacuation plans are part of protection and rescue plans that are usually delivered by local and regional government units. Building technology is directed by urban plans and building norms.

In order to reduce the impact of wind hazard we have to change or enhance existing building practices, infrastructure resilience, social behaviour patterns and evacuation processes.

2.4. Enhancing community resilience

Preparation for potential wind risk is a key method for the enhancement of resilience. Local and regional government units usually deliver periodically (every 2 or 4 years) protection and rescue plans on the basis of vulnerability assessment of the local area. Protection and emergency plans should include detail procedures what to do and where to go if a warning is received or a hazard is observed. Community resilience should be improved with informational and educational materials on protection of individuals and property in high wind events, including hurricanes, tornadoes and straight line winds from thunderstorms. Social science research should include social vulnerability analysis as well as organizational and community emergency preparedness and response.

3. Croatian legislation

These parts of the report will overview the legislation currently active in Croatia. The report covers both European legislation, as well as national legislation.

3.1. Population

Each unit of local and regional government (County, Municipality) is legally obligated to adopt two strategic documents: Risk assessment and Protection and rescue plan. In these documents all causes of hazards are defined and measures for the prevention and mitigation of consequences are proposed.

Natural hazard causes in Split and Dalmatia County associated with extreme weather conditions include drought, heat wave, hail, storm and hurricane storm, snowfall and others. The weather conditions are pronounced extreme when average values of strength, intensity or consequences are exceeded.

Official agency responsible for wind (and other meteorological parameters) measurement, forecasts and alarms in case of a prediction of hazardous event in Croatia is Meteorological and Hydrological Service (*Croatian: Državni hidrometeorološki zavod - DHMZ*).

According to law, DHMZ is responsible for alarming county center 112 which is a part of National protection and rescue directorate (*Croatian: Državna uprava za zaštitu I spašavanje* - DUZS), about forecasting possible hazardous weather including rain, storm, sleet and wind, drought.

County center 112 individually brings decision about alarming county (Mayor) or Chief of Staff of protection and rescue. Further activities are carried out according to Protection and rescue plan.

Protection and rescue plan deals only with the plan of operation during the wind event (rescue) and after the event (sanitation). Since extreme wind hazards are usually of local significance, strategic operative forces for protection and rescue are rarely included in activities of wind hazards. These forces are included only sometimes in solidarity basis during event and later by providing financial help.

Forces included in protection and rescue, are given in Table 1 taken from Split and Dalmatia County protection and rescue plan.

Table 1: The protection and rescue forces

Sequence number	Forces	Tasks
Regular forces in Split-Dalmatia County		
1.	County Public firefighting unit	Carry out measurements for technical intervention, rescue from the water pumping water and removing flotsam.
2.	County voluntary firefighting unit	
3.	Building companies	Work on the sanation of flood consequences on request of the Headquarters.
4.	Utility (communal) companies	

5.	HEP-electric power company		Ensure a continuous supply of power and energy and mitigate the consequences of flooding the electro-energy plants.
6.	Water supply companies		Ensuring a regular supply of drinking water, working on the rehabilitation of damaged and / or destroyed water infrastructure
7.	Clinical Hospital CentreSplit		Provide health care of seriously injured and ill.
8.	County Medical center		Provide emergency medical assistance to the injured and ill.
If necesary, folowing forces are required as a support			
No.	Forces	No. of executors	Tasks
1.	Protection and rescue Headquarters	22	Plans, organizes, commands, co-ordinates and supervises the implementation of protection and rescue tasks.
2.	Commandment of county civil protection	18	Plans, organizes, commands,, coordinates and supervises the implementation of the protection and rescue tasks.
3.	Special civil protection unit for logistic	99	Specialist Unit of Civil Protection County are activated as additional forces to protection and rescue forces.
4.	Troops of special and general purpose for local government unit		The city / municipality Specialist Unit of Civil Protection County are activated as additional forces to protection and rescue forces.
5.	Civic associations engaged in protection and rescue (County red cross hunting clubs, diving companies...)		

Source: Split and Dalmatia County protection and rescue plan.

DHMZ is the only agency legally allowed to give warnings in case of prediction or observation of high winds. In that case, warning or alarm is broadcasted by the media – TV, radio, internet portals.

Natural disaster can be proclaimed on state, county, municipality and City level. When natural disaster causes significant damages, city/municipality can request proclamation of natural disaster. Depending on the extend of the area affected by the disaster (state, county or city), State/County/Municipality/City committee for assessment of damage caused by natural disaster meets and investigates. As outcome, the committee makes final proposal to the Major to, or not to declare natural disaster.

In case of natural disaster, damage mitigation financial aid is given by committee for the assessment of damage.

3.2. Infrastructure

All parts of urban infrastructure have to obtain a permit to build. To obtain permission, infrastructure has to be designed according to code and in compliance with specifics of infrastructure and surrounding. Current building code in Croatia is Eurocode, same as in rest of the European Union. Its current version is translated to Croatian language and supplemented with National Annex for Croatia (NA).

Eurocode is implemented by Croatian Standards Institute. Implementation began with signing of Agreement on Cooperation in the Process of Adoption of the Eurocodes as Croatian Standards on the 5th of September 2007 by the Ministry of Construction and Physical Planning, Croatian Chamber of Civil Engineers and Croatian Standards Institute. Technical committee established on the 28th of November 2006 is based on the structure of CEN/TC 250 (Technical committee in charge of Eurocode standardization). Decision of TC is to adopt Eurocode in English immediately, following by translation of norms and further publishing of NA. There were some difficulties in implementation process but finally, after several postpones and extensions, this task was finalized.

Eurocode is divided in sections and subsections. The structure of norm is given in list below:

- EN 1990: Basis of structural design
- EN 1991: (Eurocode 1) Actions on structures
- EN 1992: (Eurocode 2) Design of concrete structures
- EN 1993: (Eurocode 3) Design of steel structures
- EN 1994: (Eurocode 4) Design of composite steel and concrete structures
- EN 1995: (Eurocode 5) Design of timber structures
- EN 1996: (Eurocode 6) Design of masonry structures
- EN 1997: (Eurocode 7) Geotechnical design
- EN 1998: (Eurocode 8) Design of structures for earthquake resistance
- EN 1999: (Eurocode 9) Design of aluminum structures

Section concerning loading to all constructions, including infrastructure is *HRN EN 1991 Action on structures.* More specific, loads regarding wind are presented in subsection *HRN EN 1991 -1-4 Actions on structures: Part 1-4: General actions - Wind actions*.

In Croatian legislation that part of Eurocode have undergone two iterations:

- HRN EN 1991-1-4:2008 en
- HRN EN 1991-1-4:2012 hr (based on EN 1991-1-4:2005; EN 1991-1 4:2005/AC:2010; EN 1991-1-4:2005/A1:2010 (CEN))

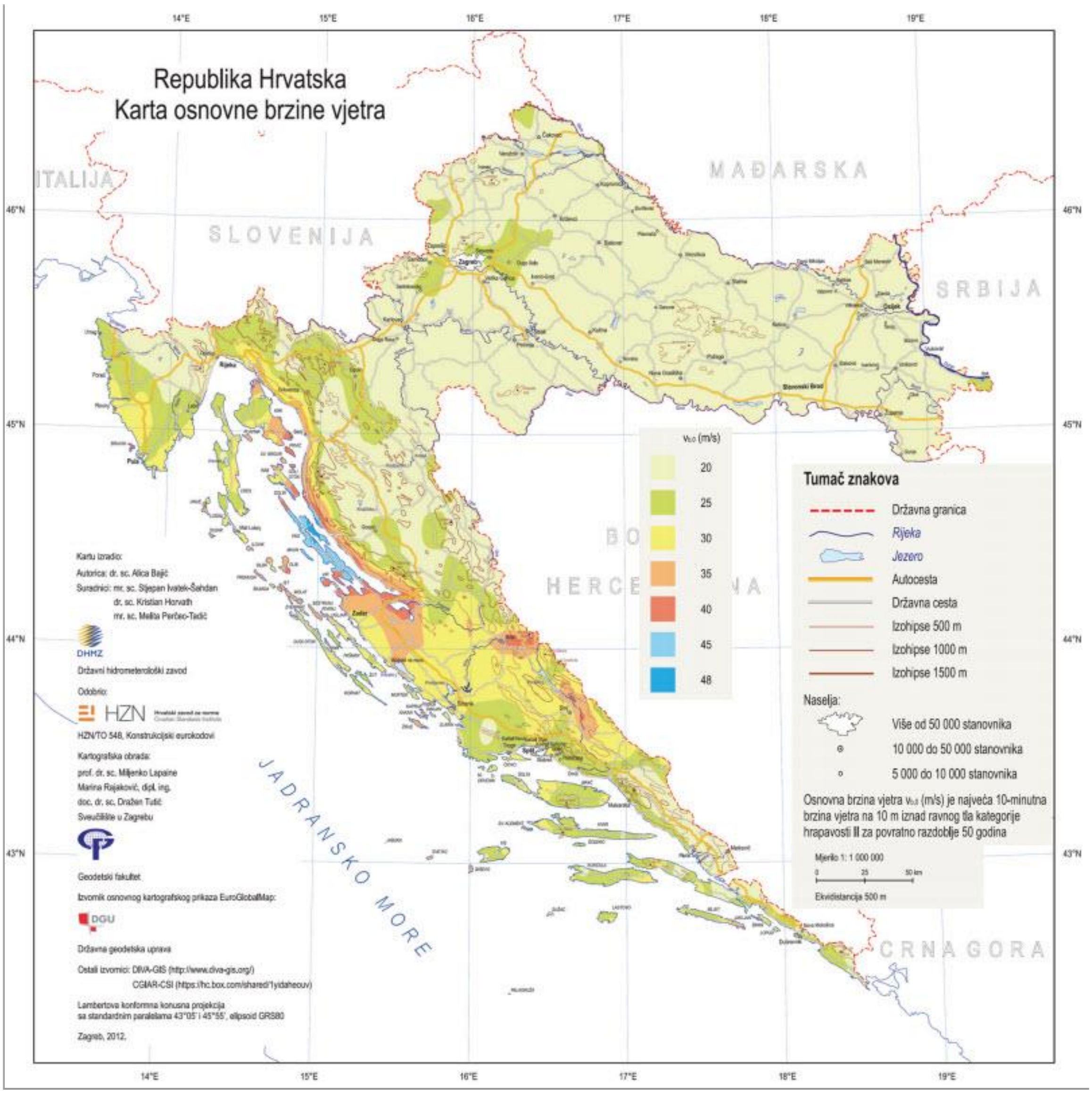
NA had only one version:

- HRN EN 1991-1-4:2012/NA:2012

One of the crucial parts of NA regarding wind load is basic wind speed map. Basic wind speed is maximum expected wind speed with return period of 50 years of 10-minute averaged wind speed, measured at 10m above ground level, over terrain of class II of terrain classification according to EN 1991-1-4. Basic wind speed map is obtained from long term measurements of wind speed at meteorological service stations in Croatia, interpolated by means of meteorological numerical atmosphere model (ALLADIN, Croatian National Meteorological Service). Complete work is published in a PhD thesis of Alica Bajic, and that PhD thesis is publically available online. Map is shown in

Figure 2.

Figure 2: Basic wind speed map



Source: HRN EN 1991-1-4:2012/NA:2012

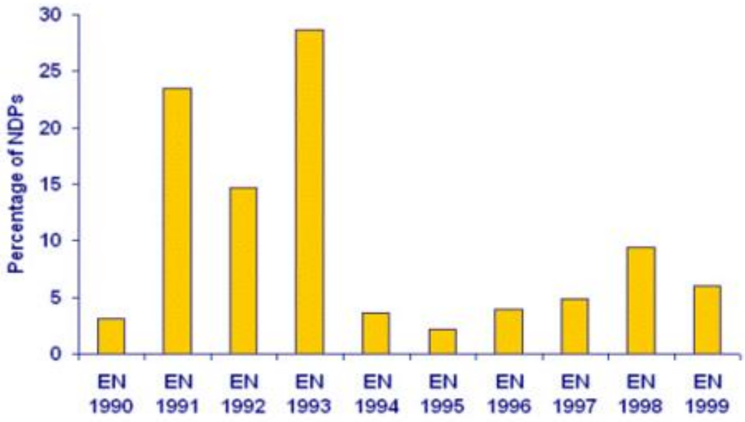
As it can be seen in Figure 2, Croatia is divided into seven wind speed regions. The area with the lowest wind speed is the north of Croatia, and the area with the highest wind speed is the north coast beneath Velebit mountain range.

Stated codes are based on a Limit State Design which is also known as a load and resistance factor design. According to EN 1990, a limit state is a condition of a structure beyond which it no longer fulfils the relevant design criteria. Eurocode distinguishes between two limit states – Ultimate limit state and Serviceability limit state. Ultimate limit state is an agreed computational condition that must be fulfilled in order to comply with the engineering demands for strength and stability under design loads. Serviceability limit state is also an agreed computational condition that ensures that the functioning of construction is retained under design loads. Both of these states are implying that factored values of resistance and loading are used. Magnification factors of loading and reduction factors of strength are in relation with reliability of construction. Eurocode norms generally proscribe procedures of performing these checks and values of factors for various situations that should be done by construction designers. NA defines typical loads for location of construction with Nationally Determined Parameters (NDP).

Generally, codes are not written with the whole specific infrastructure in mind. In codes, wind loading is described on generic part of construction or whole generic construction that satisfies given dimensional and mechanical criterion. That way, codes do not distinguish between construction of infrastructures and buildings subjected to wind loads.

NDP are a part of NA with a purpose to allow nations that use Eurocode norms to incorporate local differences to national legislation. No other changes to Eurocode are allowed except for those defined in NDP. NDP are stated in a foreword to each EN Eurocode part. Distribution of NDP over all parts of Eurocode is shown in a figure Figure 3.

Figure 3: Distribution of NDP over Europe



Type	Number	%
Values of parameters	397	26.3
Reference to values or tables	170	11.3
Choice of procedure	501	33.3
Land specific data	18	1.2
National maps or tables	1	0.1
Diagrams	15	1.0
Reference to NCCI	23	1.5
Status informative annexes	249	16.5
Indicate extra detailed information	102	6.8
Reference to informative annex	30	2.0

Source: http://eurocodes.jrc.ec.europa.eu/showpage.php?id=51

As expected, significant amount of NDPs are in a loading section of Eurocode.

There is no legislation concerning infrastructure functioning during strong winds. For utilities, operators of systems are responsible for shutting it down in cases of emergency on orders from the authorities. There was not such occasion in Croatia that operators had suspended part or whole system due to high winds as a preventive measure. System failures that occurred in those conditions were outcome of fail of elements of infrastructure (power pylon, cables or antenna towers) subjected to high wind actions.

In the case of damage on the infrastructure caused by strong winds, the costs of repairs are covered by the insurance company if the individual part of infrastructure is insured. Otherwise, the proprietor is covering the cost.

3.3. Transport

Currently there are no regulations concerning road planning in order to avoid wind gusts. Skilled planners are incorporating their knowledge to avoid high wind risk zones but usually traffic needs, land ownership and tackling land obstacles are more demanding challenges in road planning.

Location of bridges is part of road and railway plans. Usually, high winds are taken into consideration while planning but sometimes other aspects supersede those. Also, until recently, Croatia didn't have detailed wind chart and many locations that are remote from measurement station were badly interpolated without concern of topological and climate data. Wind loading for bridges is covered by HRN EN 1991 norm.

According to Air traffic law (NN 69/09, NN 84/11, NN 54/13, NN 127/13 and NN 92/14), article 76., airports should be built to allow safe landing, grounding and harboring airplanes. Different types of airports accept different types of airplanes. Specification of airplanes defines top wind speeds for safe operations and keeping. Government issues special authorization for airport building when all requirements for potential location are met.

Same as road planning, railway have no special regulation concerning planning in high wind zones.

Wind loading regarding to harbors has two main issues. First issue is the security of personnel and vessels guarded during high winds. Second issue is maintaining structural strength of all elements of harbor constructions under direct wind loading and indirect loading from the wind generated waves. Harbor management is under Law of maritime domain and harbors (NN 158/03, 100/04, 38/09, 123/11). Depending on the size of the harbor, expected traffic, type of operations and location, harbors are classified with local, regional, state or international importance. Public harbor building, maintenance and modernization are taken into account with 10 year development plan of Croatian harbor system (article 45.) that is enacted by the Croatian parliament on claim of the Government.

Harbor planning is performed as a part of the building process. The selection of the harbor location is usually defined by naval traffic routes and topographical properties of region. The orientation of the harbor entrance is chosen to provide the best trade-off between manoeuvrability and security to vessels. There are no national norms that support the design of harbors. Marine harbor engineers commonly use:

- British standard BS 6349
- US Army Corps of Engineers – Coastal engineering manual

These norms and this manual are worldwide recognized and used as standards in countries where norms for this designs are unavailable.

Constructions in marines can be designed using Eurocode norms. Typical marine constructions, such as breakwaters, wharfs, keys moorings, shore walls, are mostly concrete and rubble mound and therefore Eurocode 1992 Design of concrete structures and Eurocode 1997 Geotechnical design are used.

Traffic is usually limited or closed during high wind season under order of proprietor of the roads (for highway it is HAC (Croatian Highways)) in cooperation with HAK (Croatian Auto Club). Croatian highways have a grid of automatic meteorological stations that monitor wind speed and direction along another atmospheric parameters and have developed algorithms along with Croatian Hydro Meteorological Service that indicates that the part of the highway should have limited traffic. Local roads are not equipped with such measurement stations and rely on the support of the nearby meteorological stations for such data. The decision of limiting traffic on those kind of roads are left for their owners which are defined by road category (county road – County administration for roads etc.).

Bridges are concerned as part of roads and same rules apply to them such as to roads if additional rules are not given by bridge designers. In bridge design, wind loads are defined in two scenarios: lesser wind speed and full traffic load and higher wind speed and no traffic load. If lesser design speed is lower than roads closing wind speed, then bridges should be closed at bridge design speed. Also, if the bridge is equipped with the wind speed monitoring system then stated system should be used as an integral part of the decision support system.

Regulation concerning closing or limiting operation in railway traffic is defined by HŽ Infrastructure Limited Liability Company for Management, Maintenance and Building of Railway Infrastructure. Its internal regulation for Railway traffic (1997) is in compliance with the Railway traffic safety law (NN 77/92, NN 26/93), article 32 and HŽ statute (*Službeni vjesnik* br. 5/94) article 16. In article 72. of that regulation, it is stated that for railroads where strong winds can occur a special regulation is required which takes in account strength, duration and direction of strong winds, railroad condition and achieved measures of wind protection.

Air traffic control can define complete stop or partial limitation of air traffic due to high winds for different types of aircrafts. Air traffic control redirects airplanes to the nearest acceptable airport, capacity and weather condition wise.

Sea meteorological service, which is functioning as a part of the Croatian Meteorological Service, is giving meteorological warnings about meteorological hazards, including high winds, twice a day. In accordance with the meteorological warnings, port Capitan can close harbor for sea traffic or forbid leaving port for a specific ship. There is no strict regulation; it is a part of the port captain's authority.

In road traffic, for public roads, responsible for reparations of roads and objects along the roads in case there is a damage is up to Local road authority, County road authority or concessionaire depending who is managing the road. This is stated under Road maintenance and protection law (NN 25/98, NN 162/98).

Regarding railway traffic, maintenance of railroad is responsibility of company for managing railroad infrastructure according to Railway law (NN 94/13, NN 148/13), article 15. Company managing railroad infrastructure is either the owner of infrastructure or concessionaire. Reparation of transfer lines is considered under general and special maintenance.

Expenses of reparation bear local government for roads, company managing railroad infrastructure for railway with government financial support, for public roads and railways of national significance. In the case of nationally declared natural disasters, government can subsidize the cost of reparation.

3.4. Buildings

According to the Protection and rescue law (NN 174/04, NN 79/07, and NN 38/09), local government is issuing Assessment of hazards for local region. That regulation is describing potentially dangerous zones in area for population, buildings, infrastructures and objects of historical value. Areas subjected to high wind hazards are defined, as well as potential effects and mitigation of problem.

Another set of regulations are local urban plans which are developed accordingly to the Urban planning law (NN 153/13). They contain measures of special protection for areas subjected to strong winds. Usually, these two regulations are overlapping on this subject and are in general accordance.

Building regulations are same as stated for infrastructure. Design of both is in the accordance to Euronorm HRN EN supplemented with National Annex document.

There is no legislation concerning protection of buildings during high wind. The building design should predict such actions on constructions and buildings should be designed to left reserve capacity to handle extreme wind loading statistically predicted for return period of the life span of the building.

Building restoration are performed by companies licensed for building reparations.

According to the Law of protection from natural disasters (NN 73/97, NN 174/04), strong winds with wind speeds of 8 Beaufort and above (17.2 m/s and above) are considered as natural disaster. In case of a natural disaster, plans for damage mitigation are set in motion according to the Plans for protection and rescue. Citizens and, in special cases, companies can get costs reimbursement from the government after damage assessment is made by the local authorities.

In cases when natural disaster is not declared, costs of restoration of buildings are covered by the owners. For buildings insured for damages from windstorms, insurance companies are covering the cost of reparation.

3.5. Forests

According to the regulation on forest management, forest management plans are delivered for the following actions:

- Forest Management Area of the Republic of Croatia
- Basis for management of area units
- Programs for waste management units in the Karst
- Programs for the management of private forests
- Programs for the management of forests with special purpose
- The annual forest management plans
- Annual operating plans

With the exception of annual plans, all other documents are delivered on 10 years basis.

The decisions on the measures for forest protection against winds are left to the forest owner. In Croatia the majority of forests are owned by the public company Croatian forests Ltd. There are also county, municipality and private forests. Forest owners are responsible for forest management.

If a tree fell due to the high wind or any other reason in the urban environment and it needs to be removed, the utility (communal) company responsible for this kind of work (in Split this is a public company Parks and plantations) and a unit of local government goes onsite and repairs the consequences. The same work is done by firefighters, depending on the urgency and whether the tree threatens human lives directly.

In the event that the tree fell in a rural area or forest, further action responsibilities depends on whether this has happened on a privately owned land or land that belongs to the Croatian Forests. If the tree has fallen on the area managed by the Croatian Forests, the appropriate field service of the forestry companies and the private owner will remove the fallen tree by themselves or with the help of local fire brigades and local businesses who has the appropriate equipment and machinery for this kind of work.

4. Slovenian legislation

This chapter comprises brief overview of legislation currently active in Slovenia. The legislation of activities that are performed before the wind, during and after them, are presented for each of the endangered aspects (population, infrastructure, transport, buildings and forests).

4.1. Population

The most important law, governing the area of protection against natural and other disaster is Law on the Protection against Natural and other Disasters. It regulates the protection of people, animals, property, cultural heritage and environment against natural and other disasters systematically. Pursuant to Article 93, Law on the Protection Against Natural and Other Disasters (RS Official Gazette, no. 64/94, 33/00, and 87/01) the Government of the Republic of Slovenia adopted The Doctrine on Protection, Rescue and Relief (No. 812-07/2002-1). The Doctrine is based on the Resolution on National Security of the Republic of Slovenia. It is harmonised with the Defence Strategy of the Republic of Slovenia and the Civil Defence Doctrine of the Republic of Slovenia. The Doctrine is a document which is comprised of common principles and views concerning professional and operational guidance, organization, and conduct of protection, rescue and relief efforts in the event of natural and other disasters. The use of common principles provides for a functionally unified and harmonized approach for disaster preparations as well as harmonized and interlinked operations of all those who carry out protection, rescue and relief efforts.

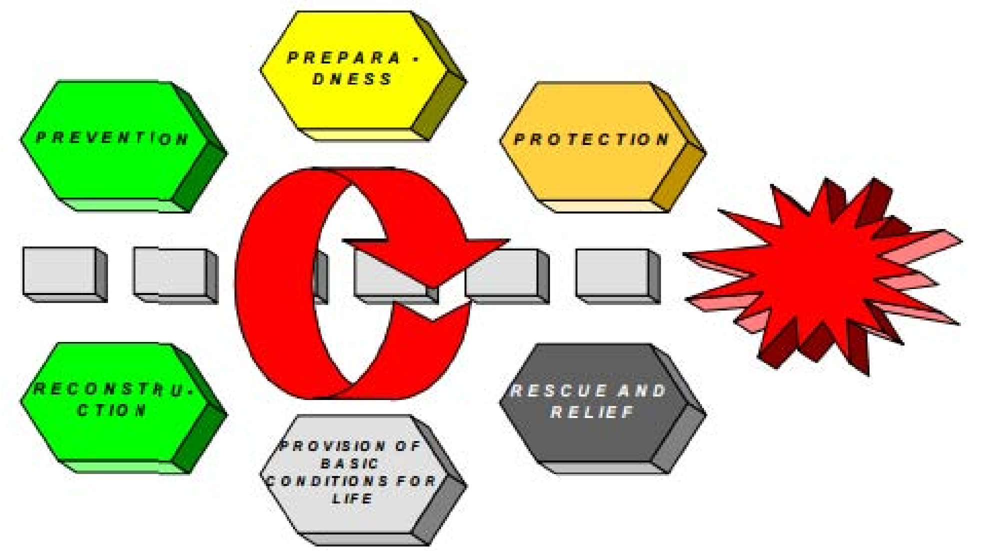
By the Decree on the Contents and Drawing up of Protection and Rescue plans the emergency plan is dismembered idea of protection, rescue and aid in case of natural or other disasters. It is based on: risk assessment, proposals for protection, rescue and aid arising from the risk assessment, available forces and means for protection, rescue and aid (ACPDR, 2004).

The Slovenian system of protection against natural and other disasters is intended to protect people, animals, cultural heritage and the environment from natural and other disasters. The protection and rescue plans are issued by Ministry of Defence, Administration for Civil Protection and Disaster Relief of Republic of Slovenia. These plans define authorities and tasks to assure protection, rescue and relief. Further, plans are based on risk assessment and available forces for protection, rescue and relief. They are prepared by the type of a disaster on national, regional and local level, however, they are public an available on internet (Hazard monitoring for Risk Assessment and Risk Communication, 2008).

As is known, Slovenia lies in the area of frequent storms. At meteorological stations in Slovenia is observed more than 50 storms annually. The storm activity is strongest in late spring and early summer months, from May to July (Verhovec, 2002). The disaster may be even worse, if occur in combination with high wind. Wind during storms causes many inconveniences as for example: discovering the roof, lifting or carrying away the entire roof structure, breaking chimney-stacks as well as poorly constructed buildings, it makes damage on notice-boards, road signs and signalization, overthrows communal containers, breaking branches and pull out trees (ACPDR, 2016). Further, it tears the electrical conductors, causing high waves at the sea, snow-drifts, it obstacles or even render impossible the transport, swept away the soil and causing damage to farmland. The appropriate measures may prevent or mitigate the damage caused by strong winds.

The main functions of the Slovenian system of protection against natural and other disasters are presented in Figure 4.

Figure 4: Main functions of the Slovenian system of protection against natural and other disasters



Source: Hazard monitoring for Risk Assessment and Risk Communication, 2008

Protection and rescue plans are drawn up by state bodies, local communities, commercial companies and other organisations. As mentioned, the plans are drawn up in accordance with the Decree on Content and Drawing up of the Plans for Protection and Rescue. On all levels the plans must be drawn up and adopted by the responsible bodies. The adopted protection and rescue plans have to be presented in public, particularly to threatened people and to other publics with a vested interest.

The basic Protection and rescue plans define:

- an accident that they refer to dimension of planning
- forces and rescuers necessary and equipment and available sources
- monitoring, notifications and alarming
- activation of forces and equipment
- management of the protection and rescue system
- protection, rescue and relief
- personal and mutual protection

Preventive activities aim to prevent, abolish or reduce security risks. Preventive activities comprise organisational, technical and other measures and activities which prevent, or at least alleviate the occurrence of consequences of individual disasters or facilitate the conducting of protection, rescue and disaster relief in the event of a disaster. Preventive measures are under the auspices of ministries, local communities and enterprises, institutes and other organisations in line with their activities. Ministers are directly responsible for their capabilities. Preventive measures and activities are regulated by area legislation. They are planned, however, in the context of programs and plans for protection against natural and other disasters.

Measures to take in the case of high wind:

- monitoring weather forecast, weather conditions and weather warnings issued by Environmental Agency
- if there is predicted high wind, do not plan or perform outdoor activities;
- stay in a confined space;
- if you are outdoors, as soon as possible find wind shelter;
- watch out outdoors objects that are in the air due to high wind; be especially careful of sharp objects, tiles, damaged parts of roofs and chimneys;
- make sure pets are safe (such as cats and dogs), during strong wind should be indoors;
- make firmly and secure tent, and remove objects that could be carried away by the wind;
- do not stand on the exposed parts of the coast during strong wind and high waves;
- during high winds it is warned against sailing; if you are catch by wind at sea, as soon as possible find marine.

The above mentioned measures are issued by Administration of the Republic of Slovenia for Civil Protection and Disaster Relief. These measures are recommended for the population in case of high wind (ACPDR, 2016).

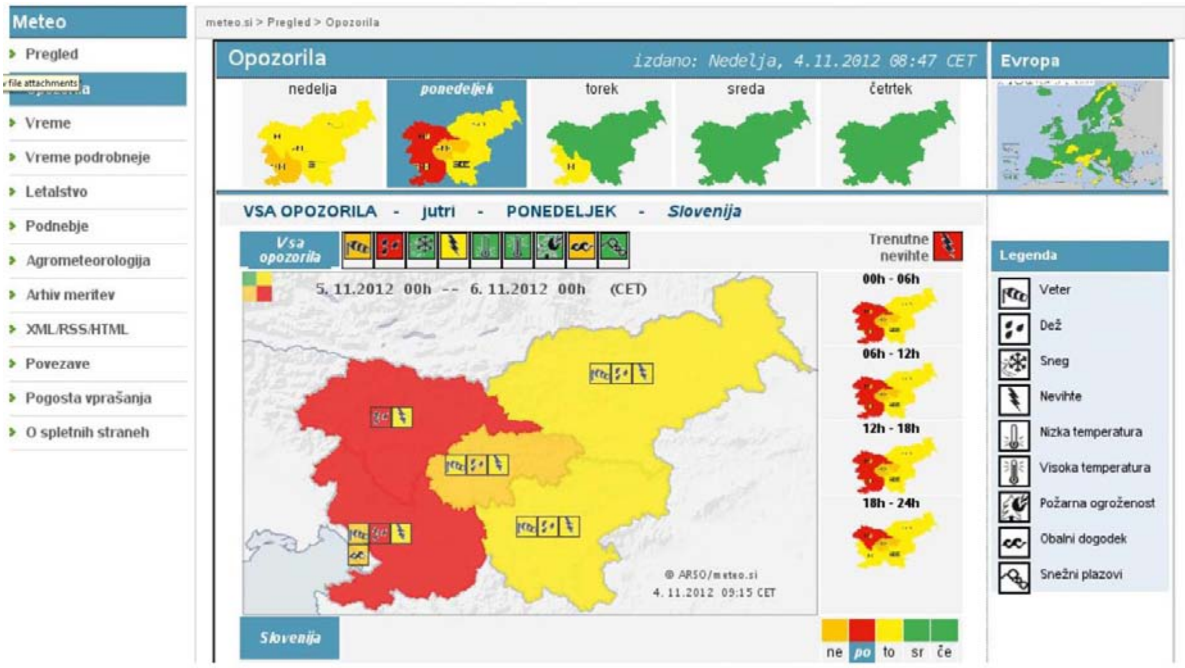
The Administration of the Republic of Slovenia for Civil Protection and Disaster Relief is obligated to monitor, notify and alert in the event of a disaster. The monitoring, notification and warning system is comprised of the monitoring network, notification centres, computer support and telecommunications service, and warning.

According to Meteorological Activity Act (RS Official Gazette, no. 49/06), the National Meteorological Service have to perform expert, analytical, regulatory and administrative tasks related to the environment at the national level. The National Meteorological Service in Slovenia is Slovenian Environment Agency which is responsible and legally obligated for measuring the current wind parameter. The Agency is a body of the Ministry of the Environment and Spatial Planning. Its mission is to monitor, analyze and forecast natural phenomena and processes in the environment, and to reduce natural threats to people and property.

The importance of the National Meteorological Service (Slovenian Environment Service) comes particularly well-defined in extreme weather conditions. At the time of the expected disaster (high wind, storms), the monitoring of current weather, the weather forecasting and the timely warnings represent the basis for further measures in protecting people’s life, environment and property. When the weather forecast indicate negative or potentially hazardous weather conditions, the Environment Agency issue warnings. These warnings are forward to public, special users and to relevant government departments and institutions, e.g. Administrations for Civil Protection and Disaster Relief.

For this reason, the cooperation between Slovenian Environment Agency and Administration for Civil Protection and Disaster Relief is the most important factor in the process of informing public, local communities and intervention services about unusual weather forecast. The quality of the warning systems and notifications about future danger is improved constantly. The warnings of dangerous event are regularly deliver to the media and also updated on the web portal of the National Meteorological Service - Slovenian Environment Agency. One of the weather alerts for Slovenia is shown in Figure 5.

Figure 5: Weather alert for Slovenia



Source: Slovenian Environment Agency, National Meteorological Service, 2013 (www.meteo.si)

Slovenian Environment Agency is the only agency legally allowed to give alerts in case of prediction of high wind. In that case, alert is broadcasted by the media, e.g. TV, radio, weather websites.

The issued weather alerts are also forward to uniformly European warning system called *MeteoAlarm*. It integrates all relevant information about storms which are prepared by the National Meteorological services of European countries. The information is presented in uniform way. The color scale indicates the degree of weather threats and the possible consequences. In this way, the coherent interpretation of weather threat all over Europe is assured.

The operation of protection, rescue and relief forces is supported by a uniform and autonomous communication and information system for protection and relief, which is interoperable with related national and international systems, especially with the EU Common Emergency Communication and Information System (CECIS). The Notification centre of the Republic of Slovenia and the 13 regional notification centres operate 24 hours a day. The key tasks of the regional centres are the response to 112 emergency calls and the provision of dispatch services for all rescue services.

The National Notification Centre is mainly responsible for the operation of the information system, while regional centres, in addition to collecting data and responding to emergency 112 calls, are in charge of dispatches for fire-fighting, emergency medical aid, the mountain rescue service, the cave rescue service, the underwater rescue service, Civil Protection and other rescue services. By dialling this number, people can obtain other important information on weather, water, snow and other conditions, disturbances and interruptions in the supply of potable water and electrical and other energy sources and other areas of life importance.

The alarming system functions as a uniform system that can be deployed at the national, regional or local level. Its operation is guaranteed by municipalities, while the Administration of the Republic of Slovenia for Civil Protection and Disaster Relief is responsible to its organisational and operational aspects namely, at the national and regional levels. Commercial companies, institutions and other organisations engaging in activities which may pose a risk for the wider environment have to organise and maintain a warning system, which corresponds to the type of threat for which they are responsible.

After the natural disaster, the municipalities show data on estimation of material damage recorded by commissions for estimating damage by type of natural disaster. The mentioned commissions estimate damage by cause of damage, areas, means and activities where the damage occurred. The results of the estimation are used for defining the measures for improving the situation and for defining the loss in comparison with GDP. The estimation made by municipalities commissions are verified by regional and national commissions. In answering the questionnaires the municipalities used the Guidelines on Unified Methodology for Estimating Damage Caused by Natural Disasters. The natural disaster is proclaimed when damage exceeds 0.3 ‰ of GDP. The natural disaster is also recorded to the application AJDA. This is an application for damage assessment on agricultural products and objects as well. The municipalities can process damage reports provided by the affected parties on different things, namely, for damage assessment on agricultural land and products, destroyed buildings, partial damage on buildings and damage on civil engineering facilities. This application is property of The Administration of the Republic of Slovenia for Civil Protection and Disaster Relief.

4.2. Infrastructure

The infrastructure and their parts have to be designed according to code and in compliance with specifics of infrastructure and surroundings. Current building code in Slovenia is Eurocode, which is implemented by Slovenian Institute for Standardization (SIST). The SIST is responsible for preparing and adopting voluntary standardization documents, and representing the interests of Slovenia in the international (ISO and IEC), and European (CEN, CENELEC, ETSI) organizations for standardization, in which it holds full membership. SIST ensures equal involvement of all interested parties in standardization activities thus enabling the co-development of European and international standardization. SIST became operational in 2001, when it took over the tasks related to preparation and adoption of Slovenian national standards from the former Standards and Metrology Institute. SIST is an active and full member of the international (ISO and IEC) and European (CEN, CENELEC, ETSI) organizations for standardization.

For electrical overhead lines, as an important part of infrastructure, the Slovenian Institute for Standardization has published Slovenian standard SIST EN 50341-3-21: 2009 (SI) Overhead electrical lines exceeding AC 45 kV – Part 3-21: National normative Aspects (NNA) for the Slovenia (based on SIST EN 50341-1:2002), which has the status of the original Slovenian standard. The standard is based on SIST EN 50341-1:2002 and applied in Slovenia for the designing and implementation of new overhead lines of nominal voltage of 45 kV and for the reconstruction by new structure.

The approach in the design and dimensioning of overhead lines is presented next.

Wind loads

The wind loads depend on the geographical position where the overhead lines are projected. For this reason, the Slovenia is divided in wind zones as is presented in Figure 6. The wind pressure, q_h, is given in expression:

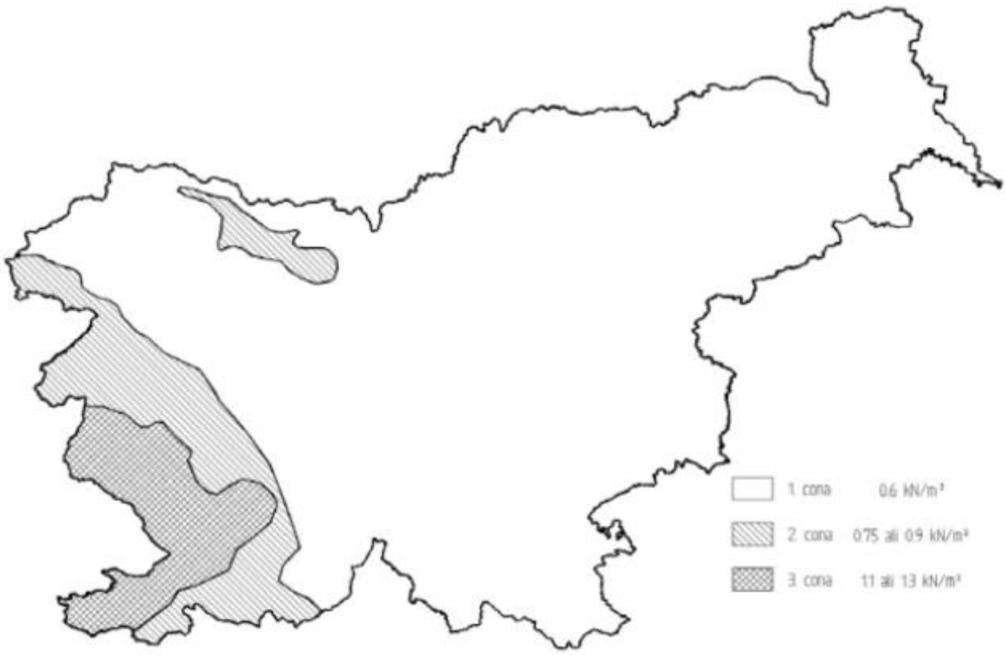
$q_h = v^2/1.6$ [N/m²]

where

v is the velocity, which has return period of 5 years, or for conductors exceeding up to AC 45 kV in long time period.

This wind pressure is validated for a basic zone altitude up to 40 m above ground and it has to be at least of 600 N/m².

Figure 6: Map of wind zones of Slovenia



Source: SIST EN 50341-3-21:2009 (based on SIST EN 50341-1:2002)

As can be seen, the Slovenia is divided in three wind zones. The related wind pressures for different altitude above ground are collected in Table 2.

Table 2: The related wind pressures for different wind zone

Wind zone	**1.**	**2.**		**3.**	
Wind pressure q_h	[N/m²]				
Altitude 0 – 40 m above ground	600	750	900	1100	1300
Altitude 40 – 80 m above ground	750	900	1100	1300	1500

Wind pressure on conductors causes forces transverse to the direction of the line as well as increased tensions in the conductors. The total wind force on the bundle of phase conductors is defined as the sum of forces on the individual sub-conductors, without taking into account possible sheltering effects on leeward conductors.

$$Q_{Wc} = q_h \, G_c \; C_c \, d \, L \; \cos^2 \emptyset \,,$$

where

q_h is the peak wind pressure given in Table 2,

G_c is the structural factor for the conductor (span factor):

$G_c = 1.0$ for span up to 200 m

$G_c = 0.6 + 80/L$ for span above 200 m

C_c is the drag factor (or force coefficient) for the conductor (see SIST EN 50341-3-21:2009; 4.3.2/SI.2),

d is the diameter of the conductor,

L is the length of span, usually calculated as $L = (L_1 + L_2/2)$,

$\emptyset$ is the angle of line direction (see SIST EN 50341-3-21:2009; 4.3.10/SI.1).

Up to this point, we present only the wind loads on conductors presented. For detailed description of wind forces on insulator sets, lattice towers as well as poles, see SIST EN 50341-3-21:2009.

Sleet (ice) loads

The sleet (ice) loads develop due to precipitation ice, which can be wet snow or glaze ice, which cover conductors. The additional ice load is a load, which occurs at the same location with return time period of 5 years, nevertheless is not lower than:

$$q_n = f \; 1.8 \sqrt{d} \qquad \text{[N/m]},$$

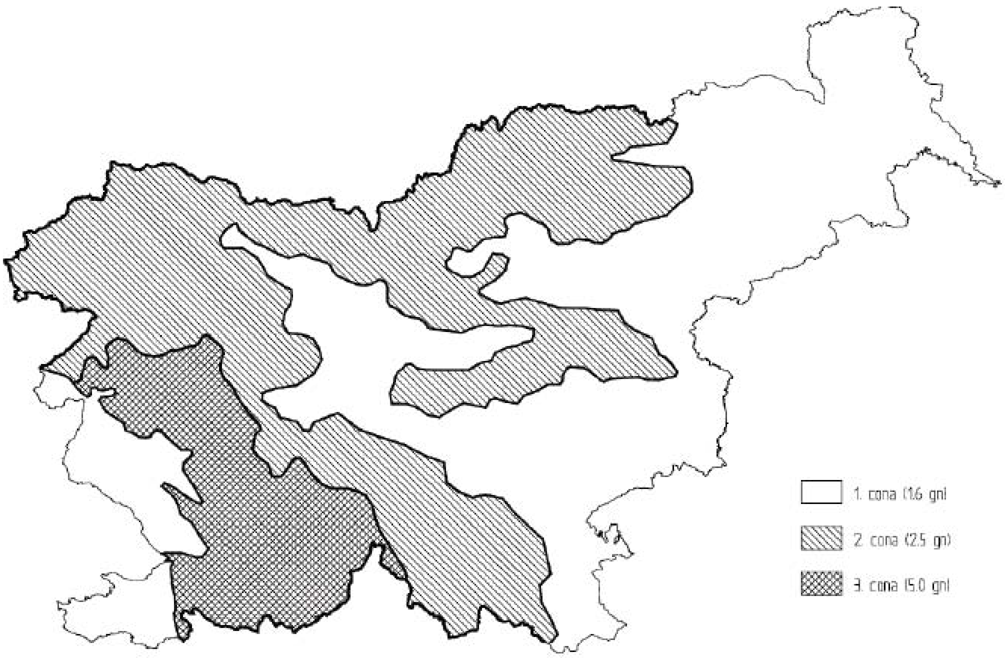
Where

d is the diameter of conductor [mm],

f is the factor of sleet zone [mm].

Figure 7 shows the Slovenian sleet zones. As can be seen, the Slovenia is divided in three sleet zones with corresponding factor of sleet zone. This map is obsolete and lean on some old analyses which were made by precursor of today meteorological institution. In 2005 there were some endeavours to create new map. Due to eliminated time, IBE, which is the biggest independent engineering and consulting company in Slovenia, corrected old map on the basis of last experiences. Thus, this matter remained incomplete. In future this will have to be fixed. The Slovenian Environmental Agency has recently presented his vision of phenomenon of sleet, but there was nothing done to improve the maps.

Figure 7: Slovenian sleet zones



Source: SIST EN 50341-3-21:2009 (based on SIST EN 50341-1:2002)

Combined wind and sleet (ice) loads

The wind force on ice covered conductors is analogous as abovementioned; the difference is in conductor diameter *d*. Even if the shape of the ice deposit is rather irregular, it is assumed as an equivalent cylindrical shape with diameter, D_1:

$$D_1 = \sqrt{d^2 + 0.00014\, g_n},$$

where

d is the conductor diameter [m]

g_n sleet (ice) load [N/m].

There is no legislation concerning infrastructure functioning during high winds. The cost of repairing damage is covered by the proprietor or by insurance company, if the individual part of infrastructure is insured. In case of natural disaster, the damage is inventoried by municipalities' commission. Damage calculations are based on approved evaluations. If damage exceeds 0.3 ‰ of GDP, the Ministry of the Environmental and Spatial Planning prepares elimination strategy and provisions of grant in aid.

4.3. Transport

According to Public Roads Act (RS Official Gazette, no. 33/06) and Rules on road design (RS Official Gazette, no. 91/05), there are no regulations concerning road planning in order to avoid high wind gusts In Slovenia. Within Rules on road design it is only noted that it is necessary to take into account the complexity of the terrain and other specific conditions of the area, e.g. wind, snow. Likewise as road planning, railways have no special regulation for planning in high wind zones (Railway Transport Act (RS Official Gazette, no. 99/15)). Apart from that, the special attention is directed to bridges. The wind actions on bridges are covered by Eurocode 1: Actions on structures- Part 1-4: General actions - Wind actions (SIST EN 1991-1-4:2005).

The airports and airfields with the necessary infrastructures should be built with recommendations and standards of International Civil Aviation Organization (ICAO) which need to be observed when projecting new airports. The main Slovenian aviation legislation is the Aviation Act (RS Official Gazette, no. 113/06), covering all aviation-related matters, including but not limited to airports, air navigation services, security and facilitation, aviation accidents and incidents, and other regulation for air traffic.

Within Maritime Code (RS Official Gazette, no. 120/06) operates harbour management in the only Slovenian port, in Koper, classified as international importance. Constructions in marines, such as breakwaters, wharfs, keys moorings and shore walls are mostly made of reinforced concrete, and therefore, the Slovenian standard SIST EN 1992-1-1 Design of concrete structure, SIST EN 1992-1-1 Design of steel structures and SIST EN 1997 Geotechnical design are used.

Public Roads Act (Article 65.) indicates limitations on the use of state roads during high wind. The measures are taken by maintainer of the road and immediately forward to Slovenian Infrastructure Agency (former Slovenian Road Agency), police, municipal police, road inspection and traffic information centre. During high wind (bora), the regional road R2-444 Razdrto - Nova Gorica in the Vipava valley is limited or restricted for traffic. The wind measuring system there is called Burja. Individually exceeded limit levels of wind do not automatically mean that a road is closed or traffic is restricted. A decision on road closure is taken on the basis of information currently available, the detected trend of wind strength and past experience. The traffic on roads is restricted when wind speeds exceed a threshold level and the increasing speed of wind is detected. A road closure ends when the decrease of wind strength under a certain threshold level is detected. The levels of load closure are presented in Table 3.

Table 3: Levels of road closure

Level	Speed km/h	Speed m/s	Road closure
I.	80-100	22-28	camper vans, refrigerator trucks and sheeted vehicles up to capacity of 8 tones
II.	100-130	28-36	all sheeted vehicles and refrigerators; if the wind speed exceeds 110 km/h (30 m/s), the speed limit for all vehicles is 40 km/h
III.	130-150	36-40	all level II, vehicles and buses
IV.	above 150	above 40	all vehicles

Source: Traffic information centre

According to Railway Traffic Safety Act (RS Official Gazette, no. 56/13), there are no special regulations of railways during high wind.

Air traffic control can define partial limitation or complete stop of air traffic due to high wind, and redirects airplanes to the nearest acceptable airport.

There is no strict regulation for forbidding sea traffic, because it is a part of port captain's authority.

According to Road Traffic Safety Act (RS Official Gazette, no. 56/08), the operators are responsible for reparations of roads and objects along the roads in case there is damage due to high wind. In Slovenia, this responsibility is up to Motorway Company in the Republic of Slovenia (DARS d.d.), local communities or other concessionaire depending who is operating the road.

In accordance with Railway Transport Act (RS Official Gazette, no. 99/15), the operator of the public railway infrastructure is Slovenian Railways, who is responsible for reparations after damage.

4.4. Buildings

Building regulations are in the accordance with SIST EN 1991 supplemented by National Annex (NA). There is no legislation concerning protection of buildings during high wind, but only some measures issued by Administration for Civil Protection and Disaster Relief. One of the recommendations is using wind resistant roofing. If necessary, the roofing tiles have to be further fixed or weighted (Primorska region). This is also defined in Rescue and protective plans for each of the municipalities.

The building design should predict such actions on structures to left reserve capacity to handle extreme wind loading. The approach in the design of buildings is in short presented additionally.

Wind actions according to SIST EN 1991-1-4:2005 and National Annex (NA), 2008

The brief review of wind actions according to Eurocode including Slovenian National Annex is presented. The national Annex may only contain information on those parameters which have left open in the Eurocode for national choice to be used for the design of buildings and civil engineering works to be constructed in Slovenian country.

Basic wind speed

The fundamental value of the basic wind velocity, $v_{b,0}$, is the characteristic 10 minutes mean wind velocity, irrespective of wind direction and time of year, at 10 m above ground level in open country terrain with low vegetation such as grass and isolated obstacles with separations of at least 20 obstacle height (terrain corresponds to terrain category II in Table 3). The basic wind velocity is calculated from expression:

$$v_{b,0} = c_{dir}\, c_{season}\, v_{b,0}\ ,$$

where:

$v_{b,0}$	is the basic wind velocity, defined as a function of wind direction and time of year at 10 m above ground of terrain category II,
v_0	is the fundamental value of the basic wind velocity,
c_{dir}	is the directional factor (Slovenian NA defines c_{dir} as 1.0),
c_{season}	is the season factor (Slovenian NA defines c_{season} as 1.0).

The influence of surrounding terrain

The mean wind velocity $v_m(z)$ at a height z above the terrain depends on the terrain roughness and orography and on the basic wind velocity, v_b, and it is determined by using expression:

$$v_m(z) = c_r(z)\, c_o(z)\, v_b\ ,$$

where:

$c_r(z)$	is the roughness factor (it exist 5 category of terrain, see Table 3),
$c_o(z)$	is the orography factor.

The Slovenian NA accepts proposed EN method.

The roughness factor $c_r(z)$:

The roughness factor $c_r(z)$ accounts for the variability of the mean wind velocity at the site of the structure due to: (i) the height above ground level and (ii) the ground roughness of the terrain upwind of the structure in the wind direction considered.

$$c_r(z) = k_r \ \ln\left(\frac{z}{z_0}\right) \qquad \text{for} \qquad z_{\min} \leq z \leq z_{\max},$$

$$c_r(z) = c_r(z_{\min}) \qquad \text{for} \qquad z \leq z_{\min},$$

where:

z_0 is the roughness length,

k_r is the terrain factor depending on the roughness length z_0 calculated using

$$k_r = 0.19\left(\frac{z_0}{z_{0,\mathrm{II}}}\right)^{0.07},$$

where

$z_{0,\mathrm{II}}$ =0.05 m (terrain category II, see Table 3),

$z_{\min}$ is the minimum height (see Table 3),

$z_{\max}$ is to be taken as 200 m.

Table 4: Terrain category

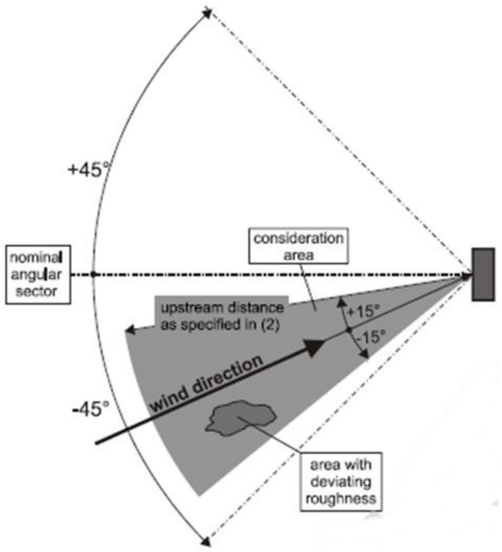
Terrain category		z_0 [m]	z_{min} [m]
0	Sea or coastal area exposed to the open sea	0.003	1
I	Lakes of flat and horizontal area with negligible vegetation and without obstacles	0.01	1
II	Area with low vegetation such as grass and isolated obstacles (tree, buildings) with separation of at least 20 obstacle height	0.05	2
III	Area with regular cover of vegetation or buildings or with isolated obstacles with separations of maximum 20 obstacle heights (such as villages, suburban terrain, permanent forest)	0.3	5
IV	Area in which at least 15 % of the surfaces is covered with buildings and their average height exceeds 15 m	1.0	10

Source: SIST EN 1991-1-4:2005, 2005

The terrain roughness to be used for a given wind direction depends on the ground roughness and the distance with uniform terrain roughness in an angular sector around the wind direction. Small areas (less than 10% of the area under consideration) with deviating roughness may be ignored (see

Figure 8).

Figure 8: Assessment of terrain roughness



Source: SIST EN 1991-1-4:2005, 2005.

When a pressure or force coefficient is defined for a nominal angular sector, the lowest roughness length within any 30° angular wind sector should be used. Further, when there is choice between two or more terrain categories in the definition of a given area, then the area with the lowest roughness length should be used.

The orography factor $c_o(z)$:

The orography factor $c_o(z)$ is defined as ratio between mean wind velocity at height z above terrain and mean wind velocity above flat terrain; that is ${w_\mathrm{m}}/{w_\mathrm{mf}}$.

The effects of orography may be neglected when the average slope of the upwind terrain is less than 3°. The upwind terrain may be considered up to a distance of 10 times the height of the isolated orographic feature. The Slovenian NA accepts EN method. Due to great extent of numerical calculation of orography coefficients, the description is here omitted.

Wind dynamics

For wind turbulence is significantly that irregular change in wind speed and directions relies on statistical description. The turbulent component of wind velocity has a mean value of 0 and a standard deviation σ_v , the latter is determined using expression:

$$\sigma_v = k_r\, v_b\, k_l\ .$$

The turbulence intensity is defined by next expression:

$$I_v(z) = \frac{\sigma_v}{v_m(z)} = \frac{k_l}{c_0(z)\ \ln z/z_0} \quad \text{for} \quad z_{\min} \le z \le z_{\max},$$

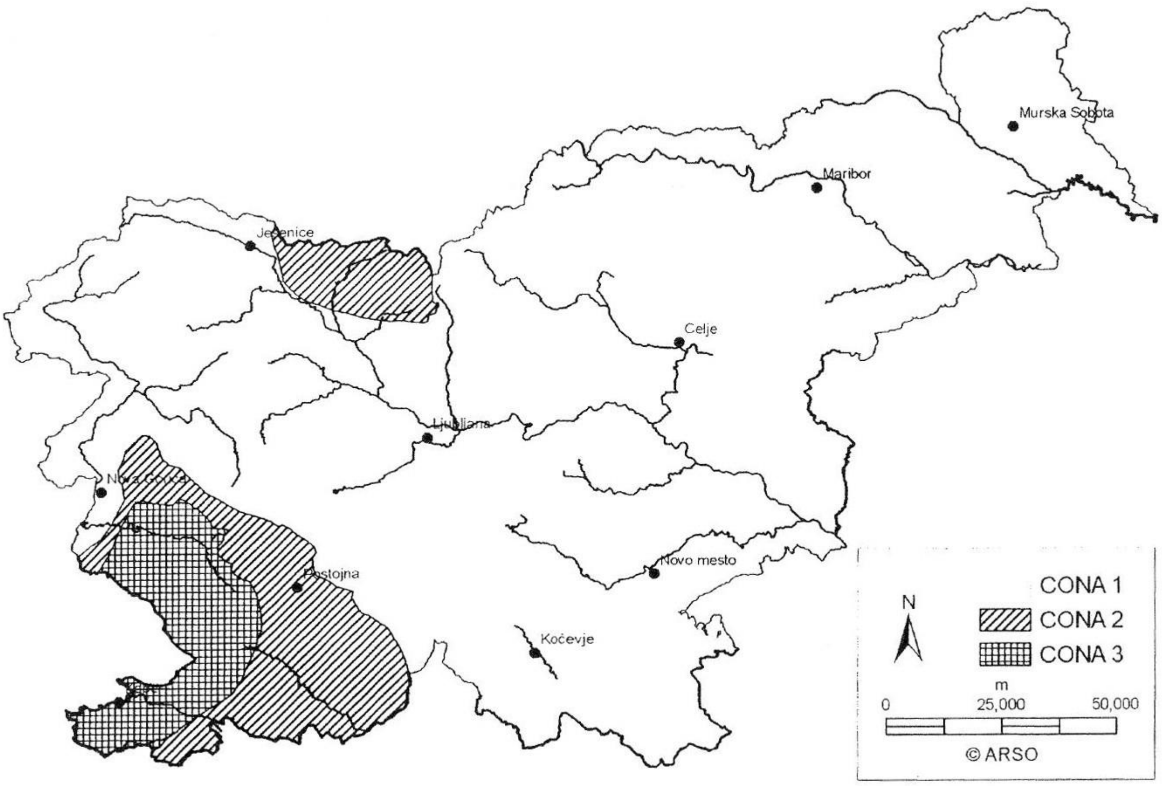
$$I_v(z) = I_v(z_{\min}) \quad \text{for} \quad z \le z_{\min}\ ,$$

where:

k_l	is the turbulence factor (k_l=1.0),
c_0	is the orography factor,
z_0	is the roughness length (see Table xyTerrain category)

The basic wind velocity, $v_{b,0}$, defined as a function of wind direction and time of year at 10 m above ground of terrain category II is presented in Figure 9.

Figure 9: Basic wind speed map of Slovenia



Source: SIST EN 1991-1-4:2005, National Annex, 2008

As can be seen in Figure 9, the Slovenia is divided in three zones. For each of them, basic wind velocity, depending on altitude, is defined:

Zone 1 (the greater part of Slovenia):

20 m/s under 800 m

25 m/s between 800 m and 1600 m

30 m/s between 1600 m and 2000 m

40 m/s above 2000 m

Zone 2 (Trnovski gozd, Notranjska, Karavanke):

25 m/s under 1600 m

30 m/s between 1600 m and 2000 m

40 m/s above 2000 m

Zone 3 (Primorje, Karst and part of Vipava valley):

30 m/s

The wind map, which is presented in Figure 9, was designed by Slovenian Environmental Agency. Data analysis was carried out by highest monthly value of the term speed of the wind. The term speed is an average 10-minute wind speed at the end of the measurement interval (usually every half an hour). The suspicious peak values of measurements were checked and eliminated. The corrections of the measured wind speed were made also due to wind barriers and vegetation in the vicinity of anemometer. The extreme of annual and monthly values of the largest 10-minute wind speed were analysed for each of the measuring point. The matching of values were analysed according to Gumbel and Weibull distribution. From the selected distributions it was determined the speed of a 50-year return period at 10 m above ground (basic design speed).

The most serious problem was in determination of wind speed over area of high foehn. At foothills of Karavanke Mountains is an area where approximately every decade appears very powerful Karavanke foehn. The Slovenian Environment Agency has there insufficient monitoring sites for making more precisely determination of this phenomenon. The area was determined with a simple model of the flow of air and by application of preceding standard. Similarly, the problem appears also over areas with bora wind. There, the area was subjectively assessed (Slovenian Environment Agency, 2016).

In case when natural disaster is not declared, the costs of building restoration are covered by owners. If damage, due to natural disaster, exceeds 0.3 ‰ of GDP, the Ministry of the Environmental and Spatial Planning prepares elimination strategy and provisions of grant in aid (ACPDR, 2016).

4.5. Forests

Forest management and forest use in Slovenia are directed by The Ministry of Agriculture, Forestry and Food as the supreme state institution in the field of forestry and by the Slovenia

Forest Service as a public forestry service. Main national documents that serve as the basis for forest treatment and management in Slovenia are (Slovenia forest service, 2016):

- The Forests Act (RS Official Gazette, no. 30/93) which regulates protection, silviculture, exploitation and use of forests on the basis of forest management plans;
- The Forest Development Programme of the Republic of Slovenia (1996), adopted by the National Assembly, which defines the national policy on close-to-nature forest management, guidelines for the preservation and development of forests and conditions for their exploitation or multipurpose use.

Besides, there are acts regulating the sphere of nature protection, environmental protection, space management, protection of plants, hunting and wildlife, building and construction, information of public interest and media.

The procedure of adopting forest management plans, as defined by Forest Act, enables co-operation of forest owners and the public in public debates. Thus everybody has the possibility of giving argumentative remarks and suggestions regarding a forest management plan which is in the case of forest management units at the end of the procedure adopted by the Ministry of Agriculture, Forestry and Food. In the case of forest management regions forest management plans are adopted by the government of the Republic of Slovenia.

In accordance with professional foundations provided by the Slovenia Forest Service, forests are managed by forest owners, who are private owners (approximately three quarters of Slovenian forests are in private property), local communities and state. Therefore, the decisions on the measures for forest protection against high wind are left to the forest owners. There are no special measures to be taken in forest during high wind.

The responsibility for fallen trees due to high wind is also left to the owner by the help of institutions which are competent for reducing damage, such as firefighters, public companies, and local government. This depends on where the tree had fallen.

5. German legislation

5.1. Population

In Germany the German Meteorological Service (*Deutscher Wetterdienst, DWD*) is legally responsible for weather forecasting and warning management. The DWD is a public-law institution belonging to the Federal Ministry of Transport and Digital Infrastructure (*Bundesministerium für Verkehr und digitale Infrastruktur, BMVI*). The legal responsibilities of the DWD are established by the 'law on the German Meteorological Service' (*Gesetz über den Deutschen Wetterdienst, DWDG*) (cf. §1 DWDG). One responsibility of the DWD is to publish weather alerts whenever public safety and order are endangered (cf. §4 (3) DWDG).

The German warning management is based on the 'one voice policy' of the DWD, meaning a principle that official weather alerts are only to be pronounced by the DWD (cf. Website DWD 2015a). These weather alerts base on the analysis and assessment of weather modelling, which are conducted and interpreted by meteorologists of the DWD(cf. DWD 2013: 3).

The official weather alerts are made public via different media sources, e.g. via television, radio or the internet. The DWD furthermore has an alert application for smart devices called 'NINA' (*Notfall-Informations- und Nachrichten-App*, *emergency information and alert app*) (cf. Bundesregierung 2008: 76). Of special importance for the warning management in Germany is a satellite-based warning system called 'SatWas'. It is also operated by the DWD and is the official weather alert platform for the federal government of Germany, the *Länder* (federal states) and the official public-sector broadcaster (TV and radio). Besides the above mentioned institutions, also e.g. the Deutsche Bahn AG (*German Rail*) is using the 'SatWas' warnings. (Cf. Website BBK BUND 2015a).

Additionally Germany's emergency response units as for example the fire brigades, the Federal Agency for Technical Relief (*Technisches Hilfswerk, THW*), the federal police, the Federal State Ministries of the Interior and the German Red Cross (*Deutsches Rotes Kreuz, DRK*) receive weather alters via the 'fire brigade warning system FeWIS' (*Feuerwehr-Warnsystem, FeWIS*).

The DWD warning management consists of three warning levels. Warnings in the first level are given by an early warning system 48-120 hours (maximum five days) before of a possible event. These early warning are spatially unspecified and therefore relevant for the whole country. The second level of warning takes place 12-24 hours before an event. During this warning level, warning reports and advance information are distributed; again spatially unspecific. In the third warning level, detailed and official weather alerts are published on the spatial basis of counties/administrative districts. Warnings of level three can only be generated 12 hours or less ahead of a possible event. (Cf. DWD 2013: 13) Furthermore, emergency response units (fire brigades, THW, Federal Ministries of the Interior, police and others) receive special information 48 hours ahead of a likely event on its possible magnitude and extent. These advance information for emergency response units are updated five times a day. (Cf. DWD 2013: 11)

In Germany, civil protection belongs to be constitutional responsibilities of the 16 federal states. According to Art. 2 of the North Rhine-Westphalian 'law on fire safety, rescue and emergency services' (*Gesetz über den Brandschutz, die Hilfeleistung und den Katastrophenschutz, BHKG*), the specific responsibilities are split up between the municipalities, the counties and the federal state itself. In principle, municipalities are only responsible for fire protection and management and are asked to set up local fire prevention plans. Emergency management including disaster preparedness and response is up the counties and country free cities (like Essen). They have to prepare disaster prevention plans and must guarantee for the necessary technical equipment and personnel. The federal state comes into play in case of large scale disasters in order to coordinate the response activities of the counties. Moreover, the federal state financially supports the necessary investments of the municipalities and counties in buildings and technical infrastructure of emergency response.

According to §§ 35ff. BHKG, an action committee and a mission control are to be constituted under the lead of the country administrator or major of a country free city in order to introduce protection measures. (Cf. §33 BHKG). A mission control is responsible for the operative-tactical risk management, performed by a special action committee of fire brigade (*Feuerwehrstab*) with help of the approved aid organizations like the German Red Cross. The mission control is provided by the respective country or country free city and coordinates action forces, resources and measures to be conducted. (Cf. §34 BHKG) Furthermore it is responsible for the coordination of fire brigades, ambulance corps and emergency services (cf. §34 (1) BHKG).

In Germany, wind related hazards are understood as natural hazards (cf. §1 BHKG), which is why the fire brigades of counties and county free cities in Germany are legally obliged to lead the mission control and to implement prevention and defense measures (cf. §3 BHKG). Furthermore, in case of wind related hazards the fire brigades are responsible for supplying with constantly trained and educated operational personnel as well as resources, such as chainsaws (cf. §3 (1), (4) BHKG). Thereby, civil protection and a fast removal of damages to critical infrastructures by logging trees can be secured. Besides regular fire service, municipal volunteer fire brigades can be requested to help in operations concerning storms. (Cf. §11 Abs. 4 BGKH) In case of severe damages, fire brigade units from other counties can be requested, as far as these are not occupied with own, prior tasks (cf. §39 (1) BHKG).

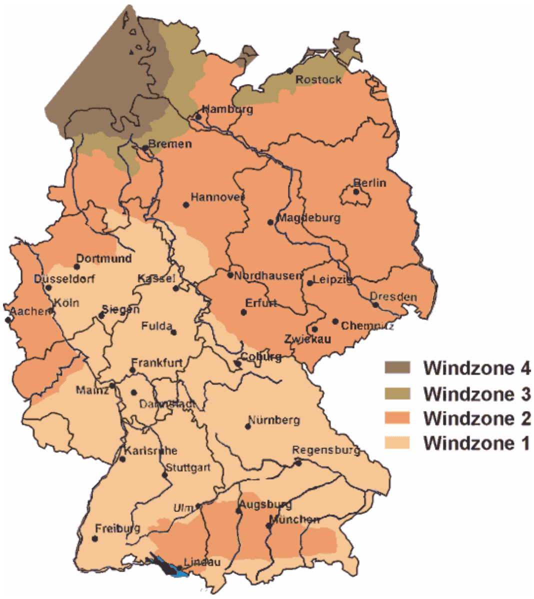
Last but not least, each adult citizen of Germany is committed to give aid in form of resources or manpower, if instructed so by the fire brigade. Property owners are furthermore under duty to implement safety precautions (*Verkehrssicherungspflicht*) on their property. (Cf. §43 (1-3) BHKG).

5.2. Infrastructure

As already described in the Croatian subchapter, the main European norm regarding wind loads is the European Norm DIN EN 1991-1 (also titled Eurocode 1), which was established in 1991. In Germany DIN EN 1991-1 was elaborated into national DIN 1055, regularly revised in cooperation with the German Meteorological Service. This norm is especially valuable for the parameters infrastructure and buildings, as the norm e.g. specifies for each type of building how the roof has to be constructed in order to withstand a certain amount of wind, snow and ice. In consequence, a building permission is only granted if the statics of the respective building take this technical norm into full account.

According to DIN 1055-4 there are four wind zones in Germany, ranking from zone one (inland regions with low velocity pressure on buildings) to zone four (mainly coast regions and islands with high velocity pressure on building). These four wind zones have the following spatial dimension in Germany (see Figure 10).

Figure 10 Basic wind speed map of Germany



Source: Eurocode 1

Table 5 contains the four German wind zones and their maximum velocity pressure in kN/m^2 for different building heights.

Table 5 Wind Zones according to Wind Load Norm (DIN 1055-4)

Wind Zones		Velocity Pressure in kN/m^2 at a building height *h** in the borders of:		
		h ≤ 10m	10m < *h* ≤ 18m	18m < *h* ≤ 25m
1	Inland	0.5	0.65	0.75
2	Inland	0.65	0.8	0.9
	Coast/Shore and Islands in the Baltic Sea	0.85	1.	1.10
3	Inland	0.8	0.95	1.10
	Coast/Shore and Island in the Baltic Sea	1.05	1.20	1.30
4	Inland	0.95	1.15	1.30
	Coast/Shore of the North Sea and Baltic Sea and Island in the Baltic Sea	1.25	1.40	1.55
	Island in the North Sear	1.40	-	-

**h = height of the building*
Source: Eurocode 1: Einwirkungen auf Tragwerke – Teil a-4

For some buildings - e.g. hospitals - and some public facilities it is necessary to have an emergency power supply in case high-voltage transmission lines are damaged and a blackout occurs. In Germany there are two DIN norms covering this necessity: DIN VDE 0100-710 and DIN VDE 0100-718. DIN VDE 0100-710 specifies the necessity for emergency power supply for medial locations, such as hospitals. It also contains the requirements for the medical personnel and patients, including behavioral precaution measures. DIN VDE 0100-718 specifies the necessity for emergency power supply for communal facilities and buildings, such as schools. It also describes how access needs to be guaranteed to evacuation routes and emergency exits. (Cf. DIN VDE 0100-710; DIN VDE 0100-718)

Apart from this level of an individual building, no wind related regulation is in force that influence land-use planning in Germany.

5.3. Transport

In Germany there are currently no regulations concerning transport infrastructure planning other than the above mentioned DIN 1055-4 (Eurocode 1). The national Annex of DIN EN 1991-1-4 also considers road and railroad bridges of up to 200 meters span width and pedestrian and bike bridges up to 30 meters span width. Furthermore, similar to the Croatian situation, wind speeds and wind gusts are considered when building bridges and other exposed transport infrastructures. Nevertheless, building precaution measures are currently estimated effective enough to neglect the wind exposure of future infrastructures.

Different to Croatia and Slovenia, there is no habit in closing highways and other roads in case of strong winds. Merely air traffic is sometimes limited due to high winds and as in Croatia, airplanes unable to land are redirected to the nearest acceptable airport, concerning capacity and weather condition.

In Germany the owners of the different transport infrastructure systems are responsible for the prevention of damages and the reparation in case of damages. In the case of roads the responsibility is e.g. divided between the Federal Government, the *Länder* (Federal States) and the Municipalities. The Federal Government has to cover cost occurring to *Autobahnen* (highways) and A-Roads, the *Länder* cover for B-Roads and the municipalities for municipal roads, each in their territory. (Cf. Fire Brigade Essen 2015)

5.4. Buildings

The most important DIN norm in the prevention of storm damages is the above mentioned DIN EN 1991-1-4 on wind loads. Additionally, there are two norms specifying the wind loads from DIN EN 1991-1-4 to windows (DIN EN 12210) and roofs and building fronts (DIN EN 18531). (Cf. Website Baunetzwissen 2016)

Another important document regarding buildings (and infrastructures) is the TRAS, the 'Technical Policies for Process Safety' (*Technische Regeln für die Anlagensicherheit, TRAS*). The TRAS originates from the ‚Federal Control of Pollution Act' (*Bundesimmissionsschutzgesetz, BImSchG*) and needs to be applied for any building which might be a source of hazard applying to the 'German Major Accidents Ordinance' (*Störfallverordnung*)[1]. The TRAS therefore considers possible loads that these potentially

[1] For example a nuclear power plant is a hazardous building according to the *Störfallverordnung*.

hazardous buildings might face. Besides wind, also snow and ice loads are described and prevention measures are included. The TRAS is regularly updated considering the latest state of the art. (Cf. BMUB 2015: 3)

In Germany there are several insurance companies that offer insurances for storm damages. If concluded, the insurance companies cover for (some) costs in case of storm damages. The insurances usually become operative in case of damages starting from Beaufort class 8 (approximately 60 km/h). It is differentiated into two sources of damages in the insurance policies: immediate damages and inevitable consequences from storms. While immediate damages result from e.g. a tree falling into an insured object, inevitable consequences result from subsequent costs to the immediate damage. An example for an inevitable consequence of an immediate damage would e.g. be that an insured car needs to be towed. (Cf. Website Haushaltsversicherungen 2016)

Municipalities can also conclude insurances for liability damages *(Kommunaler Schadensausgleich Westdeutscher St*ädte). If concluded, damage costs are covered by the federal budget. (Cf. City of Essen 2015)

5.5. Forests

The most important German law on forest management is the Federal Forest Law (*Bundeswaldgesetz, BWaldG*). Derived from the federal law each federal state has a State Forest Law (*Landeswaldgesetz/Landesforstgesetz, LFoG*), including forest master plans.

According to the BWaldG, forest owners are responsible for the management and therein the condition of the forests in Germany. The owner is required to cultivate the forest 'properly and sustainable' *("ordnungsgemäß und nachhaltig"*). (Cf. §11 (1) BWaldG). More detailed guidelines are described in the forest master plans according to the LFoGs. These master plans include specific statements on the forest stand and the intended development, including measures (cf. §8 LFoG NRW). The forest master plans shall also guide forest owners to cultivate the German forests in a sustainable way, including measures to prevent clearcuttings, measures to choose native tree species and measures to increase the regeneration/greening of forests (cf. §1b LFoG NRW).

In Germany, the entering of forests is always at people's own risk (cf. §14 Abs. 1 BWaldG). Specifications on this regulation may be necessary and are to be governed in the LFoGs. In case of storm damages, the entry of forest may completely be prohibited according to §14 (2) BWaldG.

Generally speaking each owner of a forest is responsible for clearing (storm) damages to forest trees; no matter if the forest is private property of publicly owned. The removal of fallen trees is usually conducted by the forestry commission offices of the municipalities or – in case of private property – by an assigned forest administration. (Cf. §6 LFoG NRW) Furthermore it is again the fire brigade which is able to assist in the removal of damages, as long as the damages pose a threat (cf. Fire Brigade Essen 2015).

6. Conclusions

In this document we assessed the legislation in project partner countries regarding various aspects of wind risk. Partner countries are Slovenia, Germany and Croatia. All countries are members of European Union and thus subject to laws of European Union, but regularly deliver national laws and annexes as well.

All countries have specialized state agency which is responsible for official measurement of meteorological conditions, forecasting and alarming. Although there are many amateur and unofficial forecasting and measurement associations these measurements are unofficial and cannot be used. Official warnings are given by state meteorological agency to the institutions responsible for protection and rescue.

Protection of population in case of strong wind event is organized according protection and rescue plans on local, regional and national levels. Risk assessment and Protection and rescue plans treat wind hazard as a natural hazard.

Infrastructure, transport infrastructure and buildings are obliged to be designed according to building norms. Eurocode norms are extended with national annexes to better fit location specificities.

Important issue in wind risk related legislation is lack of recommendations regarding road route planning in regards to dominant wind direction. This is the reason why some roads are closed during strong wind.

Protection of forest from strong wind should be taken into account in forest management plans that are responsibility of forest owners. There are no official or unified recommendations on how to protect forests from the strong wind, only experienced managers plan to plant more resistant trees in certain areas that can bring problems.

Strong wind events are often case in partners' countries, and should be better taken into account in country laws and policies to avoid further damages and losses. Lots of preventive and protective actions are not proscribed but are left on subjective evaluation.

7. References

Air traffic law (NN 69/09, NN 84/11, NN 54/13, NN 127/13 and NN 92/14)

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»With the contribution of the Civil Protection
Financial Instrument of the European Union«

Funded by
European Union
Humanitarian Aid &
Civil Protection

WIND RISK

Task C – Risk/Vulnerability assessment

Action C.6: Evaluation of socio-economic cost of the impacts of high wind disaster

For the Wind Risk prevention project

University of Ljubljana
Technical University of Dortmund
University of Split
Municipality of Ajdovščina

European Civil Protection
»With the contribution of the Civil Protection Financial Instrument of the European Union«
WIND RISK
Funded by European Union Humanitarian Aid & Civil Protection

Chapter C.6 – Evaluation of socio-economic cost of the impacts of high wind disaster

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1. Introduction

The Wind Risk prevention project aims to improve the effectiveness of existing policies and financial instruments through guidelines for local-based disaster risk reduction actions and tools in instances of high wind, also taking into account the influences of climate change. The main reason for the necessity of the project is to improve the understanding of high wind and wind gusts, to raise the awareness of wind risk and to improve the preparedness of national and civil protection, especially with regards to higher erratic winds due to the ongoing climate change.

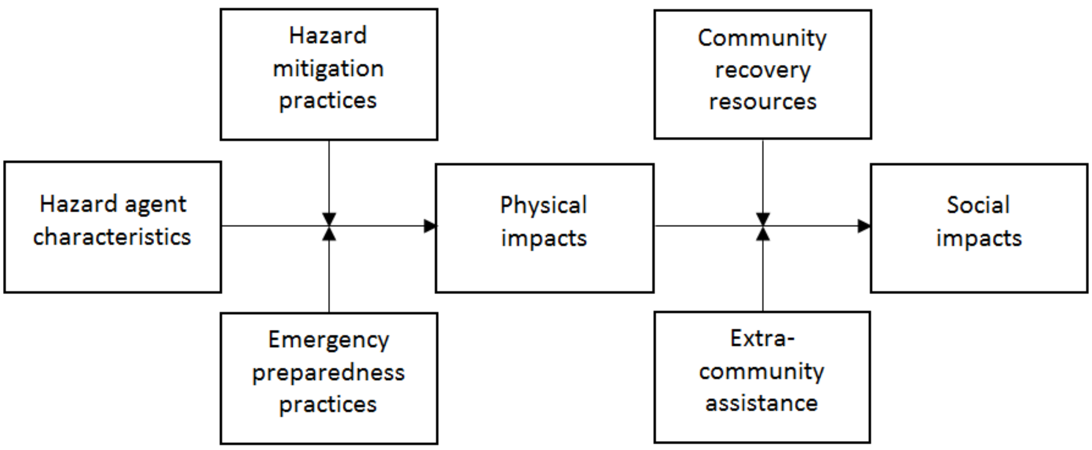
This document aims to describe connections between high wind phenomenon and type of cause of wind with social and economic impact the phenomenon has on population, infrastructure, transport, buildings and forests.

The document will evaluate case studies for local phenomenon in Central Dalmatia (Croatia), North Rhine Westphalia (Germany) Ajdovščina and Ljubljana (Slovenia).
The rest of the document consists of definitions and model for impact of natural disaster evaluation, general description of high wind events for each target area , evaluation of specific event for each target area.

2. Definitions and evaluation model

By the term **vulnerability** we consider the capacity of the buildings to withstand hazards (relates damage to hazard for a specific building type). Vulnerability can also be defined as exposure and susceptibility to losses. The term **hazard** can be defined as a potential threat to humans and their welfare. Hazard defines the risk that a property will sustain losses, in this case due to strong winds. A hazard's impact intensity can generally be defined in terms of the physical materials involved and the energy these materials impart. **Risk** is the probability of hazard occurrence. In addition, **wind risk** can be defined as probability that wind intensity measurement at a site exceeds a specified threshold within a time period of interest. Impacts of high wind disasters are both sociological and economic.

Figure 1: Model of evaluation of natural disasters



Source: Lindell and Prater, 2003

Social impact is the effect of an activity or event on the social fabric of the community and well-being of the individuals. On the other hand, economic impact is the effect that the event will have on the economic factors. In other words, the property damage caused by wind creates losses in asset values that can be measured by the cost of repair or replacement. In addition to before stated direct economic losses, there are indirect losses that arise from the interdependence of community subunits.

The model of evaluation (Lindell and Prater, 2003) of risk related costs is shown in Figure 1. The following paragraphs describe this model in detail.

Hazard agent characteristics – Defining hazard agents in terms of specific characteristics are often hard to define. Certain hazard can cause a number of different threats, e.g. volcanoes can impact human settlements through ash fall, explosive eruptions, lava flows, mudflows and floods, and forest fires. Still, the most important characteristics for assessing the impact of the disaster are its speed of onset and availability of perceptual cues (wind, rain, ground movement, intensity, scope, duration of the impact and the probability of occurrence). The above mentioned attributes determine the extent of casualties among the population and the degree of damage to structures in the affected area. The impact intensity of a natural hazard can be defined in terms of the physical materials involved and the energy that these materials impart. The physical materials involved in disasters differ in terms of their physical state. Strong wind is hazardous because it can destroy structures and accelerate debris that can itself cause traumatic injuries. The scope of impact defines the number of affected social units (individuals, households, and businesses).

Physical Impacts of Disasters – The physical impacts of disasters refer to casualties, deaths and injuries and property damage. All these significantly vary across hazard agents.
Determining the rate of deaths and injuries that are "due to" a disaster is sometimes very hard or even impossible. For example, sometimes it is impossible to determine the number of missing persons and if this is due to death. Furthermore, some casualties are indirect consequences of hazard agents.

Damage and destruction of structures, animals and crops are likewise important measures of physical impacts. These kinds of losses are usually result of physical damage or destruction, but can be also a result of other losses. Damage to the built environment can be affecting residential, commercial, industrial, infrastructure or community services sector. Damage within each of the named sectors can be divided into damage to structures and contents, and it is usually the case that damage to contents results from collapsing structures.

Similar to estimation of casualties the estimation of losses to the built environment is likely to error. Damage can be estimated properly when trained damage assessors enter each building to assess the percent of the damage to each of the major structural systems.

Some other important physical impacts relate to damage or contamination to cropland, rangeland and woodland. Such impacts may be well understood for some hazard agents, but not for others.

Hazard Mitigation Practices – way of coping with the physical impact of disaster is adopting the hazard mitigation practices. Hazard mitigation practices can be defined as pre-impact actions that protect passively against casualties and damage at the time of hazard impacts, as opposed to and active emergency response. Hazard mitigation practices include community protection works, land use practices and building construction practices. This can be achieved by building construction practices that make individual structures less vulnerable to natural hazards, e.g. elevating structures out of flood plains, designing structures to respond more effectively to lateral stresses, and providing window shutters to protect against wind pressure and debris impacts.

Emergency Preparedness Practices – Adopting emergency preparedness practices are another way of reducing disaster's physical impacts. This can be defined as pre-impact actions that provide the human and material resources needed to support active responses at the time of hazard impact. It is essential to identify the demands that a disaster of given magnitude would place upon the community. The following four basic emergency responses can be used to meet these demands: emergency assessment, expedient hazard mitigation, population protection and incident management. Emergency assessment correspond to those actions that define the potential scope of the disaster impacts; expedient hazard mitigation corresponds to short term actions that protect property; population protection actions protect people from impacts and incident management actions activate and coordinate the emergency response. Determining which community organization will be responsible for achieving each function is the following step. Finally, every organization must acquire response resources personnel, facilities and equipment to implement their plans. After that they need to maintain preparedness for emergency response by continuous planning, training, drills and exercises.

Social Impacts of Disaster – Social impacts include psychosocial, socio-demographic, socioeconomic and sociopolitical impacts. These can develop over a long period of time, and can be difficult to assess. Although there can be difficulties in assessing social impacts it is very important to observe them because they can cause considerable problems for the long-term functioning of specific types of households and businesses in affected community. Monitoring can also provide us better understanding of disasters social impacts, which can further provide a basis for pre-impact prediction and development of plans for prevention of adverse consequences occurrence.

Community Recovery Resources – Community recovery resources originate from a variety of individuals and organizations. Victims can have financial and tangible assets, depending on their income. Furthermore, depending on their level of income, victims can be more or less prone to become victims of insurance redlining. Victims can promote their recovery by overtime work and consumption reduction. Also, other people can assist recovery through financial and in-kind contribution. On the other hand, the impact of a disaster on the housing recovery of affected households depends upon a number of community characteristics. One of these is the availability of housing vacancies, which vary by size, quality, and price, as well as location.
Recovery resources can be administrative as well as financial. Some of the needed financial resources come from the house- holds themselves, but kin networks are another major source of assistance.

Extra-Community Assistance – Extra-community assistance can be obtained from a variety of sources as well. One major source is nongovernmental organizations (NGO) in-kind contributions of goods, food, medicine, shelter and services. These organizations can also provide financial support through grants and low-interest loans. The amount and timeliness of extra-community assistance depends upon the resources that remain undamaged in the remainder of the country, which is a function of the disaster's impact ratio. Also, important factor is the degree to which a community is vertically integrated with higher levels of government and horizontally integrated with other jurisdictions at the same level of government. Communities that are more strongly integrated are more likely to receive the resources they need to recover.

3. High wind events assessment in Split area

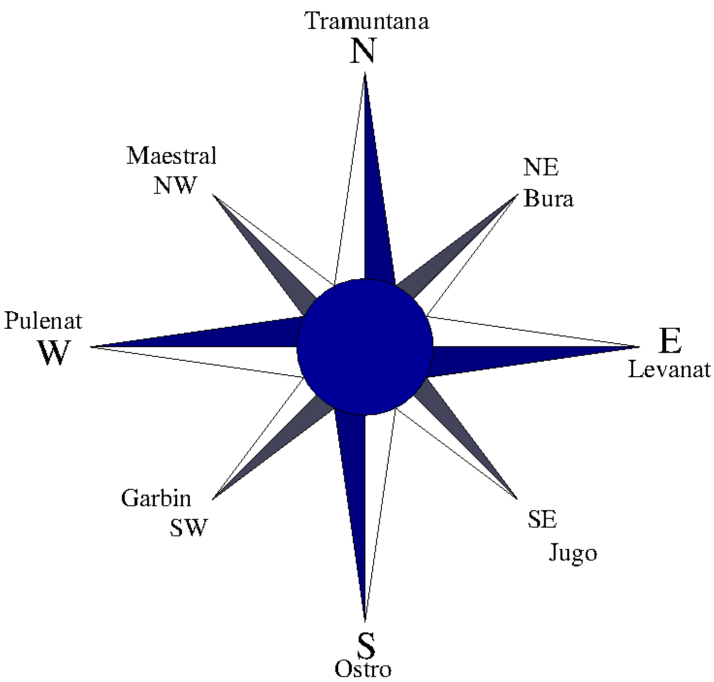
Regardless of its mild climate conditions, Split, its surroundings and the whole Dalmatia County occasionally suffers from strong winds, gusty winds or other kinds of troublesome winds.

Generally, winds in the Adriatic area are stronger and more frequent during the winter. Most frequent winds in Dalmatia are Bora (bura) from the North-east and South wind (Jugo or Široko) from the South-east. Both of these winds can blow for several days and can be strong enough to cause interruption of land, air and sea transportation. Winds form the West and South-west quadrant called Pulenat and Garbin (or Lebić) usually do not last long but can be very dangerous as they come suddenly and develop violent squalls.

Wind-rose with winds from eight main directions for the Dalmatia County is given in Figure 2. However, due to configuration of the Croatian coast line with high mountains rising directly from the sea forming a natural obstacle to the normal atmospheric air-flow, wind direction can significantly vary for different micro locations.

3.1. Winds in Dalmatia

Figure 2: Wind-rose with eight main winds for the Dalmatia County



Source : Self depiction

Bora is a cold wind blowing horizontally up of coastal peaks towards the sea. It raises sea dust thus decreasing visibility. Since it brings cold and heavy air, it finds its way to the sea through mountain faults and between higher ranges. The area where some of the strongest bora winds occur is the Velebit mountain range in Croatia. This seaside mountain chain, spanning 145 kilometers, represents a huge weather and climatic divide between the sharp continental climate of the interior, characterized by significant day/night temperature differences throughout the year, and the Adriatic coast, with a Mediterranean climate. Bora occurs because these two divided masses tend to equalize. Similar situation is in the region of mountain Biokovo, second-highest mountain range in Croatia. Biokovo is located along the coast of the Adriatic sea, between the rivers Vetina and Neretva.

Levanat is an moderate easterly wind which usually brings clouds and moisture. It usually occurs as transition from bora to jugo or vice versa and does not last long.
Sirocco (jugo or šiloko) is a wind from the southeast. It blows along the Adriatic while a cyclone is coming above the Adriatic area, usually bringing clouds and rain. The air pressure drops. It develops slowly and can usually be noticed two or three days before. It usually lasts much longer than Bora, five to seven days, and even longer in winter. Unlike Bora, Sirocco is a constant wind, and usually intensifies steadily and gradually. On the sea, Sirocco develops huge waves, especially on the southern parts of the Adriatic sea.

Oštro is warm and humid south wind, usually moderate to strong.

Garbin is gusty wind from the South-west quadrant which comes suddenly and can reach stormy energy. If does not last long but it is considered one of the most dangerous winds on the Adriatic sea. It is especially dangerous when Jugo deflects to Garbin, resulting in huge wave crossings on the open sea and rising of the sea level due to cyclonic tide, with strong impacts of huge waves in harbors that are partially open to the south-west.

Pulenat is short-lived wind from the West which comes suddenly and can be dangerous in winter. During summer, pulenat is usually mild to moderate wind.

Maestral is a summer daily wind, created by the differences in temperature between the mainland and the sea, blowing from the North-west. It usually starts before midday, reaching its top strength at the afternoon and fades at the sunset. It is usually not to strong but sometimes can deflect to Tramuntana and Bura which can be dangerous on the sea.

Tramuntana is local and short-time wind blowing from the North. It can be moderate to strong but usually not so strong and dangerous as Bura.

3.1.1. Wind monitoring and alarming

The Croatian Meteorological and Hydrological Service (DHMZ) is Croatia's national agency for weather forecasts. It produces operational weather forecasts and supplies them to the other agencies, especially County 112 Centre, which is part of National Protection and Rescue Directorate. Based on reports and warnings received from DHMZ, County 112 center communicates with County Prefect or County Chief of Staff of protection and rescue.
Based on weather forecasts DHMZ can state different levels of alert within Meteoalarm system. The levels are as follows:

- Green - No particular awareness of the weather is required.
- Yellow - The weather is potentially dangerous. The weather phenomena that have been forecast are not unusual, but be attentive if you intend to practice activities exposed to meteorological risks. Keep informed about the expected meteorological conditions and do not take any avoidable risk.
- Orange - The weather is dangerous. Unusual meteorological phenomena have been forecast. Damage and casualties are likely to happen. Be very vigilant and keep

regularly informed about the detailed expected meteorological conditions. Be aware of the risks that might be unavoidable. Follow any advice given by your authorities.

- Red - The weather is very dangerous. Exceptionally intense meteorological phenomena have been forecast. Major damage and accidents are likely, in many cases with threat to life and limb, over a wide area. Keep frequently informed about detailed expected meteorological conditions and risks. Follow orders and any advice given by your authorities under all circumstances, be prepared for extraordinary measures.

3.1.2. Observed impacts of wind conditions

Parts of roads are sometimes closed to avoid danger of wind force impact on vehicles. This is especially applicable to bridges, where side impact of wind is very dangerous. If there are restrictions in land transportation HAC (*Hrvatske autoceste* – Croatian Highways) in cooperation with HAK (*Hrvatski autokub* – Croatian Automobile Club) gives warning on restriction of movement due to strong winds or other meteorological phenomena when these phenomena exceed safety parameters measured by the instruments on a highway.

Ferry lines are interrupted on the sea in case of strong winds and high waves. Marine meteorological service in the Adriatic Sea (PMC), which is part of the Meteorological and Hydrological Institute, publishes weather reports and warnings about bad weather, synoptic data and weather forecasts for seafarers. In accordance with the received warning and its assessment the port can be closed or ship can be prohibited from sailing out. Decision on canceling ferry and regular ship lines is issued by Agency for Coastal Line Marine Transportation (*Agencija za obalni linijski pomorski promet*).

Air traffic control can limit or completely interrupt operation of air traffic due to weather conditions. However, flights are more often canceled by airline company bases on the aircraft “maximum cross-wind component” declared by the manufacturer or by aircraft pilot after unsuccessful landing attempt. Split airport was never officially closed due to strong wind.

Variations in wind direction and gust with relation to terrain configuration, like gorges, can cause danger with high intensity. In latest years, as a result of global warming, besides winds, whirlwinds occur more regularly in Dalmatia. This kind of circular wind can damage property, agricultural crops and can even cause casualties. Real time monitoring of wind conditions, prediction of danger and proper reaction can decrease the cost of damage the wind is causing.

4. Evaluation of the specific events in Croatia

In this document we will review two specific events from year 2015 with interesting consequences. First is the sirocco happened at the end of the January, an event that was discussed widely in the Croatian media because of its specificity and high impact. Second is the bora at the beginning of the march. This event caused many damages which are well documented since there was official natural disaster proclamation after the event.

4.1. Sirocco in the end of January

The following chapter gives and overview of strong Sirocco on the 30th to 31th of January 2015 in the area of Split.

4.1.1. Event situation description

DHMZ stated red alert for the dangerous weather conditions at the area of Split and Dubrovnik. The alert was stated for the South and South-west wind with average velocity exceeding 65km/h and gusts exceeding 95km/h. Visibility reduced due to rain and showers. Waves, higher than 2 meters, submerged waterfronts in numerous coastal cities.

Most critical situation was in the town of Komiža at the island Vis. Strong sirocco was blowing from the early morning with the atmospheric pressure at 975 millibars. On the approximately 20:00 at the evening Sirocco deflected to squall Garbin with violent storm wind gusts above 70 knots (130km/h) with high waves and cyclonic tide. Komiža harbor is open to the south-west which resulted in damage to the infrastructure, private property and injuries.

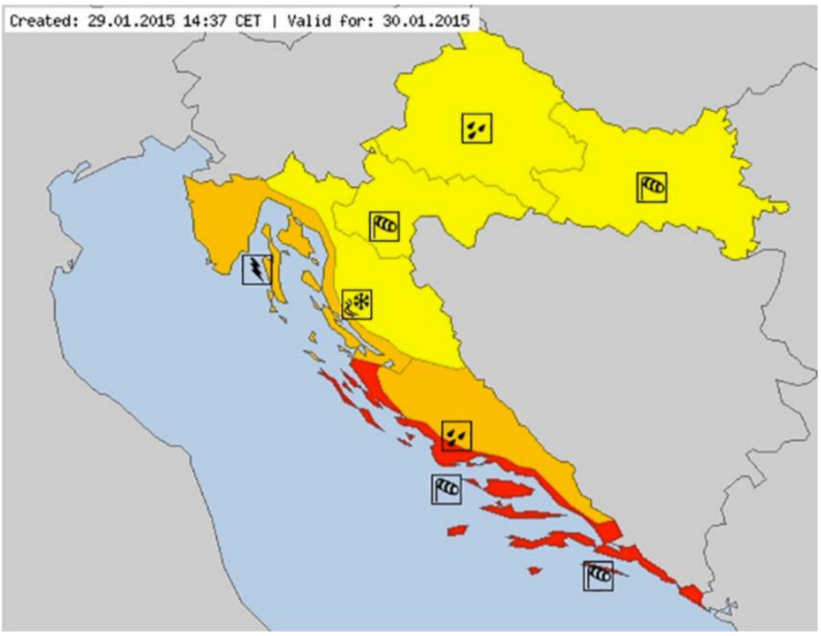
Figure 3: High waves stroke Komiža harbor

Source: Foto by Tonio Vitaljic

Figure 4: High waves stroke Komiža harbor

Source: Foto by Tonio Vitaljic

Figure 5: Alert levels for the date of strong Sirocco in January



Source: DHMZ (Državni hidrometeorološki zavod)

The wind caused great damage. Maritime transportation was paralyzed due to high waves and great wind speed. Small boats along the coast were sunken and damaged and some waterfronts were flooded. Also some taverns and facilities by the sea suffered flooding.

4.1.2. Wind measurements during event

Presented data is provided by the Split Airport meteorological service. Data includes measurements at the Split airport:

Split / Resnik (Croatia)
Lattitude: 43.5384112N
Longitude: 16.2982097E
Attitude: 19m

Split airport is located near the town of Kaštela. Airport is located in partly sheltered site. Split airport is protected from bora by mountain Kozjak, which stretches from the pass of Klis in the southeast, to the above Split airport in the northwest. From the south and south-west, airport is protected by island Čiovo, while peninsula of Split protects airport from the winds from east.

All data used in this chapter is publicly available from OGIMENT Weather Information Service (http://www.ogimet.com/).

Table 1: Wind measurements at the Split Airport

Date	Time	Direction	Wind speed (kt)	Gust (kt)	Atm. Pressure (mbar)
2015/01/30	00:00		09		0994
2015/01/30	00:30	090	11		0993
2015/01/30	01:00	090	09		0992
2015/01/30	01:30	120	10		0991
2015/01/30	02:00	150	08		0990
2015/01/30	02:30	140	09		0989
2015/01/30	03:00	120	15	25	0989
2015/01/30	03:30	120	15	25	0988

Date	Time	Direction	Wind speed (kt)	Gust (kt)	Atm. Pressure (mbar)
2015/01/30	04:00	120	15	25	0987
2015/01/30	04:30	150	14	25	0986
2015/01/30	05:00	160	14	24	0986
2015/01/30	05:30	150	14	26	0985
2015/01/30	06:00	150	15	25	0984
2015/01/30	06:30	150	15	25	0984
2015/01/30	07:00	160	15	26	0983
2015/01/30	07:30	160	15	25	0983
2015/01/30	08:00	160	13	24	0983
2015/01/30	08:30	160	15	25	0982
2015/01/30	09:00	160	15	25	0981
2015/01/30	09:30	160	15	25	0981
2015/01/30	10:00	170	15	25	0981
2015/01/30	10:30	160	16		0980
2015/01/30	11:00	170	12	22	0979
2015/01/30	11:30	160	11		0979
2015/01/30	12:00	230	12		0979

Date	Time	Direction	Wind speed (kt)	Gust (kt)	Atm. Pressure (mbar)
2015/01/30	12:30	210	13		0978
2015/01/30	13:00	190	10		0978
2015/01/30	13:30	190	14		0978
2015/01/30	14:00	200	15	25	0977
2015/01/30	14:30	220	16	26	0977
2015/01/30	15:00	230	17		0978
2015/01/30	15:30	150	06		0977
2015/01/30	16:00	330	04		0976
2015/01/30	16:30		03		0976
2015/01/30	17:00	280	15	25	0977
2015/01/30	17:30	270	18	31	0977
2015/01/30	18:00	270	24	37	0978
2015/01/30	18:30	280	08		0978
2015/01/30	19:00	280	08		0979
2015/01/30	19:30	290	04		0978
2015/01/30	20:00	270	17	27	0980
2015/01/30	20:30	270	18		0981

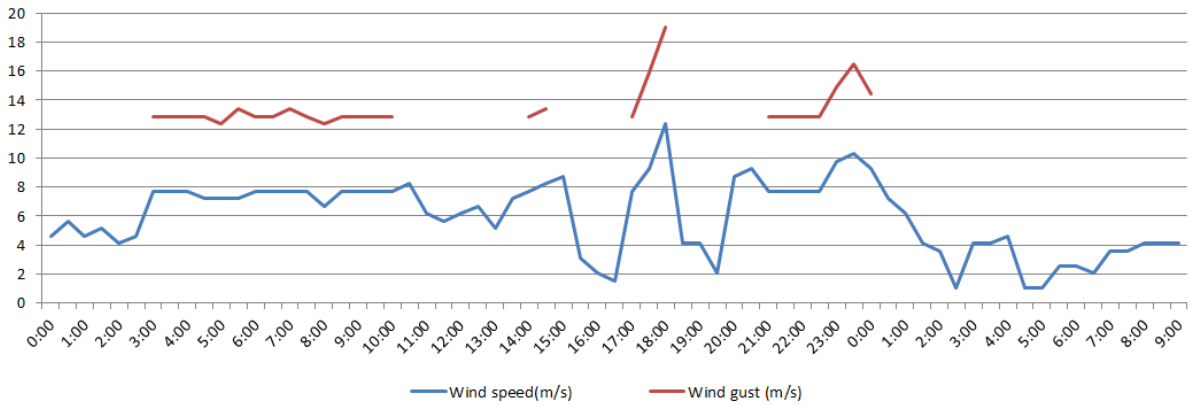
Date	Time	Direction	Wind speed (kt)	Gust (kt)	Atm. Pressure (mbar)
2015/01/30	21:00	280	15	25	0981
2015/01/30	21:30	280	15	25	0981
2015/01/30	22:00	280	15	25	0982
2015/01/30	22:30	270	15	25	0983
2015/01/30	23:00	260	19	29	0984
2015/01/30	23:30	280	20	32	0985
2015/01/31	00:00	300	18	28	0985
2015/01/31	00:30	310	14		0985
2015/01/31	01:00	300	12		0986
2015/01/31	01:30	310	08		0986
2015/01/31	02:00	320	07		0987
2015/01/31	02:30		02		0987
2015/01/31	03:00	300	08		0987
2015/01/31	03:30	310	08		0987
2015/01/31	04:00	310	09		0987
2015/01/31	04:30		02		0987
2015/01/31	05:00		02		0988

Date	Time	Direction	Wind speed (kt)	Gust (kt)	Atm. Pressure (mbar)
2015/01/31	05:30	330	05		0989
2015/01/31	06:00	340	05		0989
2015/01/31	06:30	320	04		0989
2015/01/31	07:00	060	07		0989
2015/01/31	07:30	040	07		0989
2015/01/31	08:00	070	08		0989
2015/01/31	08:30	080	08		0990
2015/01/31	09:00	100	08		0991

Source: OGIMENT Weather Information Service

Time series of wind speed and wind gusts from above table is shown in Figure 6.

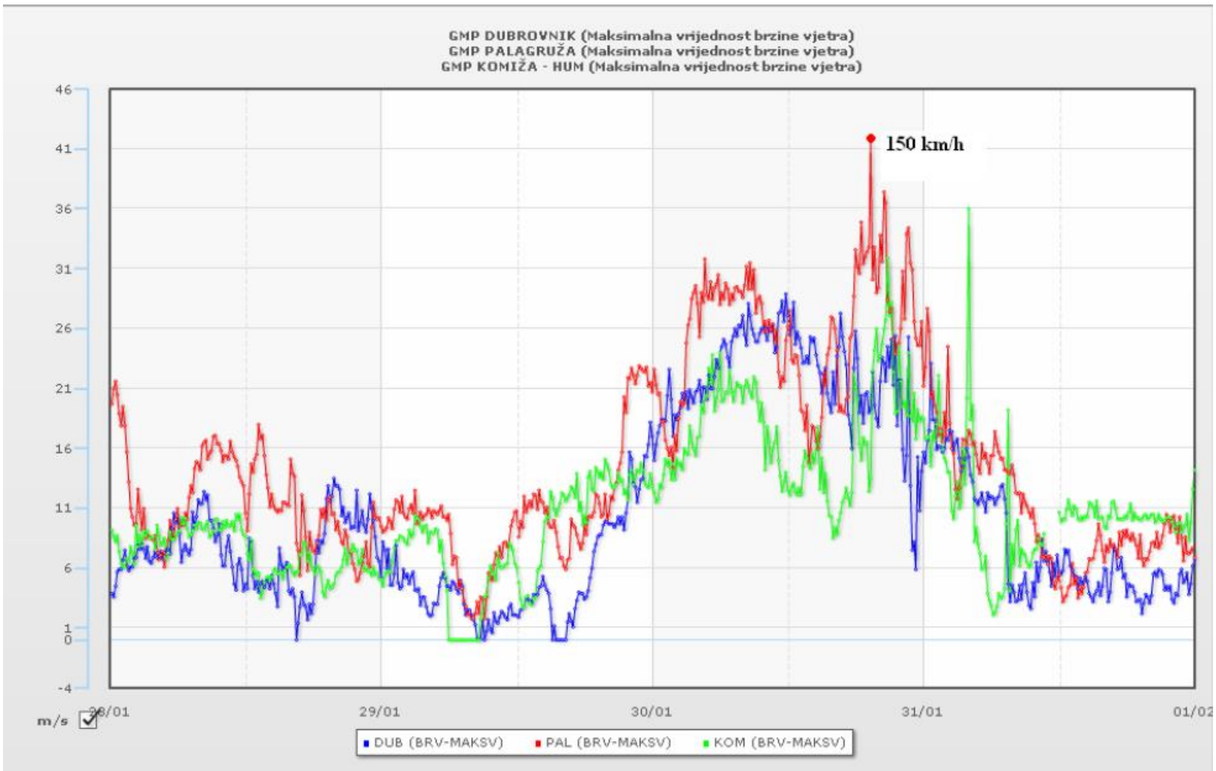
Figure 6: Wind speed and wind gusts during strong Sirocco in January 2015



Source: OGIMENT Weather Information Service

Official measurements of DHMZ during the event are shown in figure

Figure 7. Wind gusts during the event of Sirroco in January 2015



Source (Fister,Botica,2015)

4.1.3. Social impact of wind disaster

Most of major Internet portals broadcasted the news about the harsh weather in the Country. TV and radio stations regularly informed residents about weather conditions and weather changes. Internet portals inform about blocked roads, paralyzed maritime transport and damage on properties.

Worst situation was in Komiža where Sirroco turned to Garbin in the night from 30. to 31. January and developed violent storm strength. High waves stroke Komiža from the South-west in combination with cyclonic tide, resulting in 7 meters of waterfront destroyed. Waves and pieces of waterfront, some weighing more than half a ton, broke the doors and wall of the house facing the waterfront injuring two womens inside. Several boats where damaged or immersed.

Figure 8: Destroyed waterfront in Komiža

Source: Dalmacija News

Figure 9: Debris from the waterfront destroyed the house wall, two women were injured inside the house

Source: Dalmacija News

4.1.4. Economic impact of wind disaster

There is no official data on economic impacts for this event as natural disaster was not declared and there was no official damage assessment report. Based on the data collected from the media reports, the most serious consequences where recorded in the town of Komiža where sirocco turned to violent storm garbin wind. Seven meters of stone waterfront was destroyed. Reinforced wall along the street was also destroyed. In the other parts of the port harbor infrastructure was damaged. At least six private boats where broken and submerged. Streets near the harbor where flooded and impassable due to scattered debris. On the house facing the waterfront house wall was destroyed by huge waves and stones detached from the waterfront wall. The interior of the house was destroyed at ground floor.

Storm also hit other towns in Dalmatia. In Šibenik wind and heavy rain resulted in damages on infrastructure, public facilities and private property. At least ten private boats were stranded or submerged.

Figure 10: Man trying to save boat near Šibenik

Source: www.24sata.hr

Debries and flood made streets impassable in Primošten. Boulders from the wave buffer were dumped on the coast in the streets and yards of the nearby houses. Several boats was destroyed in Dolac near Primošten. Streats were also flooded in Vodice and Trogir. In Rogoznica part of the waterfront was destroyed.

Roads were closed in several places due to fallen trees.

Figure 11: Flooded waterfront in Vodice

Source: Šibeniški portal

Figure 12: Flooded streats in Brodarica near Šibenik

Source: Šibeniški portal

Figure 13: Destroyed waterfront in Rogoznica

Source: Šibeniški portal

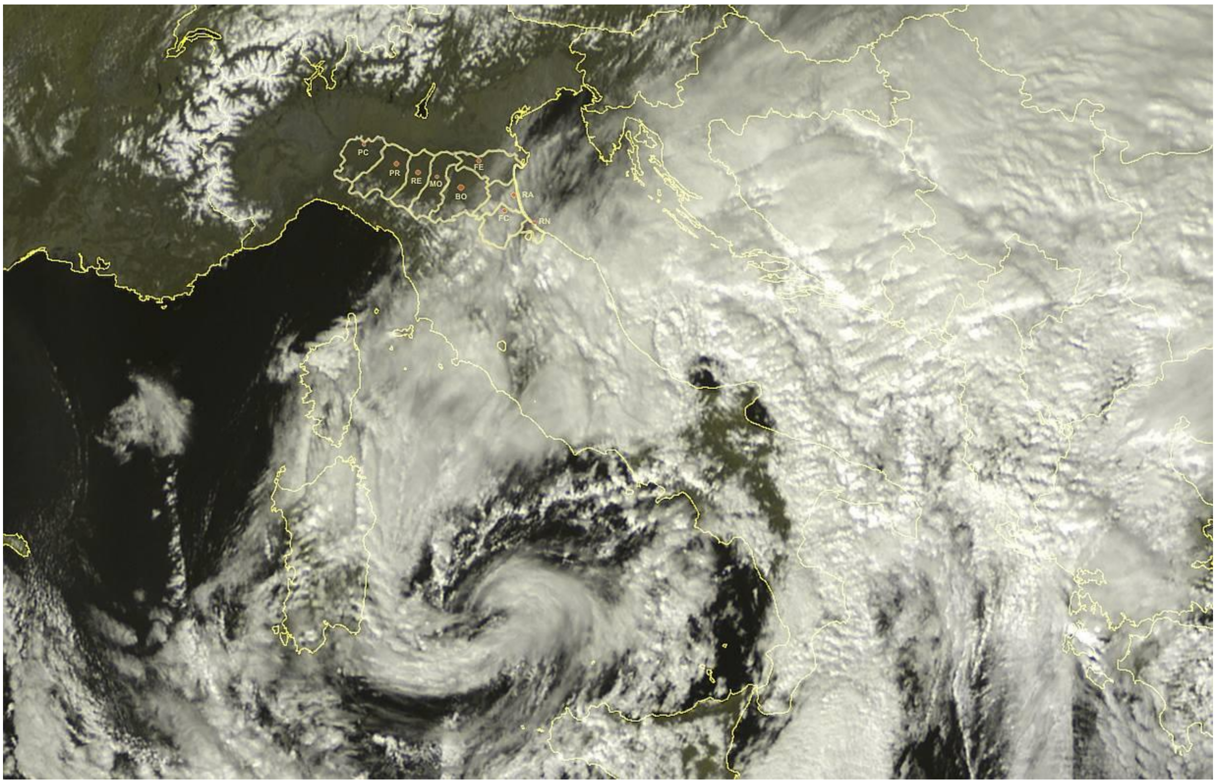
4.2. The first Bora of March

Following chapter provides data for events that occurred in the Split area – the city of Split, municipality of Dugi Rat and municipality of Podstrana during the period of 5th to 7th of March 2015.

4.2.1. Event situation description

Strong gusts of Bora starting from 4th or 5th of March 2015. were announced by the DHMZ. Predicting the strong gusts red alert, which is the highest level of alert in Croatia, was stated on the 5th of March 2015. This event adopted a number of problems along the coast, especially in Dalmatia. After 18 hours on the 5th of March the official weather station on the hill of Marjan recorded gust at speed of 165.7 km/h naming this storm the strongest in Split since November 2004. Previous strong gusts of Bora were recorded the month before, and the maximum speed of gust was 155 km/h.

Figure 14: Satellite image of the Rea cyclone taken on 5th of March 2015.



Source: (Fustar, Botica,2015)

National protection and Rescue Directorate, in their short report stated that the storm winds have caused problems throughout the Split-Dalmatia County. Facades of buildings and roofs of houses and apartment buildings have suffered damage. There were occasional interruptions in the supply of electricity to consumers in the whole area, and were difficulties in the overall traffic. There were no injured people, and there were no reports of marine pollution. Marine Metrological Center Split in its warning stated the wind on a part of the Adriatic above 100 knots, for the first time in its history. Predicted maximum was later 130 knots (130 knots is approximately more than 240 km/h).

The overall conclusion for the given area is that this Bora caused enormous material damage and was life-threating. The city of Split and the municipality of Podstrana declared the state of natural disaster for the given period. It demolished facades and roofs, tore down traffic signs, street lighting, billboards and mostly trees. In terms of traffic, local and international marine traffic were completely paralyzed and most of the roads in Dalmatia were closed due to harsh weather conditions.

4.2.2. Wind measurements during event

Presented data is provided by the Split Airport meteorological service. Data includes measurements at the Split airport. The same source of data applies as the data from previous event.

Table 2: Wind measurements at the Split Airport

Date	Time	Direction	Wind speed (kt)	Gust (kt)	Atm. Pressure (mbar)
2015/03/04	23:00	050	07		1013
2015/03/04	23:30	040	09		1013
2015/03/05	00:00	040	16	28	1013
2015/03/05	00:30	040	20		1013
2015/03/05	01:00	040	21	32	1012
2015/03/05	01:30	040	23	33	1012
2015/03/05	02:00	040	22	32	1012
2015/03/05	02:30	040	23		1012
2015/03/05	03:00	030	25	38	1011
2015/03/05	03:30	040	25	37	1011
2015/03/05	04:00	040	25	35	1011

Date	Time	Direction	Wind speed (kt)	Gust (kt)	Atm. Pressure (mbar)
2015/03/05	04:30	040	24	37	1011
2015/03/05	05:00	040	27	42	1011
2015/03/05	05:30	040	27	45	1010
2015/03/05	06:00	040	25	42	1010
2015/03/05	06:30	050	24	43	1010
2015/03/05	07:00	040	31	45	1010
2015/03/05	07:30	040	27	40	1010
2015/03/05	08:00	050	20	31	1010
2015/03/05	08:30	050	28	45	1009
2015/03/05	09:00	050	28	47	1009
2015/03/05	09:30	050	27	50	1009
2015/03/05	10:00	040	29	46	1009
2015/03/05	10:30	050	25	43	1010
2015/03/05	11:00	040	34	50	1009
2015/03/05	11:30	030	32	56	1009
2015/03/05	12:00	050	26	45	1009
2015/03/05	12:30	040	33	50	1009

Date	Time	Direction	Wind speed (kt)	Gust (kt)	Atm. Pressure (mbar)
2015/03/05	13:00	050	27	40	1008
2015/03/05	13:30	050	31	53	1008
2015/03/05	14:00	050	27	53	1008
2015/03/05	14:30	050	34	56	1008
2015/03/05	15:00	040	35	61	1008
2015/03/05	15:30	040	34	50	1008
2015/03/05	16:00	050	33	54	1008
2015/03/05	16:30	040	32	60	1008
2015/03/05	17:00	040	40	65	1008
2015/03/05	17:30	040	35	54	1009
2015/03/05	18:00	060	23	38	1011
2015/03/05	18:30	050	29	52	1010
2015/03/05	19:00	050	36	59	1010
2015/03/05	19:30	050	26	50	1010
2015/03/05	20:00	050	25	50	1011
2015/03/05	20:30	060	27	52	1012
2015/03/05	21:00	070	24	40	1013

Date	Time	Direction	Wind speed (kt)	Gust (kt)	Atm. Pressure (mbar)
2015/03/05	21:30	060	29	47	1013
2015/03/05	22:00	060	23	27	1013
2015/03/05	22:30	040	31	51	1013
2015/03/05	23:00	040	30	48	1013
2015/03/05	23:30	040	32	47	1014
2015/03/06	00:00	040	34	50	1014
2015/03/06	00:30	040	35	52	1014
2015/03/06	01:00	040	34	54	1014
2015/03/06	01:30	030	36	53	1015
2015/03/06	02:00	040	35	53	1015
2015/03/06	02:30	30	36	53	1015
2015/03/06	03:00	040	35	49	1016
2015/03/06	03:30	030	35	52	1016
2015/03/06	04:00	030	31	45	1016
2015/03/06	04:30	030	33	56	1017
2015/03/06	05:00	030	32	46	1017
2015/03/06	05:30	030	34	45	1018

Date	Time	Direction	Wind speed (kt)	Gust (kt)	Atm. Pressure (mbar)
2015/03/06	06:00	030	37	50	1018
2015/03/06	06:30	030	36	50	1018
2015/03/06	07:00	030	34	47	1019
2015/03/06	07:30	030	35	51	1020
2015/03/06	08:00	030	34	47	1020
2015/03/06	08:30	030	35	55	1020
2015/03/06	09:00	030	31	43	1020
2015/03/06	09:30	030	35	52	1020
2015/03/06	10:00	030	33	46	1021
2015/03/06	10:30	030	27	41	1021
2015/03/06	11:00	030	23	37	1021
2015/03/06	11:30	030	24	37	1022
2015/03/06	12:00	040	31	46	1022
2015/03/06	12:30	030	32	45	1022
2015/03/06	13:00	040	37	48	1021
2015/03/06	13:30	040	32	46	1021
2015/03/06	14:00	030	32	47	1021

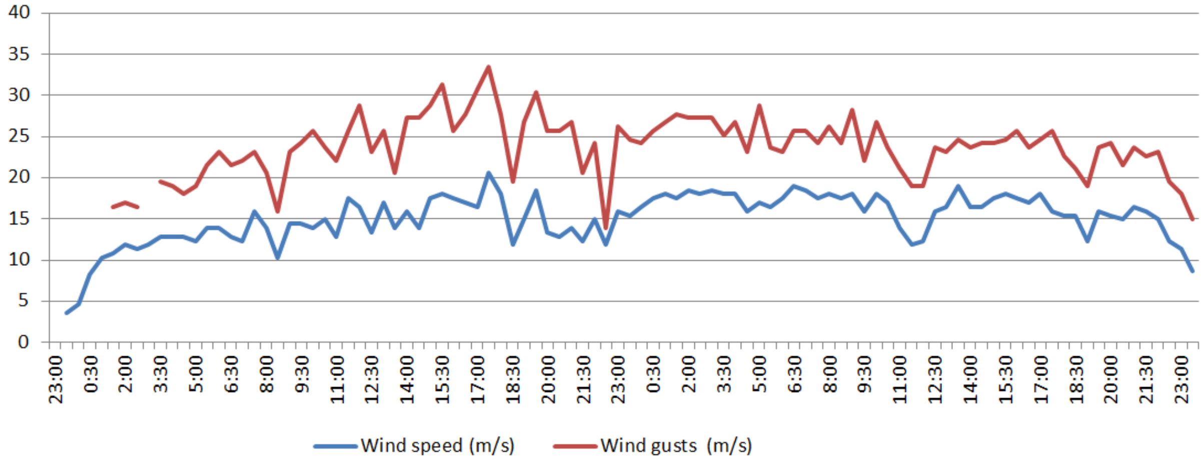
Date	Time	Direction	Wind speed (kt)	Gust (kt)	Atm. Pressure (mbar)
2015/03/06	14:30	030	34	47	1021
2015/03/06	15:00	030	35	48	1021
2015/03/06	15:30	040	34	50	1021
2015/03/06	16:00	030	33	46	1021
2015/03/06	16:30	030	35	48	1022
2015/03/06	17:00	030	31	50	1022
2015/03/06	17:30	030	30	44	1023
2015/03/06	18:00	030	30	41	1023
2015/03/06	18:30	020	24	37	1023
2015/03/06	19:00	030	31	46	1023
2015/03/06	19:30	030	30	47	1023
2015/03/06	20:00	030	29	42	1023
2015/03/06	20:30	030	32	46	1024
2015/03/06	21:00	030	31	44	1023
2015/03/06	21:30	040	29	45	1023
2015/03/06	22:00	030	24	38	1024
2015/03/06	22:30	040	22	35	1024

Date	Time	Direction	Wind speed (kt)	Gust (kt)	Atm. Pressure (mbar)
2015/03/06	23:00	050	17	29	1025

Source: OGIMENT Weather Information Service

Time series of the data is shown graphically in Figure 15.

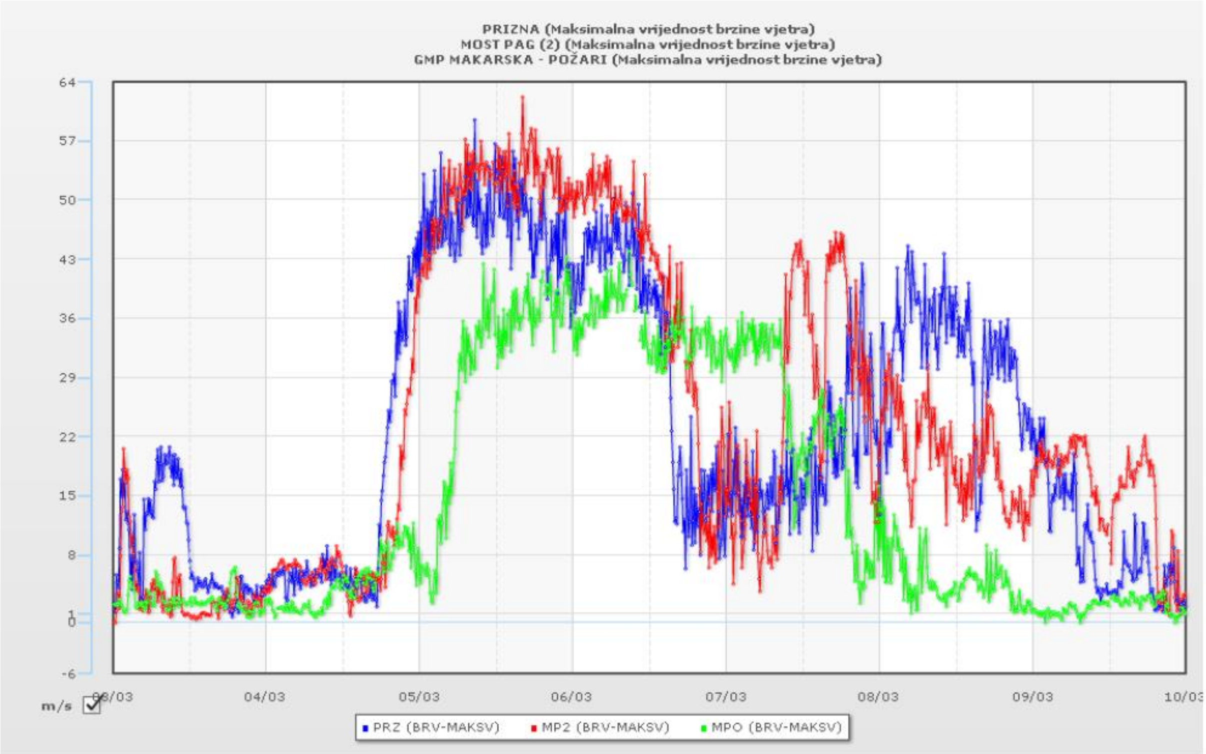
Figure 15: Wind speed and wind gusts during strong Bora in March 2015



Source: OGIMENT Weather Information Service

For comparison, official data for wind gusts during this event are shown in Figure 16.

Figure 16. Wind gusts in three measurement stations during the event of Bora in March 2015.



Source: (Fistar, Botica,2015)

4.2.3. Social impact of wind disaster

The following paragraphs present official data on social impact of natural disaster stated for the city of Split, municipality of Podstrana and municipality of Dugi Rat. Natural disaster was declared during the period of 5th to 7th of March 2015 when violent storm raged throughout the region.

During the period there was no information of human casualties, i.e. no reported deaths. Injuries were reported by fallen trees and branches. Truck driver was injured when bora overturn its truck on the Split-Dugopolje fast road.

Croatian Electrical Utility (Hrvatska elektroprivreda) reported that at least 16000 households lose power in the Dalmatia region. In Rijeka region elementary school “Jelenje-Dražice” was evacuated when bora blow up building roof.

All ferry and ship lines in Split area were canceled. Helicopter emergency medical interventions necessary for providing emergency medical treatment for more than 30000 residents of the Mid-Dalmatian islands was also temporarilly interrupted. Emergency medical intervention was requested for 82 year old patient with hearth attack from Supetar, island of Brač. As no other way of transportation was possible, patient had to be transported to Split by small private boat.

There were several unsuccessful landing attempts on Split Airport on 4. and 5. of March. After that airline companies canceled all flights until 6. March. Airport meteorological service recorded wind gusts above 70 knots (130 km/h).

Most of major internet portals broadcasted the news about the harsh weather in the Country. TV and radio stations regularly informed residents about weather conditions and weather changes. Internet portals inform about blocked roads and damage on properties, as well as light injuries caused by strong wind. Citizens are informed to avoid travel if possible.

4.2.4. Economic impact of wind disaster

This chapter presents official data on damage assessment for natural disaster stated for the city of Split, municipality of Podstrana and municipality of Dugi Rat. Natural disaster was declared during the period of 5th to 7th of March 2015 when violent storm raged throughout the region and caused severe material damage.

Data is provided by the Commission for damage assessment of the damage caused by natural disasters in Split-Dalmatia County. It is first presented for the area of city of Split, followed by the data for municipality of Podstrana and presenting the data for the municipality of Dugi Rat in the end.

4.2.4.1. *City of Split*

Total number of 264 applications were received, 42 given by the legal entities and 222 reported by the natural persons. However, only 18 legal entities provided valid applications, and 184 applications by the natural persons were found valid. According to the applicants, property damaged by the natural disaster was not insured by natural and legal persons.

Damage to the agricultural crops was present as well. Additional costs of removing the consequences of natural disaster were determined. It was also found that there were disturbances in the production and non-production environment of legal entities. The city of Split did not receive inland or outland help for the damage sustained.

Self-help in eliminating and mitigating the effects of these natural disasters was made possible by applying technical measures by the owners of damaged property, members of the Civil protection general purpose unit of City of Split, Public utility members, unit OPC purposes Civil Protection City of Split, utility companies, Fire brigades of cities of Split and Žrnovnica and numerous volunteer fire departments.

Total estimated damage for natural person is shown in Table 3, and for legal entities in Table 4. Data is shown with the values corrected after auditing 5 % of processed applications (errors were found in methodology application i.e. in filling of the application form).

Table 3: Total estimated damage for natural person

Damage for natural person	
Type of damage	**Amount of damage in HRK**
Damage on buildings	264.815,60 HRK
Damage on perennial crops	41.563,62 HRK
Damage on working capital	18.136,26 HRK

Damage on other goods	238.991,80 HRK
TOTAL	**563.507,28 HRK (approx. 73.800,00 EUR)**

Source: Commission for damage assessment

Table 4: Total estimated damage for legal entities

Damage for legal entities	
Type of damage	**Amount of damage in HRK**
Damage on buildings	7.364.036,67 HRK
Damage on forests	2.712.410,00 HRK
Damage on other goods	32.722,75 HRK
TOTAL	**10.109.169,42 HRK (approx. 1.350.000,00 EUR)**

Source: Commission for damage assessment

4.2.4.2. Municipality of Podstrana

Total number of 151 applications were received, 8 given by the legal entities and 143 reported by the natural persons. Only 2 legal entities provided valid applications. All of 143 applications given by the natural persons were valid. Due to minor administrative and technical problems applications deadline period was extended, so the data will be shown in accordance with these deadlines. According to the applicants, property damaged by the natural disaster was not insured by natural and legal persons. Damage to the agricultural crops was present as well. Additional costs of removing the consequences of natural disaster were determined. There were no disturbances in the production and non-production environment of legal entities. The municipality of Podstrana did not receive inland or outland help for the damage sustained.

Self-help in eliminating and mitigating the effects of these natural disasters was made possible by applying technical measures by the owners of damaged property, Public utility members and members of volunteer fire department.

Total estimated damage for applications received before 12th of March 2015 for natural person is shown in Table 5, and for legal entities in Table 6.

Table 5: Total estimated damage for natural person

Damage for natural person, applications received before 12th of March 2015.	
Type of damage	**Amount of damage in HRK**
Damage on buildings	417.095,72 HRK

Damage on equipment	360.310,00 HRK
Damage on perennial crops	34.002,00 HRK
Damage on agriculture	488.495,10 HRK
Damage on other goods	56.480,00 HRK
TOTAL	**1.356.382,82 HRK (approx. 181.000,00 EUR)**

Source: Commission for damage assessment

Table 6: Total estimated damage for legal entities

Damage for legal entities, applications received before 12th of March 2015.	
Type of damage	**Amount of damage in HRK**
Damage on buildings	30.240,00 HRK
Damage on equipment	5.200,00 HRK
Damage on perennial crops	240,00 HRK
Damage on agriculture	1.292,80 HRK
TOTAL	**36.972,80 HRK (approx. 5.000,00 EUR)**

Source: Commission for damage assessment

Damage for the late applications, received before 31st of March 2015, is collected in Table 7.

Table 7: Total estimated damage for late applications

Damage for natural person, applications received before 31st of March 2015.	
Type of damage	**Amount of damage in HRK**
Damage on buildings	93.027,60 HRK
Damage on equipment	501.700,00 HRK
Damage on perennial crops	4.788,23 HRK
Damage on agriculture	25.003,12 HRK
Damage on other goods	13.615,71 HRK
TOTAL	**638.134,66 HRK**

Source: Commission for damage assessment

4.2.4.3. Municipality of Dugi Rat

Total number of 73 applications was received, of which 58 by the natural person and 15 legal entities. According to the applicants, property damaged by the natural disaster was not insured by natural person and only one legal entity had its property insured. Additional costs of removing the consequences of natural disaster were determined. Damage to the agricultural crops was present. There were no disturbances in the production environment, but there were high disturbances in non-production environment of one legal entity. The municipality of Dugi Rat did not receive inland or outland help for the damage sustained.

Self-help in eliminating and mitigating the effects of these natural disasters was made possible by applying technical measures by the owners of damaged property, Public utility members and members of volunteer fire department.

Total estimated damage is shown in following tables, in Table 8 for natural person, and in Table 9 for legal entities. Amounts shown in table which presents damage for legal entities id reduced for the mount of insurance provided for the Messer Company.

Table 8: Total estimated damage for legal entities

Damage for natural person	
Type of damage	**Amount of damage in HRK**
Damage on buildings	352.027,59 HRK
Damage on equipment	11.000,00 HRK
Damage on perennial crops	1.797,00 HRK
Damage on agriculture	9.011,80 HRK
Damage on other goods	107.483,40 HRK
TOTAL	**481.319,79 HRK**

Source: Commission for damage assessment

Table 9: Total estimated damage for legal entities

Damage for legal entities	
Type of damage	**Amount of damage in HRK**
Damage on buildings	469.058,40 HRK to be decreased for 302.400,00 HRK
Damage on equipment	46.000,00 HRK
Damage on perennial crops	512,00 HRK
Damage on agriculture	323,20 HRK
Damage on other goods	96.000,00 HRK to be decreased for 20.000,00 HRK
TOTAL	**611.893,60 HRK** **to be decreased by 289.493,60 HRK**

Source: Commission for damage assessment

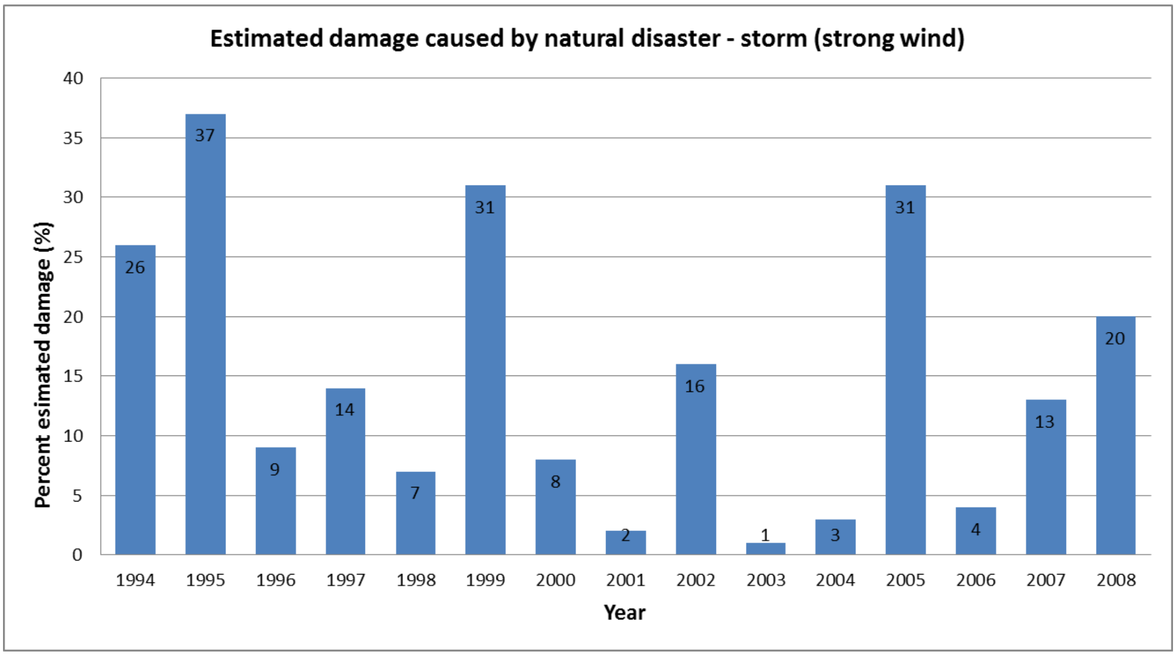
There were interruptions in power supply throughout the region; no other infrastructure interruptions were present.

5. Evaluation of the specific events in Slovenia

Slovenia lies at the junction of the Alpine, Pannonian, and Mediterranean areas of climatic impact. It is characterized by extremely different relief. The weather situations, which create extreme weather events (storm, high wind) above Slovenia, come largely from the west side (Pavšek, 1994). These storms cause a major damage, sometimes as natural disaster. Natural disasters are becoming more frequent and severe every year, and cause significant damage to agricultural products, buildings and infrastructure. The most damage in Ljubljana is usually caused in summer. On contrary, the bora wind in the Vipava valley causes a lot of problems in cold part of the year (from November to March). Due to high wind and high wind gust, there are many roadblocks and closure of Koper port as well.

The estimated damage caused by storms for period from 1994-2008 is presented in Figure 17

Figure 17: Estimated damage caused by natural disaster – thunderstorm (strong wind))



Source: Statistical Office RS, 2016

Presented data are collected and archived by Statistical Office of the Republic of Slovenia. All municipalities in Slovenia were asked for damage assessment. As can be seen, there exist a high variation between low and high percent of estimated damage. It extends up to 37 % in year 1995. The rest of natural disasters in each year are arranged to other levels such as earthquakes, floods, fire, drought, hail, frost, etc. Moreover, there is no strict trend in caused damage.

5.1. Basic principles of estimating the damage

Slovenian system of protection against natural and other disasters is specialty in the European Union. Among many tasks of the Administration for Civil Protection and Disaster Relief (here and after ACPDR), which is a constituent body of the Ministry of Defence and performs administrative and professional protection, rescue and relief tasks, the assessment of damages to agricultural products and objects after natural and other disasters is also included since year 2003. In other European countries, the assessment of damage and indemnification are left in terms of 'insurance company – insurant' or they have no developed national aid for their citizens for the elimination of consequences of natural disaster.

Since 2004 Slovenia has elaborated procedures in detail at all three levels of organization – country, regions and municipalities. By the Decree on damage evaluation methodology (Official Gazette RS no. 67/03, 79/04, 33/05, 81/06 and 68/08), the special forms as well as price list were defined. At the beginning of using these forms, in the year 2003 and 2004, the municipal commissions, which carried out the major part of assessment, had a hard work to complete these forms. Moreover, due to large numbers of forms and extensive data, there also occurred some errors at copying collected data. A great deal of troubles with collected data had also Ministry of Agriculture, Forestry and Food (MAFF), Ministry of the Environment and Spatial Planning (MESP), and Ministry of Infrastructure (MI), who are responsible for preparing programs for the elimination of consequences of natural disaster. The Ministry of Infrastructure is the latest competent agency.

Based on these experiences, ACPDR decided to develop an information system that would allow users of all levels the same and up-to-date information. AJDA is a centralized web-based information system, which enable friendly, easy and uniform environment for work, while ensuring the transfer of verified data from official public evidences of various institutions, particularly MAFF, MESP and MI. The development of AJDA, originally designed only for assessment on agricultural products, started in the year 2006. The system AJDA was upgraded in 2008, however, it introduced assessment of damage on objects as well (Jakšič, 2010).

Before the ACPDR took over the task of estimating the damage, this was the task of the Statistical Office of the Republic of Slovenia. The Statistical Office collected data on estimated damage caused by natural disasters every year with the ELNES report, which was filled in by municipalities. The legal obligation was imposed by the National Statistic Act (Official Gazette RS no. 45/95, 9/01), the National Programme of the Statistical Surveys (Official Gazette RS no. 102/02) and the Protection Against Natural and Other Disaster Acts (Official Gazette RS no. 64/94). The task of estimating the damage was in their competence between 1994 and 2008. In 2008, the information system AJDA was upgraded; however, the estimating of damage was not any more the competence of Statistical Office.

ACPDR prepared procedure rules for damage assessment after natural disaster, and by this rules the tasks for each level were dismembered (state, region and municipality). Within three days after natural disaster, the municipalities should report the relevant ACPDR region about extensiveness of natural disaster (e.g. floods, hail, storms, high wind, drought, etc.). Beside description of the disaster, the report should contain also graphical view of damage area and the initial damage assessment on agricultural products and objects. The number of municipalities by ACPDR regions is gathered in Table 10.

Table 10: Numbers of municipalities by ACPDR regions

Region	Number of municipalities
Posavska	4
Zahodnoštajerska	33
Obalna	3
Gorenjska	18
Ljubljanska	32
Vzhodnoštajerska	22

Pomurska	27
Severnoprimorska	13
Dolenjska	14
Notranjska	10
Podravska	19
Koroška	12
Zasavska	3
Together	**240**

Source: Jakšič, 2010

The regional ACPDR inform national ACPDR about occurred natural disaster and propose resolution for the following damage assessment on affected area of one or more municipalities. In case the initial damage assessment on agricultural products and objects is close to approximately 0.3 ‰ of total Slovenian GDP, the national ACPDR issue resolution for beginning of damage assessment. This resolution contains more accuracy information about damage value and gives more specific rules to the affected municipalities. The municipalities publish the local people to report to municipal commission about damage. Afterwards the municipal commission estimates the damage value (on agricultural products and objects) of the affected person and entry them to information system AJDA (Jakšič, 2010).

The damage assessment on agricultural products and objects is performed on the basis of Protection Against Natural and Other Disasters Act (Official Gazette RS no. 64/94 and 28/06), Natural Disaster Recovery Act (Official Gazette RS no. 75/03, 90/07 and 102/07) and the Decree on damage evaluation methodology (Official Gazette RS no. 67/03, 79/04, 33/05, 81/06 and 68/08). Municipalities can now process damage reports provided by the affected parties on special forms:

- Form 1 for damage assessment on agricultural land,
- Form 2 for damage assessment on agricultural products,
- Form 3 for damage assessment on buildings destroyed,
- Form 4 for assessment of partial damage on buildings and
- Form 5 for damage assessment on civil engineering facilities.

Damage calculations are based on approved evaluations.

The regional and national commissions of estimating the damage check the reported damage. On survey visits are invited the competent inspectors of the Inspectorate of the Republic of Slovenia of the Agriculture, Forestry and Food and competent inspectors of the Inspectorate of the Republic of Slovenia for environment. All committees are composed of agricultural experts and civil engineers, representatives of ministries and other experts.

Further, the national commission of estimating damage prepares final assessment of damage on agricultural products and other staff, and sends it to government. In case that final damage assessment on agricultural products and other staff exceeds 0.3 ‰ of total national GDP, government confirms it; however, MAFF (for agricultural products), MESP (for objects) and MI (for infrastructure) are then responsible for preparing a program for the elimination of the consequences of damage. The government confirms programmes prepared by MAFF and MESP, and after all, the provisions for allocations of goods are issued.

The main advantages of information system AJDA are:

- It is user friendly,
- It significantly reduces mistakes in damage calculations,
- It allows various types of extracts at municipal, regional and national levels,
- There is no need for the re-entering of data at the Ministry of Agriculture, Forestry and Food (MAFF) and the Ministry of the Environment and Spatial Planning (MESP),
- It saves time and money because of the simplified procedure,
- It ensures the application of data at several institutions simultaneously,
- It ensures data verification,
- It allows traceability of the data entered,
- It facilitates any further upgrading and the simple archiving of data,
- It prevents unauthorized acquisition of national aid.

6. High wind events assessment in Slovenia

6.1. Event situation description on July 13th and 14th 2008

On July 13th the middle Europe and the northern Mediterranean was covered by area of low pressure. The cold front passed Slovenia. The area of high pressure broadened from above Western Europe and proceeded by the strong south-westerly winds which flowed as warm and moist air. It became cloudy, the showers and thunderstorms with high wind, hail and heavy rain occurred. In the beginning, thunderstorms with high wind occurred in Ljubljana region and after then moved towards northeast and covered the northern part of Lower Sava, Savinja, Carinthia and Mura region. This thunderstorm was one of the worst in the last few years. The wind damaged more than 500 objects (Bertalanič, 2008).

The day before, on July 12th, the Slovenian Environment Agency issued notification for approach of thunderstorms with hail, high winds and heavy rain. For majority of Slovenia it was proclaimed the 2nd level of weather alerts. In the morning on July 13th the weather alarm was increased to 3rd level. The notification was referred to thunderstorms with hail and very high wind gusts (Vertačnik, 2008).

Although there was a lot of damage, the very high wind gusts were not record at any of the automatic measurement station, because the thunderstorm with its central part did not cross any of this station. Therefore, we present only the continuous wind measurements recorded at the Ljubljana Bežigrad station.

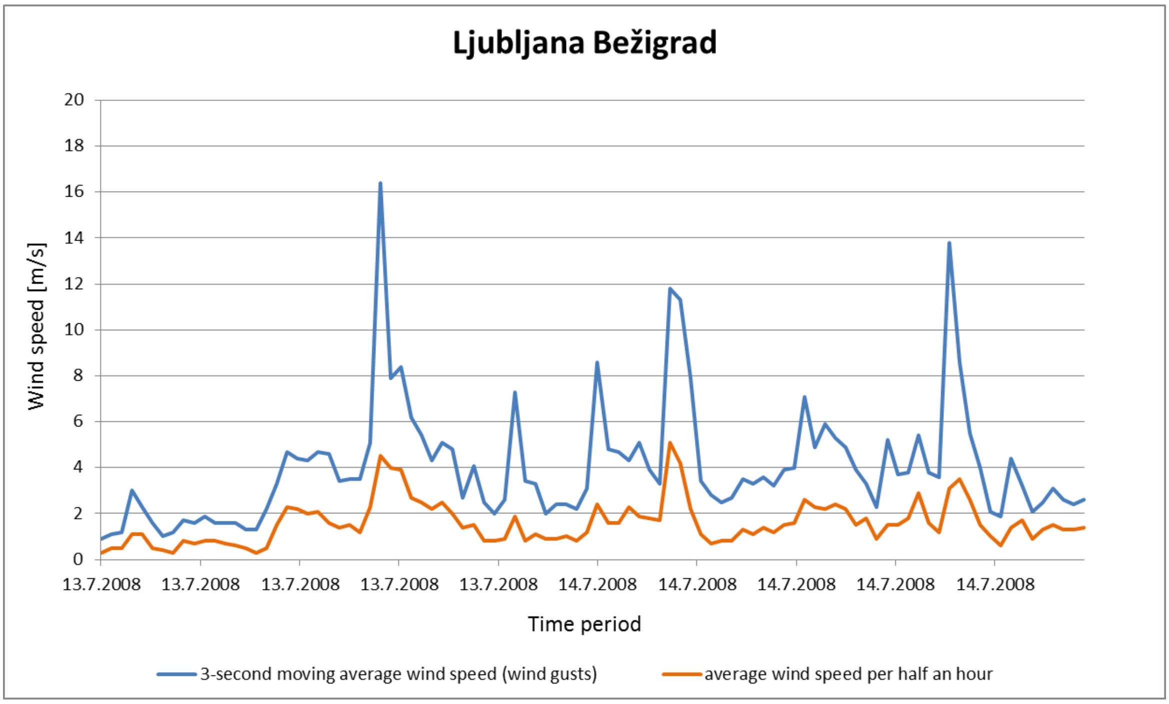
6.1.1. Wind measurements

Following data are provided by the Slovenian Environment Agency. Data includes measurements at the Ljubljana Bežigrad station:

Ljubljana Bežigrad (Slovenia)
Lattitude: 46.0658 N
Longitude: 14.5172 E
Attitude: 299 m

Ljubljana Bežigrad station is located in the city centre. The wind measurements are recorded at each half per hour at elevation 22 m above the ground. The wind speed represents average wind speed per half an hour and the wind gust represents the highest 3-second moving average in each half an hour. All data used are publicly available at Slovenian Environment Agency site (http://www.meteo.si/met/sl/archive/).

Figure 18: Wind measurement at Ljubljana Bežigrad



Source: Slovenian Environment Agency, 2016

As can be seen in Figure 18, the highest wind gust blew through Ljubljana with the speed of 16 m/s (60 km/h). This was one of the highest values that occurred on July 13th in Ljubljana City. The average wind speed per half an hour reached the value up to 5 m/s (18 km/h). In other station was recorded only the maximal value of wind speed, which occurred in Kamnik Municipality. The wind gusts reached a speed of up to 25 m/s (90 km/h).

6.1.2. Social impact of wind disaster

The storm occurred in the area between Ljubljana and Kranj. The wind damaged some trees and partly or totally uncovered more than 150 roofs. It also uncovered roof of library and many farm buildings were also affected. The high wind gusts blew away the entire roofing of primary school Vodice.

Figure 19: Damage on primary school Vodice.

Source: Slovenian Press Agency, 2008

Most of the damage was caused by an afternoon thunderstorm on July 13th in the zone from Ljubljana basin to Mura region. The asymmetric thunderstorm outflow uncovered roofs and broke trees in many forests. In the Medvode Municipality, which lies around 10 km out of Ljubljana, the wind damaged around 15 housing roofs and the roof of the apartment block. There it was around 30 fallen trees. Therefore many roads were closed.

The wind made a major damage also in Kamnik Municipality, which lies 20 km northeastern out of Ljubljana. Regarding to damage made by high wind, the speed was up to 120 km/h. The wind uncovered roof of primary school, 68 housing roofs, 9 civil engineering facilities and fallen many trees. Wind caused a lot of damage also at other counties in Kamnik Municipality. Many fallen tress made the roads impassable. It was reported that four people were injured due to tree which fall on the car during thunderstorm (Slovenian Press Agency).

There was also reported about damage on motorized hang-gliders and microlights in Kamnik Airport (see

Figure 20).

Figure 20: Damaged Kamnik Airport.

Source: Slovenian Press Agency, 2008

The above mentioned damaged occurred in the area of Ljubljana region. The similar or even worse damage occurred in other parts of Slovenia. The economic impact of wind disaster is presented additionally.

6.1.3. Economic impacts of wind disaster

Storm with high wind occurred in the whole of Slovenia. The event was proclaimed as natural disaster. The damage assessments per individual regions are collected in Table 10.

Table 11: Damage assessment per region

No.	Region (Slovenian name)	Total	Form 1	Form 3	Form 4	Form 5
		No. Application	No. Application	No. Application	No. Application	No. Application
		Damage	Damage	Damage	Damage	Damage
1	Upper Carniola (Gorenjska)	39			1	38
		529.810,21 €			65.584,68 €	464.225,53 €
2	Carinthia (Koroška)	13	2		2	9
		30.892,76 €	10.644,25 €		4.405,21 €	15.843,30 €
3	**Central Slovenia (Ljubljanska)**	**938**	**275**		**575**	**88**
		7.179.966,83 €	**4.163.625,15 €**		**2.786.228,36 €**	**230.113,32 €**
4	Drava (Podravska)	219			10	209
		534.893,30 €			22.238,81 €	512.654,49 €
5	Mura (Pomurska)	868		6	680	182
		1.957.013,21 €		35.423,51 €	1.578.970,03 €	342.619,67 €
6	**Gorizia (Severno primorska)**	**431**			**405**	**26**
		3.467.666,25 €			**3.338.461,29 €**	**129.204,96 €**
7	Lower Sava (Vzhodno štajerska)	1008			819	189
		2.347.114,16 €			2.115.735,08 €	231.379,08 €
8	Savinja (Zahodno štajerska)	589	103	8	110	368
		5.493.054,73 €	2.905.829,38 €	81.814,44 €	333.231,45 €	2.172.179,46€
9	Central Sava (Zasavska)	126			47	79
		286.793,94 €			54.187,64 €	232.606,30 €
	Total in €	**4.321**	**380**	**14**	**2.649**	**1.188**
		21.827.205,39	**7.080.098,78**	**117.237,95**	**10.416.280,50**	**4.330.826,11**

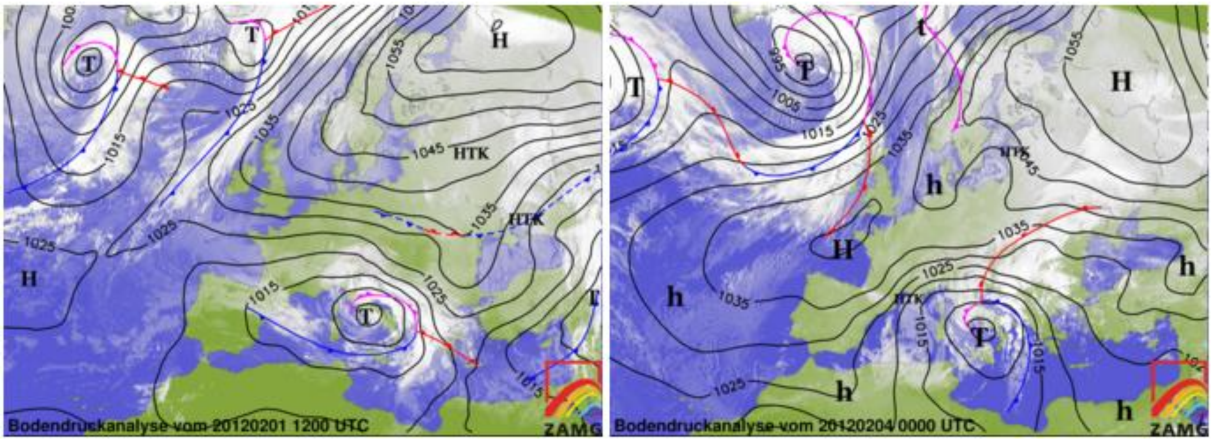
Note: Form 1 for damage assessment on agricultural land, Form 2 for damage assessment on agricultural products, Form 3 for damage assessment on buildings destroyed, Form 4 for assessment of partial damage on buildings and Form 5 for damage assessment on civil facilities.
Source: AJDA, 2016

Damage assessment on object suffered **4.321** impaired persons in **49** municipalities in the total amount of **21.827.205,39 €.** Directly assessment damage on forest was 7.080.098,78 €, damage assessment on ruined object and partly damage on objects was 10.416.280,50 €, damage assessment on building destroyed was 117.237,95 € and damage assessment on civil engineering facilities was 4.330.826,11 €. Here we have to mention, that some damage was caused also due to accompanying hail. Damage on agricultural products (Form 2) was not reported.

6.2. Strong bora between January 31st and February 14th 2012

In the end of January we had a strong anticyclone above northeastern Europe (1060 hPa) and cyclone above Mediterranean. The consequence of these air masses was a great pressure gradient force above Slovenia and therefore was created the ideal conditions for strong bora wind. The anticyclone had extended over northwestern Europe and weakened on the February 10th overnight. The consequence of this was, that the main bora wind was blowing from the north-northeastern (N-NE) site instead of from east-northeastern (E-NE) as on February 4th. This kind of situation usually brings the strong bora wind to Gorizia region. That time was the same.

Figure 21: Synoptic situation

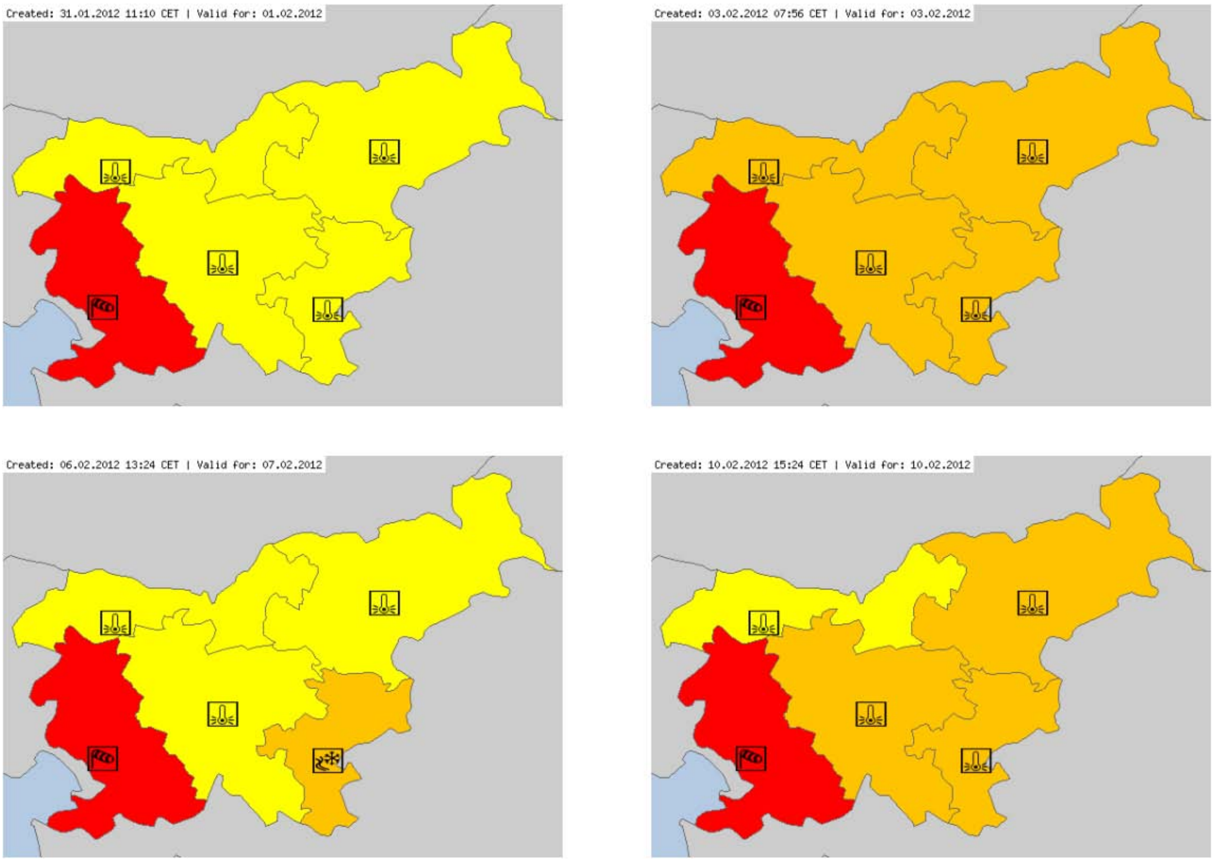


Source: Wine and weather http://www.wineandweather.net/?p=995

In the morning January 31st of the Slovenian Environment Agency issued 1st read alert for the Karst and Gorizia region, including Vipava valley. The continuation of issued alerts is presented in

Figure 22

Figure 22: Weather alerts for Slovenia



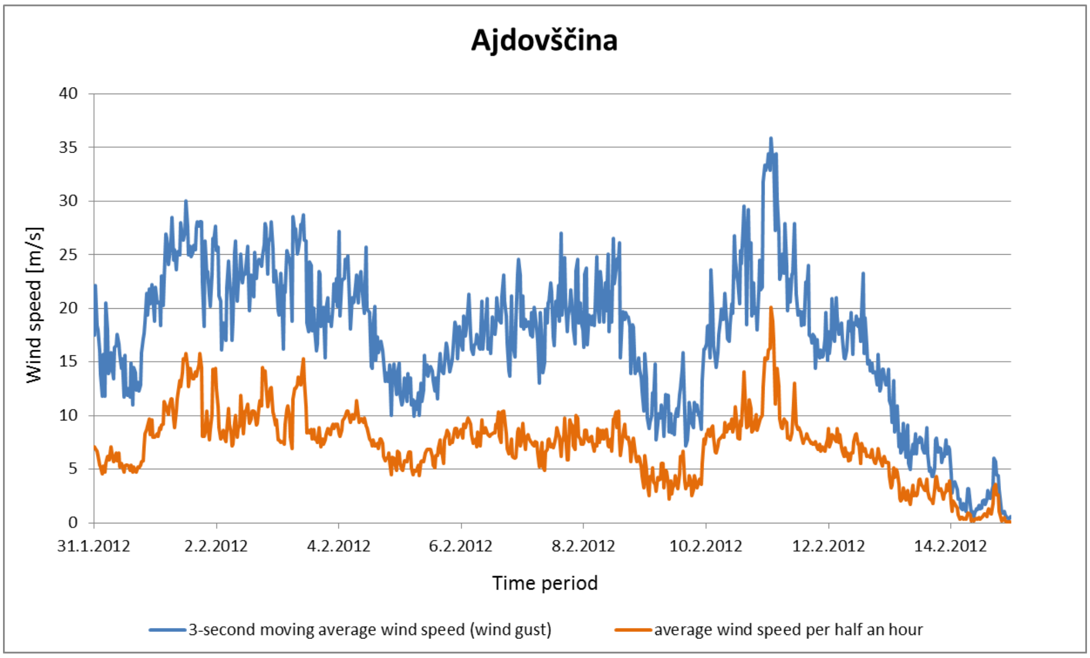
Source: Slovenian Environment Agency, 2016
http://meteo.arso.gov.si/uploads/probase/www/climate/text/sl/weather_events/burja-mraz_feb12.pdf

Following data are provided by the Slovenian Environment Agency. Data includes measurements at the Ajdovščina Dolenje station:

Ajdovščina Dolenje (Slovenia)
Lattitude: 45.8600 N
Longitude: 13.9058 E
Attitude: 83 m

Ajdovščina station is located in the city centre. The wind measurements are recorded at each half per hour at elevation 10 m above the ground. The wind speed represents average wind speed per half an hour and the wind gust represents the highest 3-second moving average in each half an hour. All data used are publicly available at Slovenian Environment Agency site (http://www.meteo.si/met/sl/archive/).

Figure 23: Average wind speed per half an hour and 3-second moving average wind sped in Ljubljana for time period between January 31st and February 14th in 2012



Source: Slovenian Environment Agency, 2016

On the morning of February 1st the first highest wind gust occurred in Vipava valley. Its speed was up to 30 m/s (108 km/h). In the February 5th the bora wind had a reduced speed, but in February 10th the wind speed repeatedly increased to the speed up to 36 m/s (129 km/h). In the February 14th the bora wind was calm down.

6.2.1. Social impact of wind disaster

Strong bora wind, lasting two weeks, caused extensive damage in the Primorska region (Karst and Gorizia region). In the first interval, comprising the first three days, the bora wind overturned many trucks, uncovered roofs of civil engineering facilities and sport structures in Ajdovščina. On January 31st the approximately 500 customers in Podnanos remained without electricity.

In the second interval, between February 1st and 2nd, the primary schools in Dobravlje, Ajdovščina and Šturje, as well as kindergartens in Ajdovščina were closed due to further forecasting of bora wind. The high school Veno Pilon Ajdovščina and majority public institutions were also closed. In February 3rd and 4th the Ajdovščina Municipality accepted resolution on further closure of kindergartens, schools and other institutions.

In the morning of February 4th strong bora wind in Goriška region caused several power outages. Around 1143 customers stayed without electricity. The most affected areas were Brda, Kojsko and Biljana and the Sežana surroundings.

Bora wind caused many inconveniences and damages also in that interval. It unroofed a few houses, torn off billboards, overturned containers or broke down electricity masts or electricity overhead liens. The bora wind overturned a few trucks in the Vipava valley. There were no reports about people deaths.

Additionally, the worst part of consequences occurred in the night of February 11th, especially in Vipava valley. Strong bora between Vipava and Nova Gorica uncovered roofs, broke trees and swept away different objects. The wind in Šempas almost pulled down the prefab house. Due to plenty of dust in the bora wind many of cars in the area between Ajševica and Osek stuck in gutter. The wind also unroofed the petrol station on the highway between Selo and Nova Gorica. It was highly damaged eastern tower and roof of a Kromberk castle too. Owing to the blown wind through a tunnel causing a high fire risk the Kastelec tunnel towards Kozina was closed.

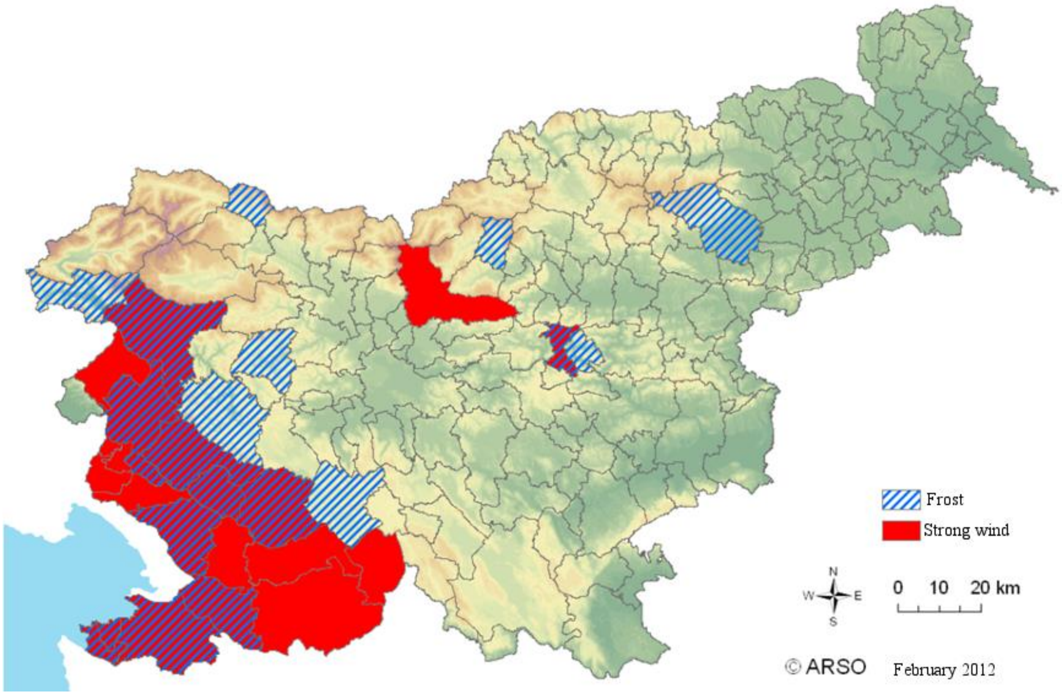
The coastal fishermen did not fish for at least two weeks. This brought less fish and earnings as usually during winter months. Further, the Port of Koper was limited and each ship was manually controlled by the operation. The cargo transfer was also reduced due to strong bora wind. More than a week there were a lot of waiting trucks in parking spaces due to closed roads.

Strong bora wind caused at most damages to roofs, especially to roofs covered by newer tiles. In Gorizia region it was damaged approximately 150 structures, more than a half of them in the area of Šempas and Ajševica. The fully restoration was necessary on 5 objects including the music school building. A lot of damage was also caused on smaller buildings, chimneys, channels and windowpanes. Many of cars were damaged by broken branches and trees which fall on them.

In the Vipava valley, bora wind blew away soil from fields into streams. The melioration ditches and street gutters were filled in by fertile soil. Major damage was caused to the vegetables, field crops and greenhouses. The assessment of damage on winter cereals crops was also very high. More than 200 ha of crops were completely damaged. A lot of damage was also on fruit and olive trees. Owing to strong bora wind the tourists cancelled about 5.000 nights.

Beyond damages caused by wind, the severe frost also occurred in the extensive area of Karst and Gorizia region. The assessment of damage became even higher (Bertalanič, 2012). The areas affected by strong wind and frost as well are shown in Figure 24.

Figure 24: Damaged areas due to strong wind and frost.



Source: Slovenian Environment Agency, 2012; ACPDR, 2012.

As can be seen, the majority damage it was caused in Gorizia and Karst region. In some areas it appeared even both. It was reported, that damage caused by frost was not greater than damage caused by strong wind. We may notice some strong wind over Karavanke area.

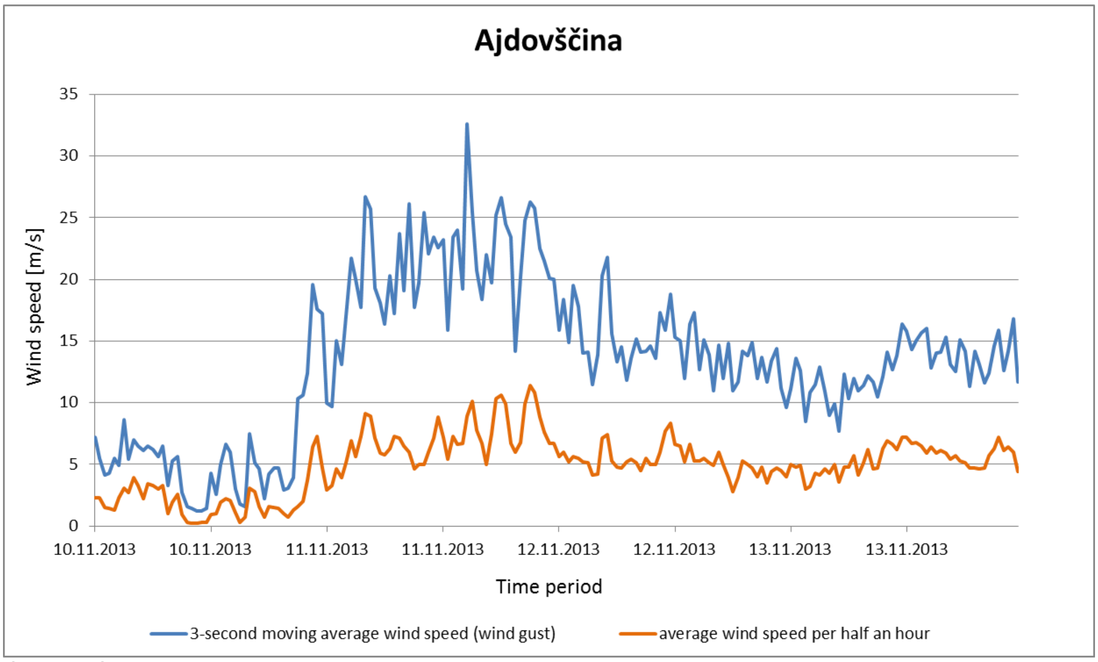
6.3. Strong bora in 2012, 2013 and 2014

6.3.1. Wind measurements between November 9th and 12th 2013

On the November 9th we had a strong cyclone above middle Europe. The secondary cyclone occurred above Northern Mediterranean, which moved above northern Italy and middle Adriatic. The high wind pressure increased above middle Europe at the same time. The valley of cold air moved above Alps. It was blowing strong southwestern wind and jugo on coast. On November 11st it was blowing northeastern wind and bora wind at the coast. On the next day the bora wind started to weaken.

Following data are provided by the Slovenian Environment Agency. Data includes measurements at the Ajdovščina Dolenje station (lattitude: 45.8600 N, longitude: 13.9058 E, altitude: 83 m)

Figure 25: Average wind speed per half an hour and 3-second moving average wind sped in Ajdovščina for time period between November 10th and 14th in 2013



Source: Slovenian Environment Agency, 2016

In Figure 25 we notice a gradually increasing of the average wind speed and wind gusts. The maximal value of average wind speed per half an hour reached maximal value of 12 m/s on November 12nd. The speed of wind gusts increased up to 32.5 m/s (117 km/h).

6.3.2. Social impact of bora wind

The increased values of wind speed were recorded at stations over Karst and Gorizia region. The highest wind gust was recorded at Ajdovščina Dolenje station. The strong bora wind caused a lot of damage on objects not only on Karst and Gorizia region but also in the rest of the Slovenian country. Besides Gorizia and Karst region, the Upper Carniola and Lower Sava region were also affected. The majority damage was made on structures and cars. Strong bora wind in Gorizia region caused several power outages, therefore, many customers stayed without electricity for day or two (Bertalanič, 2013).

Over the northern coast, were bora reached the maximum power density on November 11st, it was damaged about 120 buildings and facilities. The worst it was in Kobarid and Tolmin municipalities, where wind damaged 15 farm and administrative buildings. The wind was breaking trees, spreading out branches, moving communal containers, tore the steel plates from the roofs and damaged roofs. Many of the broken trees fell on parked vehicles. In the Bovec area, the damage occurred on the roof of chemical products factory in Srpenica. A pretty considerable damage was caused to roofs of an industrial undertaking. The most of damages occurred due to fallen trees on overhead lines, discontinuity of telecommunication lines and fallen electrical masts. The worst damage was made on 100 kV network in the area of Ilirska Bistrica. The high bora wind pulled down trees on the roads; therefore, many of roads were closed. All sheeted vehicles and refrigerators were prohibited on the road

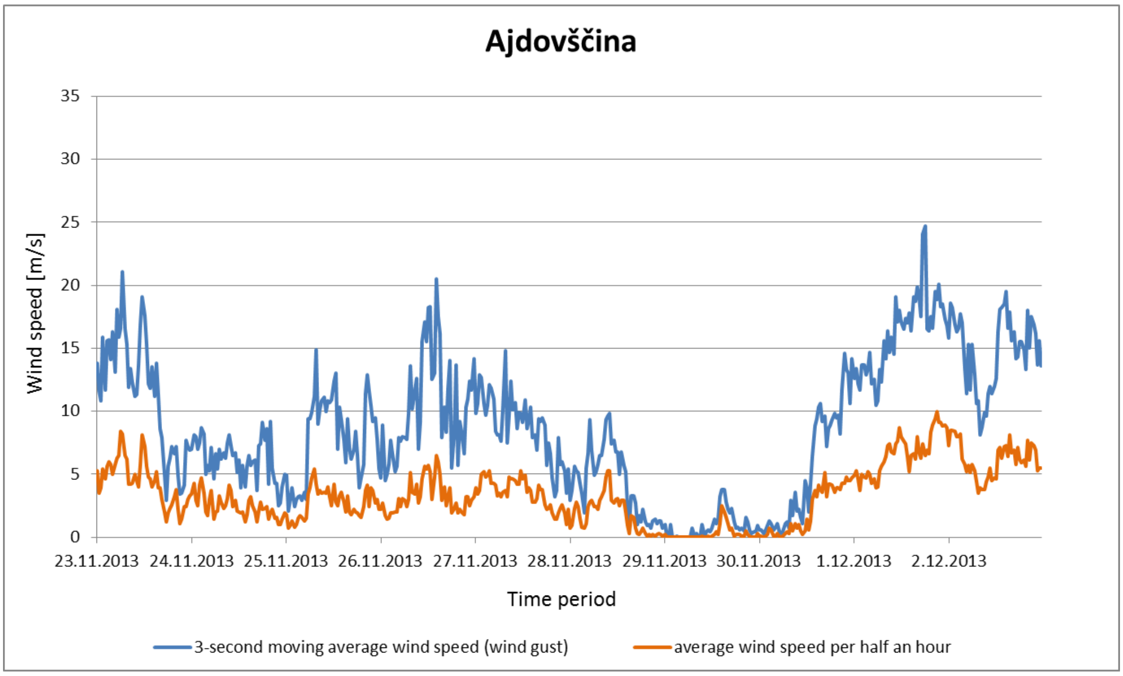
Podnanos-Ajdovščina. The Port of Koper was limited and each ship was manually controlled by the operation.

6.3.3. Wind measurements between November 23th and December 2nd in 2013

Above western and middle Europe and western Balkan Peninsula it was an area of high air pressure, but above Mediterranean area it was area of low pressure. In a lower layers of air it was blowing eastern and northeastern wind and in Primorska region it was blowing strong bora wind.

Following data are provided by the Slovenian Environment Agency. Data includes measurements at the Ajdovščina Dolenje station (latitude: 45.8600 N, longitude: 13.9058 E, altitude: 83 m)

Figure 26: Average wind speed per half an hour and 3-second moving average wind sped in Ajdovščina for time period between November 23th and December 2nd in 2013



Source: Slovenian Environment Agency, 2016

In Figure 26 we notice a gradually increasing and decreasing of the average wind speed and wind gusts. The maximal value of average wind speed per half an hour reached maximal value of 10 m/s on December 1st. The speed of wind gusts increased up to 25 m/s (90 km/h).

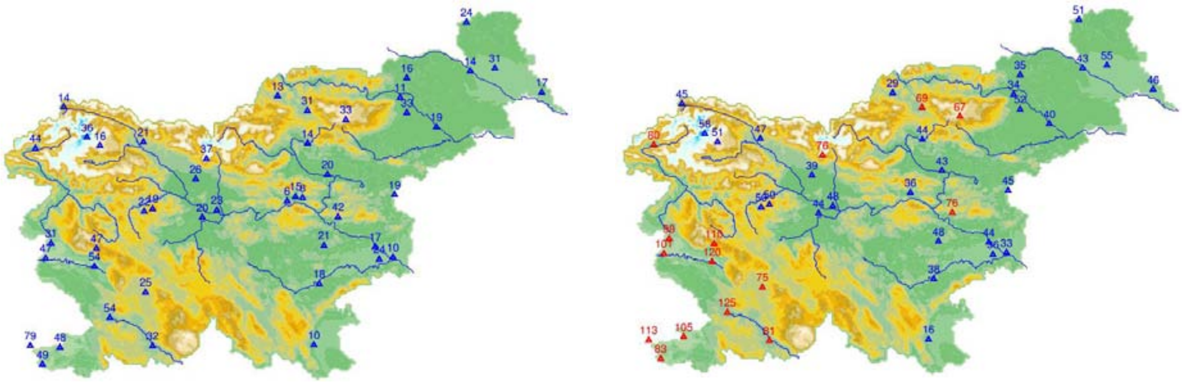
6.3.4. Social impact of bora wind

Due to bora wind it was a lot of fallen trees and electrical masts, therefore a lot of costumers were out of electricity. Many of houses were unroofed due to strong bora wind. The roof of agricultural cooperative was totally unroofed as well as roof of farm building. There were also a lot of damaged cars because of the fallen trees. All sheeted vehicles and refrigerators were prohibited on the road Podnanos-Ajdovščina.

6.3.5. Wind measurements between February 5th and 9th in 2015

A large part of Europe and Mediterranean was covered by cold and moist air, which arose from northern part of Atlantic. The southwestern boundary seceded from main body and moved above Mediterranean and caused proportionally deep cyclone. Between February 5th and 6th, the area of Slovenia lied on sharp crossing between cyclone anti anticyclone, therefore the eastern wind was blowing in higher layers and bora wind in the Primorska region. For Slovenia was issued the highest weather alerts. The maximal values measured at automatic stations are presented in Figure 27.

Figure 27: Maximal value of measured average wind speed (left) and wind gusts (right) [km/h].



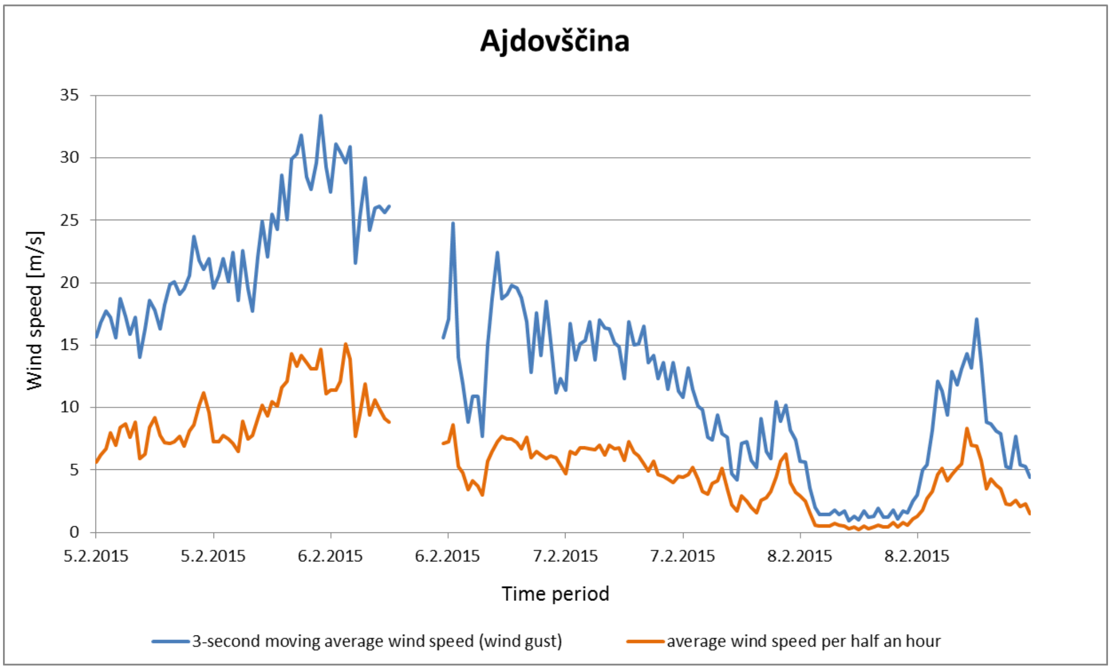
Source: Slovenian Environment Agency, 2015

The highest value of measured average wind speed was recorded in the Vipava valley at Ajdovščina Dolenje station with the speed of 15 m/s (54 km/h). The highest wind gust was also recorded in Ajdovščina Dolenje, where the value reached 33.3 m/s (120 km/h). The high values were also recorded over the Bovec area and on higher altitudes (Krvavec, Rogla, Lisca).

Following data are provided by the Slovenian Environment Agency. Data includes measurements at the Ajdovščina Dolenje station (latitude: 45.8600 N, longitude: 13.9058 E, altitude: 83 m). There are some missing data due to device troubles.

As above mentioned, the highest value of measured average wind speed reached 33.3 m/s (120 km/s). It is obviously, that wind speed increased gradually to maximum value. On February 8th wind calmed down.

Figure 28: Average wind speed per half an hour and 3-second moving average wind sped in Ajdovščina for time period between February 5th and 9th in 2015



Source: Slovenian Environment Agency, 2016

6.3.6. Social impact of wind disaster

Strong bora wind, lasting four days, caused extensive damage in the Primorska region (Karst and Gorizia region). The primary schools in Vipava valley, as well as kindergartens were preventively closed due to read alerts of bora wind. The closure was justifiable, because primary school in Ajdovščina was unroofed (see Figure 29).

On February 6th the high voltage transmission Ajdovščina – Krombek was damaged; therefore approximately 4000 customers in Gorizia region were broken down. Majority damaged was caused to roofs of houses. There were also affected the roofs of post office and police station. It torn off billboards, overturned containers or broke down trees and branches, which fall on the roads and caused roadblock. A lot of trees fall on cars and caused additionally damage. There were no reports about people deaths.

By unpleasant event the local firefighters intervened. They had a lot of work with installing and fixing the containers and roofs, which were blown in different ways. Safety measure was used on the road Ajdovščina – Lokavec. The road was closed for the sake of probability of falling trees. Not only schools and kindergartens, the closure was ordered also for libraries, sport institutions and protection work center. The cultural events were canceled.

Figure 29: Unroofed primary school Danilo Lokar in Ajdovščina

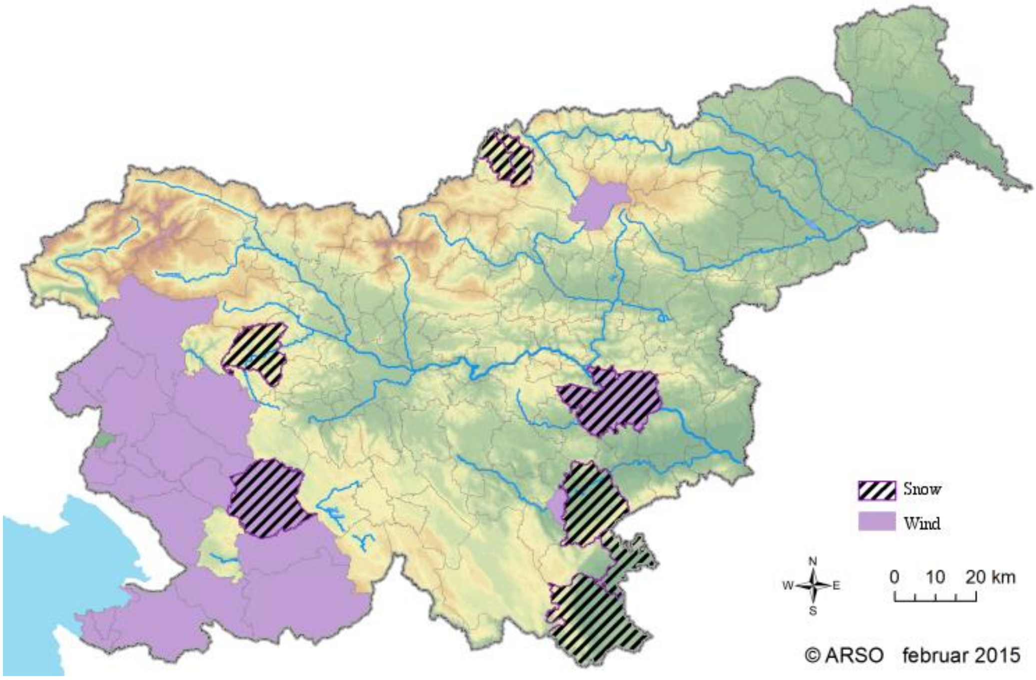
Source: Ajdovščina Municipality, 2016

Figure 30: Unroofed building in Ajdovščina

Source: Ajdovščina Municipality, 2016

Beyond damages caused by wind, the snow also occurred in the smaller area of Karst region. The assessment of damage was not higher (Slovenian Environmental Agency, 2016). The areas affected by strong wind and snow as well are shown in Figure 31.

Figure 31: Damaged areas due to strong wind and snow.



Source: Slovenian Environment Agency, 2016; ACPDR, 2015

6.4. Economic impact of strong bora 2012 - 2015

There is no official data on economic impacts for abovementioned events as natural disaster was not declared. There were no official damage assessment reports made by ACPDR in information system AJDA. For that reason we obtained some data from the insurance company Triglav.

The insurance company Triglav also gave us some description about asked data.

- The total amount of estimated damage in the population (natural persons, damage private action ...): the data has not been separated according to the legal status of the insured- actions in this kind of damage are not recorded.

- The total amount of the estimated damage to infrastructure, transport (protection, damage, destruction, rescue ...): these data are not available separately.

- The estimated amount of damage to buildings by type of building - new construction or building of antique origin or type of components: these data are not available.

- The frequency of occurrence of damage after storms in different areas (Municipality of Ajdovščina, Ajdovščina city, parts of the city of Ajdovščina, Municipality of Nova

Gorica, the Gorizia region in comparison with Slovenia): damage frequency of the small areas is not monitored.

- Typology of insurance policies offered in cases of bora and strong winds: insurance cover is in property given in classes of fire, lived insurance and household insurance while for vehicles under the car insurance.

In Table 12 the number of the reported damage with an average damage payments in one year period are collected, while in Table 13 the statistic of major events with damage assessment are presented.

Table 12: The number of the reported damage with an average damage payments in one year period

Year	Number of the reported damage	Average assessment of damage	Total payments
2012	7289	479 €	3.491.431,00 €
2013	4051	357 €	1.446.207,00 €
2014	1841	287 €	528.367,00 €
2015	3521	318 €	1.119.678,00 €
Total 2012-2015	16702	360 €	**6.012.720,00 €**

Source: Insurance Company Triglav, 2015

Table 13: The statistic of major events with damage assessment

Period (day/month)	01.02.-14.02. 2012	10.11.-13.11. 2013	23.11.-02.12. 2013	05.02.-08.02. 2015
Number of reported damage to cars	428	101	32	164
Average assessment of damage to cars	623 €	577 €	416 €	540 €
Total assessment of damage to cars	266.644,00 €	58.277,00 €	13.312,00 €	88.560,00 €
Number of reported damage to property	3716	1075	142	1354
Average assessment of damage to property	793 €	836 €	574 €	550 €
Total assessment of damage to property	2.946.788,00 €	898.700,00 €	81.508,00 €	744.700,00 €
Total per year 2012-2015*	**3.213.432,00 €**	**956.977,00 €**	**94.820,00 €**	**833.260,00 €**
Total 2012-2015*	**5.098.489,00 €**			

*Note: *only special events*
Source: Insurance Company Triglav, 2015

Referring to Table 12 and Table 13, the damage assessment per event is relatively high compared to actually damage payment in one year period. We have to give point on Table 13, where values represent damage assessment only for special events in the year and that the total values are actually even higher. This difference between damage assessment and payments come due to different amount of insurance fee of each insurant in major cases.

7. Evaluation of Summer Storm *Ela* in North-Rhine Westphalia

This chapter deals with the socio-economic impacts of summer storm *Ela*. When *Ela* occurred in June 2014, it was a so far unknown storm phenomenon for Germany. Insurance companies published that summer storm *Ela* was the second costliest storm event in Germany within the last 15 years (cf. Deutsche Rückversicherung 2015: 21). Nevertheless, the evaluation of socio-economic costs from *Ela* is still not completed. Numbers and estimations are frequently re-adjusted and so far no evaluation of indirect costs has been carried out.

In the following, first a brief hazard description of summer storm *Ela* is given in subchapter 6.1 (*→ for detailed hazard description please see C.2/C.4*). Subsequently, subchapter 6.2 contains a description of social and economic impacts. In subchapter 6.3 the socio-economic costs of summer storm *Ela* are compared to those of winter storm *Kyrill*.

7.1. Hazard Description

In the evening of June 9th 2014 (Whit Monday) there was an unusually intense thunderstorm complex moving across North-Rhine Westphalia. During Saturday June 7th and most of Sunday June 8th of Whit weekend 2014 the Ruhr Area was meteorologically determined by a large high-pressure area ('Wolfgang'), extending from the western Mediterranean Sea to Middle and Eastern Europe. The high-pressure area lead to hot temperatures of more than 30°C in large parts of Germany and created both the first heat wave of the year as well as the hottest day of 2014. Because of 'Wolfgang' the Whit weekend of year 2014 also was the hottest one since weather recordings. At the same time the low-pressure area *Ela* was located at the west coast of Ireland. Already on Sunday low-pressure area *Ela* started to infiltrate the hot, humid and labile air masses in North-Rhine Westphalia, smoothening the way to heavy thunderstorms. (Cf. Deutsche Rückversicherung 2015: 16; DWD 2015: 3f.)

The German Meteorological Service states that every two to three years, North-Rhine Westphalia is hit by a thunderstorm complex. Problematic is that usually the complexes are geographically less broad and occur in differing regions. (Cf. DWD 2015: 24)
But in the case of summer storm *Ela,* several multi-cell thunderstorm clusters arose and affected large parts of the federal state North-Rhine Westphalia. The multi-cell thunderstorms were accompanied by hail, rain and lightning, causing large damages. (Cf. Deutsche Rückversicherung 2015: 16, 20) On Whit Monday a mesoscale convective complex (MCC) developed out of the multi-cell thunderstorms above France. MCCs are characterized as the strongest thunderstorm complexes, as they are the most widespread and durable thunderstorm complexes possible. (Cf. DWD 2015: 4, 11) The socio-economic consequences of the MCC, which moved from France to Germany on Whit Monday, are described in subchapter 6.2.

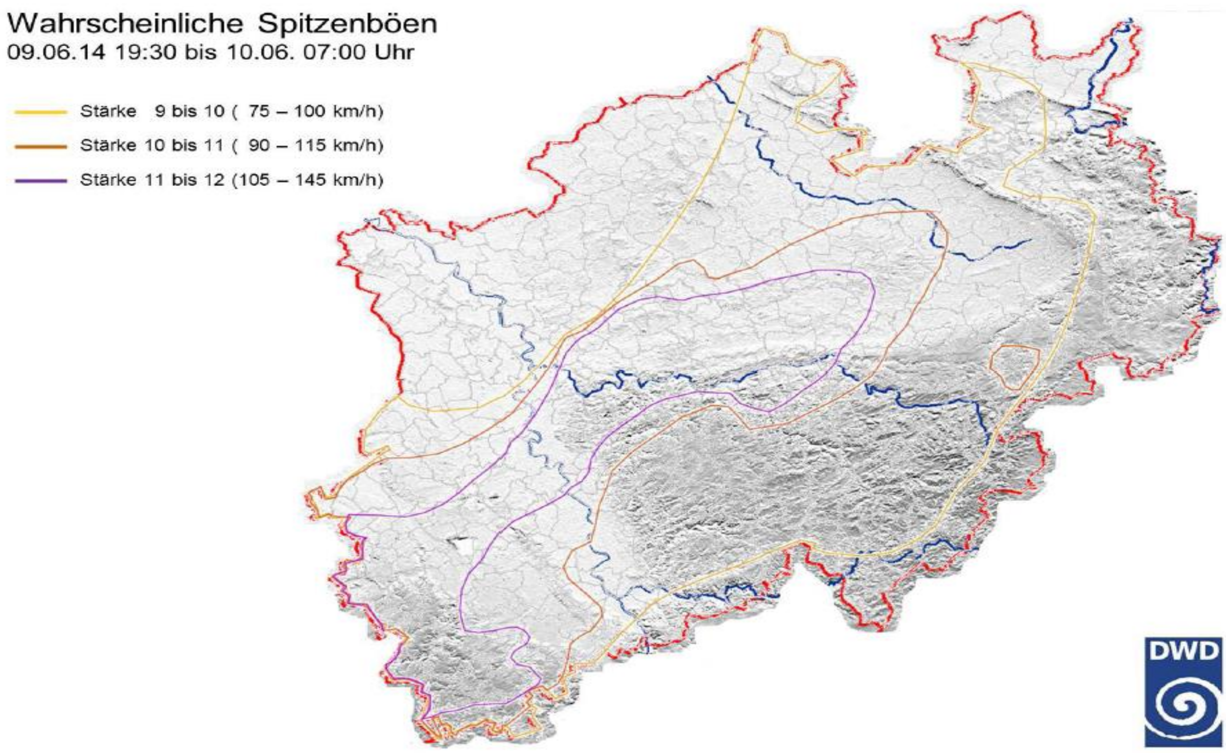
7.1.1. Wind Measurements for *Ela*

Although MCC *Ela* had a relatively broad geographic extent for a thunderstorm, it was too small to create wind field analyses as e.g. possible for winter storms. Besides, thunderstorms – compared to winter storms – do not have one distinct wind direction, so that even if wind field analyses were possible to create, they would not reflect the local wind situation. It can furthermore generally be stated that also orography and topography are only of little importance when measuring wind speeds of thunderstorms. Factors to consider though are:

- valleys, if oriented parallel with the wind direction, may accelerate wind speeds,
- hill summits are more exposed to wind as they are high off mean sea level (MSL),
- street canyons built in wind direction may generally increase wind speeds,
- the edge of a forest as well as buildings at the edge of urban areas are more exposed to wind. (Cf. DWD 2015: 23)

For estimating the probable peak wind gusts of *Ela* for North-Rhine Westphalia, the German Meteorological Service used data from radar, wind and lightning measurements. Within the purple-framed area (± 10 km) in Figure 32 wind gusts of hurricane strength were reached.

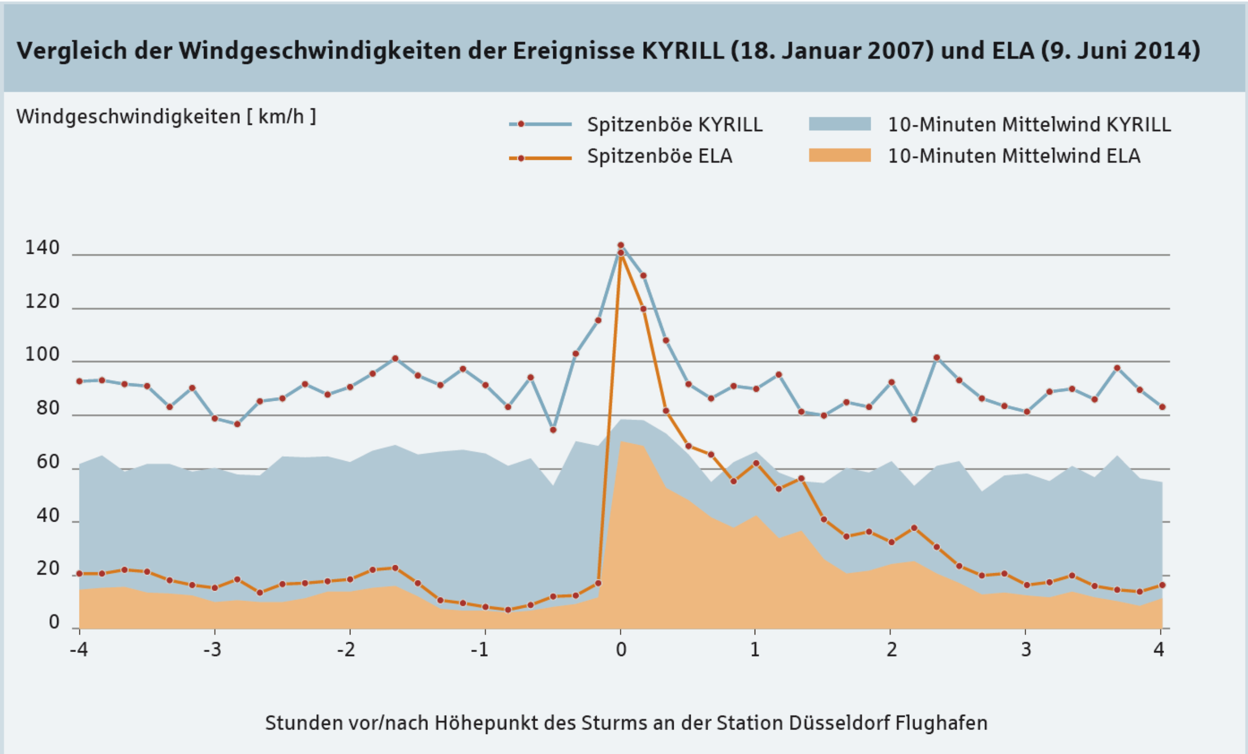
Figure 32. Probable Peak Wind Gusts during Ela according to Beaufort Scale.



Source: DWD 2015: 23

Furthermore, similar to the Croatian and Slovenian case study, weather recordings at Düsseldorf International Airport (DUS) were evaluated in order to depict both maximum wind gusts and 10-minute middle winds of *Ela*. The following Figure 33contains the results of this evaluation; the orange line shows the peak wind gusts at DUS and the orange area shows the average 10-minute wind speeds. Figure 33 furthermore reveals that summer storm *Ela* had similar maximum wind gusts as winter storm *Kyrill* (depicted in blue color). (Cf. Deutsche Rückversicherung 2015: 21).

Figure 33. Comparison of Wind Speeds of Events Kyrill and Ela



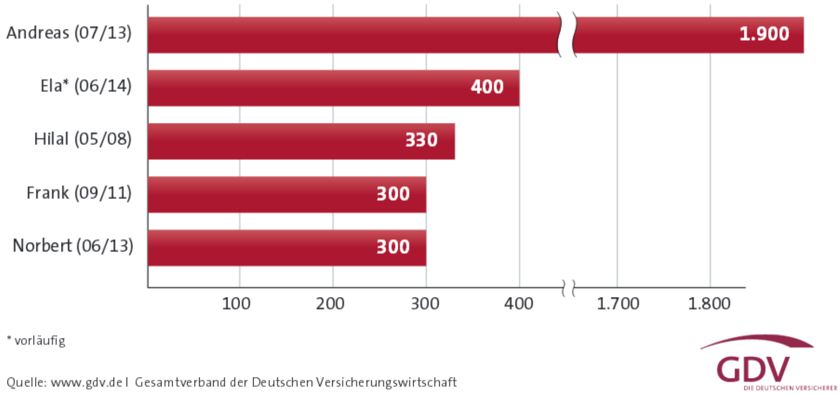
Source: Deutsche Rückversicherung 2015: 21.

7.2. Socio-Economic Impacts of Summer Storm *Ela*

The German Insurance Association (*Gesamtverband der Deutschen Versicherungswirtschaft e.V.; GDV)* recorded a number of 350,000 damages caused by summer storm *Ela* in Germany (cf. GDV 2015: 28) and recorded € 650 million insured losses.
Of these € 650 million losses, € 400 million were related to property insurances and € 250 million to vehicle insurances. The total damages in Middle Europe by *Ela* were estimated € 2.1 billion. (Cf. Deutsche Rückversicherung 2015: 23; GDV 2015: 3.)

Summer storm *Ela* was ranked second most expensive storm in the last 15 years. As the following Figure 34 shows, there were 5 thunderstorms in Germany within the last 15 years that lead to property damages amounting more than € 300 million. Except for *Ela,* the damages resulted from hail though in cases of the other 4 listed storms. *Ela* was the only storm in which damages were mainly associable with the high wind speeds of the extreme event (cf. Deutsche Rückversicherung 2015: 21).

Figure 34. Summerly thunderstorms of the last 15 years in Germany with damages* of more than € 300 million



* Damage sum only includes private property damages.
Source: Website GDV 2014.

The administration of the City of Essen estimated the total amount of public damages[1] to more than € 61 million in July 2014. As an immediate response, the Ministry of Interior of the federal state of North-Rhine Westphalia promised approximately € 5.5 million financial emergency aid. (Cf. Stadt Essen 2014: 12)

Until today the overall losses of storm event *Ela* have not been fully evaluated. Therefore the aforementioned estimations still reflect the latest state of the art. In the following subchapters the socio-economic costs are described and – where possible – also depicted in numbers (reference date 07/2014).

7.2.1. Population

In total there were six fatalities and 30 seriously and 37 slightly injured persons caused by summer storm *Ela* in Germany (cf. Deutsche Rückversicherung 2015: 23).

Due to safety regulations all 250 schools and kindergardens in Essen remained closed for three days until June 12th. Before the re-opening on June 13th all facilities were checked for damages and a corridor for entering the buildings was cleared. For all outdoor facilities of the schools and kindergardens trespassing remained prohibited, as these were of less priority in the clearing process for the emergency units. Until late August 2014 there were still 15 schools resp. kindergardens in which more than 80 % of the outdoor facilities were closed. (Cf. Stadt Essen 2014: 5)

59 of 75 sports facilities (athletics fields, gymnasiums) of the City of Essen were damaged by storm *Ela*. Since August 2014 all sports facilities are re-opened but often with unfinished restoration of fences etc. Also more than 50 trees needed to be logged in outdoor swimming pools and 230 more needed to be checked, which cost € 81,500.00. (Cf. Stadt Essen 2014: 14f.)

[1] The amount of damages was generated by considering ‚all expenses that would be necessary in order to restore the original state within the next years (so called restoration costs).' (Stadt Essen 2014: 11f., own translation)

Figure 35. Damages to playgrounds

Source: Website Stadt Essen 2016; Photograph by Peter Prengel ©

Furthermore about 14 % of public events needed to be cancelled until end of August 2014, due to the threat of branches falling out of trees (cf. Stadt Essen 2014: 6f.).

Table 14. Estimated socio-economic costs of damages related to population (health, education)

Damage inventory	Estimated amount of losses due to summer storm *Ela*	loss is insured	loss is public/private
Restoration of buildings, fences, sports grounds, etc.	€ 1,000,000.00	no	public
Expenses for pruning, felling and reports in areas for sports	€ 1,000,000.00	no	public
Educational buildings	€ 680,000.00	no	public
Total	**€ 2,680,000.00**	**no**	**public**

Source: Stadt Essen 2014: 14 and Annex

Figure 36 in subchapter 'Infrastructure and Transport' shows that in the central Ruhr Area and Düsseldorf more than 800 emergency operations were conducted per 100,000 inhabitants (cf. Deutsche Rückversicherung 2015: 23).
The emergency call numbers of the fire brigade and the police were overloaded during the night of the event because so many people called to record damages. Already until midnight the fire brigade hat 850 emergency operations to process, throughout the whole night they added up to 5,000. Problematic was, that especially during the first hours, emergency units were not able to reach their operating place due to fallen trees and branches blocking the roads. (Cf. Stadt Essen 2014: 1)

Already during the night of June 9th the emergency response units in cooperation with the city administration began to inform the population about the consequences of *Ela*. The first communication channel used was the facebook page of the fire brigade Essen. Besides facebook, other social media channels were used and information were constantly updated on the website of the City of Essen (www.essen.de). Furthermore a '*Bürgertelefon*' (*citizens' telephone*) was set up and information were spread by the local press. (Cf. Stadt Essen 2014: 1, 3f.

7.2.2. Infrastructure and Transport

All federal roads (*Bundesstraßen*) and an unknown number of municipal roads were blocked by trees due to storm *Ela*. The first priority was to clear the roads of trees and branches so that these were passible for the emergency response units in order to reach their operating places. As second priority all other acute damages in the road network were cleared and afterwards, as third priority, all 61,000 city trees were checked for damages. For both the clearance as well as the checking process, the emergency units prioritized the roads; main roads and roads to critical infrastructures, such as hospitals, were treated first.

Figure 36. Damages to roads, rail network and train stations

Soucre: Website Stadt Essen 2016; Photographs by Peter Prengel ©

Furthermore all of the rail network of the *Deutsche Bahn* and the above-ground tram network of the local transport company EVAG (*Essener Verkehrs-AG*) were not passable due to trees damaging the overhead lines. The losses due to damages to the rail network of the *Deutsche Bahn* are estimated € 20 million direct costs due to trees damaging the overhead lines and € 36 million indirect costs due to shortfall in receipts. (Cf. Bundestag 2014 ;Stadt Essen 2014: 1)

Table 15. Estimated socio-economic costs of damages to infrastructure facilities and transport

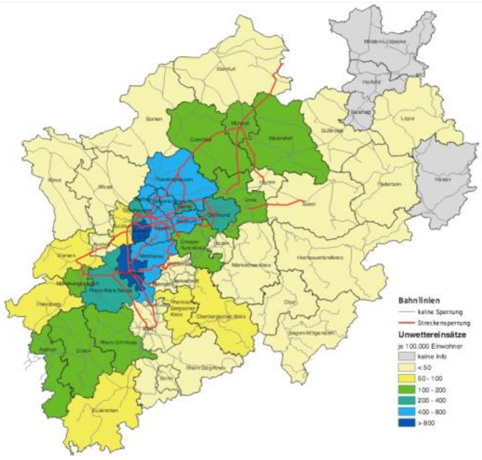
Damage inventory	Estimated amount of losses due to summer storm *Ela*	Loss is insured	Loss is public/private
Traffic Lights	€ 200,000.00	partly	public
Streetlights	€ 1,700,000.00	no	public
Road signs	€ 30,000.00	no	public
Other road works	€ 100,000,000.00	no	public
Total costs (roads)	**€ 2,930,000.00**	**mainly no**	**public**
Motor busses (EVAG)	€ 105,000.00	yes	private*
Rail vehicles in workshops	€ 38,500.00	no	private*
Train stations and elevators and clearing of damages	€ 126,200.00	no	private*
Ticket machines	€ 25,000.00	yes	private*
Clearing of damages to buildings of EVAG	€ 50,100.00	yes	private*
Loss assessment and clearing of tracks	€ 480,000.00	no	private*
Routing and restoration of transport security	€ 27,800.00	no	private*
Shortfall in receipts	€ 65,000.00	no	private*
Total costs (transport)	**€ 917,600.00**	**mainly no**	**private***
Compensatory plantation of trees as road infrastructure	€ 4,284,000.00	no	public
Cordon for clearance of acute damages within road infrastructure	€ 300,000.00	no	public
Borrowing of vehicles with elevating platforms	€ 46,800.00	no	public
Total costs (road infrastructure)	**€ 4,630,800.00**	**no**	**public**
Overall costs for infrastructure and transport	**€ 8,478,400.00**	**mainly no**	**public** (if private losses covered by City of Essen)

**private) The EVAG is a subsidiary company of the City of Essen, therefore losses are covered by the city.*
Source: Stadt Essen 2014: 12f. and Annex

There are no reported losses to infrastructure facilities of energy supply, water supply, wastewater treatment and telecommunication (cf. Stadt Essen 2014: Annex).

The storm path as well as the path of damages is visualized in Figure 37. It can be seen that most rail tracks of the *Deutsche Bahn* needed to be closed in the Ruhr Area. (Cf. Deutsche Rückversicherung 2015: 23)

Figure 37. Closure of rail tracks and operations of emergency units in North-Rhine Westphalia



Source: Deutsche Rückversicherung 2015: 23

At DUS (Düsseldorf International Airport) take-off and landing were stopped from 9 pm to 10 pm and the German Rail precautionary ceased all rail traffic in North-Rhine Westphalia (cf. Deutsche Rückversicherung 2015: 22f.).

The severe damages became even more visible the next morning, when road and rail traffic were extremely restricted and thousands of people were not able to get to their work places. Especially the German Rail had serious problems in overcoming the damages as one third of the whole rail network was unusable. All in all the police in North-Rhine Westphalia had to process more than 5,000 weather related operations in the night of June 9th/10th. (Cf. Deutsche Rückversicherung 2015: 22)

7.2.3. Buildings

The damage symptoms of public buildings were mainly the same as damage symptoms of private buildings; due to uprooted trees and falling branches, roofs, fences, windows etc. were damaged. Furthermore, fallen trees blocked doorways and driveways and outdoor facilities were unusable. Economically the costs for the restoration of buildings were only marginally higher than for the restoration of outdoor facilities. (Cf. Stadt Essen 2014: 14)

Table 16 Estimated socio-economic costs of damages to public buildings

Damage inventory	Estimated amount of losses due to summer storm *Ela*	Loss is insured	Loss is public/private
Public buildings and outdoor facilities	€ 110,000.00	no	public
Total	**€ 110,000.00**	**no**	**public**

Source: Stadt Essen 2014: 14 and Annex

7.2.4. Forests

Due to the extreme wind loads, about 20,000 of Essen's city and forest trees were damaged by summer storm *Ela*. As the storm occurred during summer, the predominantly deciduous city trees were in full leaf and therefore had even more windage. (Cf. Stadt Essen 2014: 13)

Besides completely uprooted trees, damages in the treetops were the most common damage symptoms. The latter damages are the reason why the clearing still is not completed. Each tree needed to be checked for acute damages in the first stage, afterwards it needed to be pruned and then controlled again, which is an ongoing process. The experts estimate that 10 % of Essen's city trees were either uprooted by *Ela* or needed to be pruned that heavily, they will never regenerate and need to be removed soon. (Cf. Stadt Essen 2014: 13)

Figure 38 Damages to city trees

Source: Website Stadt Essen 2016; Photograph by Peter Prengel ©

City trees are financially calculated as road inventory and have a defined fixed value within the capital assets of the City of Essen. Before *Ela*, the fixed value for Essen's city trees amounted € 36.6 million for 61,000 trees, resulting in an average fixed value of € 600.00 for each tree. (Cf. Stadt Essen 2014: 13f.)

Table 17. Estimated socio-economic costs of damages to forests and city trees

Damage inventory	**Estimated amount of losses due to summer storm *Ela***	**Loss is insured**	**Loss is public/private**
Replacement planting of trees in educational establishments (schoolyards, day care centers, etc.)	€ 4,284,000.00	no	public
Replacement planting of trees in public green spaces, cemeteries	€ 5,712,000.00	no	public
Reforestation in municipal forests	€ 4,951,000.00	no	public
Restoration of fences, benches, stairs, etc. in public green spaces, cemeteries and forests	€ 1,997,437.50	no	public
Restoration of paths and public squares (including pavement) in public green spaces, cemeteries and in forests as features of green infrastructures	€ 892,500.00	no	public
Restoration of play equipment on playgrounds (besides educational establishments)	€ 2,500,000.00	no	public
**) already calculated in the category infrastructure facilities and transport:* *Compensatory plantation of trees as road infrastructure*	*€ 4,284,000.00*	*no*	*public*
Total	**€ 20,336,937.50**	**no**	**public**

Source: Stadt Essen 2014: 13f. and Annex

Furthermore, approximately 10 % of Essen's forest trees were damaged. In total damages to forests and city trees are about 4 times higher than those of summer storm *Kyrill*. (Cf. Stadt Essen 2014: 13).

Figure 39. Damages to forests

Sources: Website Sadt Essen 2016; Photographs by Peter Wieler © and Peter Prengel ©

Another socio-economic cost resulting from *Ela* was that any kind of urban green space and forests were prohibited entering, ranging from several weeks (e.g. for playgrounds) up to several months (e.g. for parks). Until today, entering forests is at one's own risk and walking off trail is prohibited[2] (see Figure 40).

Figure 40. Warning sign in Essen's forests 'danger to life offside the main paths'

Source: Photograph by Hanna Schmitt (11.01.2016).

7.2.5. Other Socio-Economic Costs

Besides losses to the five key vulnerability parameters of the Wind Risk project, further costs arose, which are collected in Table 18. These other socio-economic costs preliminarily consist of labour costs and costs for the purging urban spaces, such as water bodies. (Cf. Stadt Essen 2014: Annex) Unfortunately, indirect costs have not been evaluated for summer storm *Ela* yet.

Table 18 Estimated socio-economic costs for purging and hazard prevention

Inventory	Estimated losses due to summer storm *Ela*	Loss is insured	Loss is public/private
Securing, felling, clearance, disposal of damaged trees on public green spaces, roads, educational establishments, cemeteries, playgrounds as measures of acute hazard prevention	€ 23,166,060.00	no	public
Securing, felling, clearance, disposal of damaged trees in forests as measures of acute hazard prevention	€ 3,285,000.00	no	public
Gathering, storing and removal of damaged trees and windthrow	€ 1,036,800.00	no	n/a
Acute hazard prevention measures of the fire brigade Essen	€ 1,927,835.00	no	public

[2] The reason is that forests got ranked lowest clearing priority by the emergency units and currently there are still other damage removal processes ranked higher, which need to be carried out first.

Purging of water bodies and riversides (incl. restoration of fences etc.)	€ 350,000.00	no	public
Traffic control measures	€ 30,700.00	n/a	n/a
Total	**€ 29,796,395.00**	**no**	**public**

Source: Stadt Essen 2014: Annex.

7.3. Comparison of Socio-Economic Impacts of Summer Storm Ela with Winter Storm Kyrill

Winter storm *Kyrill* was a large depression with great geographic extent that swept over large parts of Central and Northern Europe, leaving massive damages extending from the British Isles to Russia. *Kyrill* was characterized by hurricane force peak wind gusts and long-lasting 10-minutes middle winds of Beaufort classes 7 to 8. In comparison to abruptly occurring *Ela*, *Kyrill* was well-predicted several days in advance. It can therefore be assumed, that due to an early warning management and disaster preparedness, higher damages and fatalities have been prevented. Nevertheless, at least 46 people died from *Kyrill*. In the countries Germany, Austria, the Czech Republic and Poland there were at least 2 million houses without electricity. Also large damages on roads, railways and other transport infrastructure (e.g. aircraft and ship transport) resulted from *Kyrill* and about 62 million trees were uprooted in Central Europe, particularly in Germany, especially forest spruce trees. (Cf. Fink et al. 2009: 406)

The following Table 19 contains a comparison of economic losses of winter storm *Kyrill* (2007) and summer storm *Ela* (2014).

Table 19. Comparison of economic costs of winter storm Kyrill and summer storm Ela

	Winter Storm *Kyrill* January 2007, Central Europe	**Summer Storm *Ela*** June 2014; Western Germany
Property Damages	Damages Federal Republic of Germany: • € 2.4 billion[d] (approx. € 7 billion in Europe)[c]	Damage Federal Republic of Germany: • € 650 million (number of damages: 350,000) o thereof € 400 million damages to private houses and companies (250,000) o thereof € 250 million damages to cars (100,000)[e]
Municipal Damages		Municipal Damages: • € 300 million
Fatalities and Injuries	Number of fatalities in Europe: • 46	Number of fatalities in Europe: • 6 Number of injuries in Europe: • 37,100
Damages to Trees	Europe: • 62 million uprooted; mainly conifers	City of Essen: • 20,000 city trees; mainly deciduous trees

Damages to Railroads		Damages German Rail (*Deutsche Bahn*): • € 20 million direct damages • € 36 million indirect economic losses[a]

Sources: [a]Bundestag 2014: 1, Deutsche Rückversicherung 2015: 21; [c]Fink et al. 2009: 406; [d]Website GDV 2007; [e]Website GDV 2014.

The comparison of *Kyrill* and *Ela* is somehow problematic, as official loss statistics for *Kyrill* usually refer to Central and Northern Europe. When comparing *Kyrill* and *Ela* for the City of Essen, the differences in losses become more visible. While *Kyrill* was mainly affecting conifer forests, *Ela* lead to damages within the city. The press office of the city administration of Essen stated in June 2014 that '*the amount of damages of* Ela *exceed* Kyrill's *damages three to four times*' (Presseinformation Essen 23.06.2014, own translation).

8. Conclusions

Wind risk comes along with natural meteorological risks that can cause devastating consequences in many aspects of people's life. Social impacts of the wind disaster are mainly due to limited mobility of citizens, while economic impacts are mostly expressed in material damages.

In Croatia it is common case that a part of the motorway is closed due to the wind conditions. North wind bora with specific gusty behavior cause material damage, brakes threes and traffic signs and can cause damage on old buildings if they are not maintained well.
Wind sirocco usually raises sea level and causes high waves and damage of the facilities near sea (ports, shore, and seafront). Windwhrils are occasional short time phenomenon that usually form and take place over the sea level and in that case do not cause damage, but if take place on land can make significant damage in short time.
Economic cost of strong wind in Croatia is assessed for the event of bora in March 2015. Official damage report for natural hazard mitigation adds up to 2 mil Euro damage, while unofficially the damage is estimated to 4 million Euros.

In Slovenia, AJDA information system is used to assess the damages from disasters. In Slovenia Bora in Vipava valley causes damages, derogation of soil and problems in transport and infrastructure. Also thunderstorms with hail and sleet are problem during winter and summer (July storm with hail). During the specific event in July 2008 total damage of 21 million euros was reported. According to AJDA significant portion of material damage is due to wind events every year.

Summer storm *Ela* was a new dimension[3] of a thunderstorm for Germany. Geographically *Ela* was broader than any thunderstorm before and therefore large areas of North-Rhine Westphalia were affected simultaneously. As an MCC it also was more intense and long-lasting than any event before. Furthermore all concomitants (heavy precipitation, strong wind gusts and hail) appeared together, further increasing the damages.

The evaluation of socio-economic costs is until today not finalized. All data displayed in subchapter 7.3 bases on estimations the city administration made when applying for grants of the European Solidarity Fund in July 2014.
Ela storm in Germany resulted in estimated damage of 650 mil euros.

Ela impressively revealed an urgent need for prevention and preparedness because summerly storms events have a huge damage potential as they highly affect built structures, goods and assets within cities.

For future evaluation of social and economic impacts of wind risk disaster keeping register of damages such as Slovenian AJDA system is recommended. With such a tool it would be possible to evaluate total damage of each event with social and economic consequences, and not only extreme events, and better asses the causes and effects of the damages.

[3] at least since 1971 (further historical analyses are under preparation)

9. Abbreviations and definitions

ABBREVIATION	ABBREVIATION MEANING
DHMZ	The Croatian Meteorological and Hydrological Service (*cro*. DHMZ - Državni hidrometeorološki zavod)
HAC	Croatian Motorways, Ltd (*cro*. HAC - Hrvatske autoceste), a limited liability company for operation, construction and maintenance of motorways.
HAK	Croatian Auto Club (*cro.* HAK – Hrvatski autoklub) national association of drivers and vehicle owners
PMC	Marine meteorological service in the Adriatic Sea (*cro.* PMC – Pomorski meteorološki centar)
HRK	Croatian Kuna, approx. 0.130€
ACPDR	Administration for Civil Protection and Disaster Relief
MAFF	Ministry of Agriculture, Forestry and Food
MESP	Ministry of the Environment and Spatial Planning
MI	Ministry of Infrastructure
AJDA	Slovenian system for electronic and centralized management of damage assessment in case of natural disasters
DWD	German weather service (ger. Deutscher Wetterdienst)
MCC	Mesoscale Convective Complex
GDV	The German Insurance Association (ger. Gesamtverband der Deutschen Versicherungswirtschaft)

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WIND RISK

Task C – Risk/Vulnerability assessment

Action C.7: Assessing the roles and activities of national and local institutions in the territorial planning, infrastructure and disaster preparedness

For the Wind Risk prevention project

University of Ljubljana
Technical University of Dortmund
University of Split
Municipality of Ajdovščina

C.7. Assessing the roles and activities of national and local institutions in the territorial planning, infrastructure and disaster preparedness

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1. Identification of responsible institutions in the territorial planning, infrastructure and disaster preparedness in Slovenia

Table 1: Slovenian responsible local and national institutions

	1. National		**3. Local**	
Territorial planning	Ministry of the Environment and Spatial Planning	Spatial planning, construction and housing directorate	Municipality of Ajdovščina	Department of Environment and Spatial Planning
Infrastructure	Ministry of Infrastructure	Slovenian Infrastructure Agency	Municipality of Ajdovščina	Department of Environment and Spatial Planning
Disaster preparedness	Ministry of Defense	The Administration of the Republic of Slovenia for Civil Protection and Disaster Relief (ACPDR)	Municipality of Ajdovščina	Department of Environment and Spatial Planning

1.1. Territorial planning

In Slovenia, on the national the level Ministry of the Environment and Spatial Planning, Spatial planning, construction and housing directorate is the responsible organisation dealing with territorial planning. On the local level 212 municipalities are, according to the 21. Article of the Low on Local Self-Government, responsible for the performance of tasks related to economic and spatial development, construction of buildings, traffic management, protection against natural and other disasters, etc. Detailed municipality's tasks and responsibilities are defined within laws concerning specific fields.[1] In most cases municipalities the Departments of Environment and Spatial Planning, are responsible for local territorial planning.

1.2. Infrastructure preparedness

On the national level the Slovenian Infrastructure Agency from the Ministry of Infrastructure is responsible for the national infrastructure, while on the local level of municipalities, in most cases Departments of Environment and Spatial Planning covers this field.

1.3. Disaster preparedness

1 http://www.sos112.si/slo/page.php?src=sv7.htm

On the national level The Ministry of Defence, The Administration of the Republic of Slovenia for Civil Protection and Disaster Relief (ACPDR) is responsible for disaster preparedness, while on the local level municipalities, Department of Environment and Spatial Planning are responsible for territorial planning.

Within the present Wind Risk Action C.7 report, we will assess the roles and activities of national and local institutions in the territorial planning, infrastructure and disaster preparedness in Slovenia. We have to highlight, that the present report was made out of directly accessible and readily available data and other relevant materials.

2. Identification of local institution’s roles and activities in Slovenia

2.1. Territorial planning

In Slovenia, according to the existing spatial planning legislation, e.g. the Law on Spatial Planning, the municipalities are obliged and responsible for the preparation of the local fundamental spatial planning document Municipal Spatial Plan (OPN) and other spatial acts. The Ministry of Environment and Spatial Planning cooperates with municipalities in several stages in the process of preparing their OPN and supervises it.[2]

The OPN determines the municipal local spatial development and conditions. Within sustainable planning of interventions in space, it provides quality conditions for life and work of its inhabitants. Furthermore, it represents an important base for rational and sustainable planning. It determines land use, space interventions and spatial provisions of local importance.[3] Municipality of Ajdovščina existing municipal spatial plan is available at http://www.uradni-list.si/1/content?id=51121, but is currently being updated.[4]

Figure 1: Ajdovščina spatial planning area

The local territorial planning enables harmonised development of the area, together with public benefit. It involves environmental and landscape protection, conservation of nature

2 http://www.sos112.si/slo/page.php?src=sv7.htm
3 https://www.uradni-list.si/1/content?id=79670
4 http://www.sos112.si/slo/page.php?src=sv7.htm

and cultural heritage needs, protection of natural resources and other.[5] Thus, interventions in space also have to take into account the protection against natural and other disasters. Different technical (spatial, urban, construction etc.) measures have to be taken into account, in order to facilitate the implementation of protection, rescue and assistance and to prevent or reduce the negative aspects of natural or other disasters.[6]

Furthermore, national Administration for Civil Protection and Disaster Relief (ACPDR) issues guidelines and opinions in the field of protection against natural and other disasters also within the preparation of municipal spatial plans.[7] Different minister's additional measures and guidelines, for reducing or mitigating the consequences of accidents, influence the local spatial planning.[8]

2.2. Infrastructure preparedness

As we already discussed in the Wind Risk Action C.2., Municipality of Ajdovščina is responsible for the water supply system (Hubelj), which supplies a major part of Vipava Valley and Goriška region. Domestic water supply is sufficient.[9] There are also a number of village water basins, supplying 50 households. There are in total 350.824,99 m of drinking water pipes.[10]

The main provider of electoral energy in the Municipality of Ajdovščina, as well as the whole region, is Elektro Primorska. In Dolenje there is a 110 kV distribution station. Also on the river Hubelj there is a small hydroelectric power plant with net power of 2,1 MW. In the year 2013 there were also 30 photovoltaic power plants with a total net installed power of 5,2 MW. [11] The possibilities of utilizing alternative energy sources (particularly environmentally friendly, such as biomass, solar energy or wind energy) are large, but mostly unused.[12]

As was already mentioned in the Wind Risk Action C.2., the Municipality of Ajdovščina is responsible for 255, 9 km of municipality roads, which together with state roads represent 349, 4 km of roads within the municipality area.[13] From these municipal roads, there are 97,3 km of local roads (LC), 5,7 km aggregated urban or local roads (LZ), 19,1 km of urban (local) roads and 133,8 km of public paths.[14]

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5 http://www.sos112.si/slo/page.php?src=sv7.htm
6 http://www.sos112.si/slo/page.php?src=os6.htm
7 http://www.sos112.si/slo/page.php?src=sv7.htm
8 http://www.sos112.si/slo/page.php?src=os6.htm
9 Občina Ajdovščina: Ocena ogroženosti pred naravnimi in drugimi nesrečami v občini Ajdovščina, Ajdovščina julij 2014. (Municipality of Ajdovščina:Risk Assessment against natural and other disasters, July 2014).
10 http://gis.iobcina.si/gisapp/Default.aspx?a=ajdovscina
11 Občina Ajdovščina: Ocena ogroženosti pred naravnimi in drugimi nesrečami v občini Ajdovščina, Ajdovščina julij 2014. (Municipality of Ajdovščina:Risk Assessment against natural and other disasters, July 2014).
12 Todora Rogelja, Špela ščap, Matevž Triplat, dr. Nike Krajnc: Availability of forest biomass in the Municipality of Ajdvoščina, Ljubljana September 2014.
13 http://pxweb.stat.si/pxweb/Dialog/varval.asp?ma=2221302S&ti=Dol%9Eine+cest+po+kategoriji%2C+ob%E8ine%2C+Slovenija%2C+letno&path=../Database/Ekonomsko/22_transport/02_22212_cestni_transport/01_22213_infrastruktura/&lang=2
14 http://pxweb.stat.si/pxweb/Dialog/Saveshow.asp

Figure 2: Municipality roads network[15]

The Municipality is also in charge for local Sewerage Network and other communal services: public lighting system, cemetery services. There are 560 kg of communal waste per person.[16] There are also health care and pharmacy services, public school network and other educational and cultural institutions.

2.3. Disaster preparedness

In Slovenia, municipalities independently manage and implement the system of protection against natural and other disasters in their areas. Thus, the Municipality of Ajdovščina disposes of a fully developed and well operational Civil Protection Service, as we already discussed in detail in the Wind Risk Action C.8.

Based on the statistical data, risk monitoring in the local community, municipal spatial plan, experiences based on past accidents, regional and national protection and rescue plans, the mayor organizes and implements local protection, rescue and aid measures regards the natural disasters (Risk assessments, Emergency response plans, Plan for Mobilization and Communication of Protection and Rescue Providers, etc.). They enable the installation of early warning system for mitigation of natural disaster events.

The mayor together with the Municipal Council determines civil protection formations, the operation of protection, rescue and relief bodies (CP Commanders, CP Deputy Commander, the Heads of Interventions, rescue units and services, Civil Protection Headquarters, Head of Intervention, the municipal administration bodies) and provides material assets and

15 http://gis.iobcina.si/gisapp/Default.aspx?a=ajdovscina
16 Ibid.

equipment. He provide resources for the purpose of protection, rescue and assistance, in accordance with a uniform information communication system. The municipality also implements training programs of municipal importance and eventual CP international cooperation.

Local CP units and forces involve professional, voluntary and other types of units and services, research institutions and in case of insufficiency of the above-mentioned forces also the Slovenian Army and the Slovenian Police. However, commercial companies and other organizations can also organize CP units and services.[17]

Figure 3: Professional Fire-fighting unit in Ajdovščina

[17] http://www.sos112.si/slo/page.php?src=szr1.htm&r=1

2.4. Identification of national institution’s roles and activities in the:

2.4.1. Territorial planning

The Ministry of the Environment and Spatial Planning, The Spatial Planning Directorate is responsible for national territorial planning. It dictates national spatial development trends and guidelines in order to design sustainable development of space, settlements, efficient and economical use of land, conservation of recognizable area features and social well-being. Moreover, it aims to conserve and protect the environment, landscape diversity, natural resources, cultural and natural heritage also against natural and other hazards.[18] Slovenia's strategic territorial planning documents, involving key areas: climate change, nature and biodiversity, quality of life, and waste and industrial pollution are Spatial Development Strategy of Slovenia, Spatial Order of Slovenia and the National Housing Programme, Resolution on the National Environmental Protection Programme, etc.[19]

REPUBLIC OF SLOVENIA
MINISTRY OF THE ENVIRONMENT AND SPATIAL PLANNING

Furthermore, according to the Spatial Planning Directorate official site, it carries out the following tasks:

- integrated management of spatial planning and its legislation;
- preparation of national spatial plans;
- strategic development documents;
- general guidelines and principles of urban planning;
- collaboration and supervision of local spatial documents and
- communication and promotion for future spatial sustainable development and management.[20]

2.4.2. Infrastructure preparedness

In Slovenia, The Ministry of Infrastructure, Slovenian Infrastructure Agency is responsible for infrastructure, transport, energy and investment monitoring and finance division.

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MINISTRY OF INFRASTRUCTURE

18 http://www.sos112.si/slo/page.php?src=os6.htm
19 http://www.mop.gov.si/en/areas_of_work/
20 Ibid.

According to the Ministry of Infrastructure official site, the Infrastructure Directorate is facing issues dealing with the infrastructure. Namely development and investments in railways, maintenance and management of road infrastructure, public and civil aviation, maritime transport and port infrastructure, etc.[21]

Slovenian Infrastructure Agency deals with priorities regarding transport, such as: adoption and participation in legislative proposals (Resolution on the Transport Policy of the Republic of Slovenia, Resolution on the National Programme for Road Traffic Safety, EU legislation etc.), supervision and planning of further development of public transport service, participation in drawing-up international agreements in the field of transport, etc.[22]

The Energy Directorate performs tasks relating to the efficient use of energy and provision of renewable sources of energy, energy supply, sources of energy and mining. They include national energy policy goals, such us secure, sustainable and competitive energy supply, increasing energy efficiency and energy supply from renewable energy sources. Directorate activities include national energy policy, management of raw mineral resources and mining rights, ensuring a reliable energy supply at competitive prices, cooperation within bilateral and multilateral regional energy frameworks, energy sector database information system, elaboration of economic analyses for the energy sector, etc.[23]

2.4.3. Disaster preparedness

In Slovenia, Ministry of Defence, The Administration of the Republic of Slovenia for Civil Protection and Disaster Relief (ACPDR) performs administrative and professional protection, rescue and relief tasks. In addition, ACPDR published general guidelines, concerning natural and other hazards, for national, regional and local spatial documentation preparation.[24] Disaster management system, protection, rescue and relief activities are all part of the national security system, which is explained more in detailed in Wind Risk Action C.8.

REPUBLIC OF SLOVENIA
MINISTRY OF DEFENCE

According to the Ministry of Defence official site, the ACPDR influence national spatial planning by issuing guidelines and opinions in the field of protection against natural and other disasters within the preparation of national, inter-municipal and municipal spatial plans. [25]

21 http://www.mzi.gov.si/en/areas_of_work/infrastructure/
22 Ibid.
23 http://www.mzi.gov.si/en/areas_of_work/energy/
24 http://www.sos112.si/slo/page.php?src=os6.htm
25 http://www.sos112.si/slo/page.php?src=sv7.htm

2.5. Interaction between the local and/or national institution's roles and activities

2.5.1. Before the wind

National and local territorial, infrastructure and disaster preparedness planning, before the wind disaster, plays a crucial role in efficient protection, rescue and relief of the affected area.

Proper land use planning has a big impact in reducing the threat of natural and other disaster**.** Thus, the spatial planning enforce spatial, urban, construction and other measures, in order to prevent or reduce negative impacts of natural and other disasters and to enable activation of protection, rescue and relief.[26] Inclusion of wind hazard features into the territorial planning and infrastructure management brings beneficial consequences to the hazard areas. For example, the Municipality of Ajdovščina, defines the protected areas and their restrictions, while issuing the "Planning information" document. Thus, it can be defined, if the object location is in 3. zone of wind speed (30 m/s).[27]

National documents, regarding the wind disaster preparedness and the early warning system should be planned and prepared before the high wind disaster event. Local documents (Natural and Other Risk Assessments, Protection and Rescue Plans, Plan for Mobilization and Communication of Protection and Rescue Providers, etc.) follow them. Furthermore, as we have mentioned already above, local and national civil protection formations (CP Commanders, CP Deputy Commander, Heads of Interventions, rescue units and services, Civil Protection Headquarters, Head of Intervention, the municipal administration bodies, etc.) are formed and material resources are provided. ACPDR as well as municipalities implement training programs and support eventual CP international cooperation. Furthermore, they inform general public about the nature and consequences of (wind) disaster"[28]

Figure 5: Public awareness campaign

26 http://www.sos112.si/slo/page.php?src=sv7.htm
27 http://gis.arso.gov.si/geoportal/catalog/search/resource/details.page?uuid=%7B95F32F38-1ABC-4FEF-8EAE-FF4766301AE1%7D
28 Občina Ajdovščina: Ocena ogroženosti pred naravnimi in drugimi nesrečami v občini Ajdovščina, Ajdovščina julij 2014. (Municipality of Ajdovščina: Risk Assessment against natural and other disasters, July 2014).

2.5.2. During the wind

The interaction between local and national civil protection plays a crucial role in efficient protection and rescue during a high wind event.

The local or national CP Commander, or eventually the Mayor takes the decision on alarming and activating the operational and professional units of protection, rescue and relief (CP Headquarter members, responsible municipal officials and technical municipal staff, CP Support Service members, etc.).29 They are responsible for intervention in case of potentially hazardous damage caused by wind and/or isolating the high-risk areas. For a successful protection, rescue and relief it is necessary to:

- act in accordance with the local/national Protection and Rescue Plan;
- act in accordance with the local/national Plan for Mobilization and Communication of Protection and Rescue Providers,
- take action to protect people and their property;
- organize people and animal protection and rescue;
- organize health care for people at risk, carry out the evacuation;
- in case of infrastructure damage (electricity, water, telecommunications, sewer, roads, care), immediately accede to their repair;
- hazard event monitoring and
- other. [30]

2.5.3. After the wind

After the wind calms down, the restoration and recovering of damage begin. In case of a wind event direct consequences most likely occur, such us infrastructure damage (electricity, telecommunications, roads, etc.), damage on vehicles, traffic facilities (fences, traffic lights and signs…), damages on roofs, etc. Even more severe are indirect consequences, such us injuries due to flying objects blown away by wind, interruption of production, damage in agriculture, delays in shipment of goods, reduction in number of travellers, costs of interventions of Civil protection units, etc.

29 Občina Ajdovščina: Načrt zaščite in reševanja ob zemeljskih plazovih, julij 2014, Municipality of Ajdovščina: Protection and Rescue Plan for Landslides, July 2014.
30 Občina Ajdovščina: Ocena ogroženosti pred naravnimi in drugimi nesrečami v občini Ajdovščina, Ajdovščina julij 2014. (Municipality of Ajdovščina:Risk Assessment against natural and other disasters, July 2014).

Figure 4: Wind roof damage

In Slovenia, local as well as national authorities are responsible for disaster recovery and consequence mitigation. The expenses of interventions bear the local authority, while the expenses of direct damage are the matter of insurance companies or individuals. The municipality has to announce the responsible regional canter for notification about the consequences of damage. Furthermore, if ACPDR assess that the damage is high enough, it issues a decree under which the municipalities assess the damage and report it to the national authorities. However, it is difficult to assess the costs of direct and indirect damage of a certain period of strong wind.

Let us have a look at the strong wind event in Ajdovščina, at the beginning of February 2012. The figure below demonstrates the assessment of interventions[31] occurred during this event based on the emergency calls, concerning the type of the buildings. It can be summarized as follows. First, the assessment demonstrated that the most vulnerable objects to high winds are dwelling houses, followed by new constructed business facilities (which are not properly designed and/or constructed, in terms of Vipava valley needs). Second, the assessment of the emergency calls revealed that almost 50% of all calls were dealing with damaged roof issues, which were proved to be the most damaged part of the buildings.

[31] Jošt Černigoj: Burja v občini Ajdvoščina med 31.1. in 11.2.2012, Poročilo, Ajdovščina februar 2012. (Jošt Černigoj: Bora in the Municipality of Ajdovščina 31.1.-11.2.2012, Report, Ajdovščina February 2012)

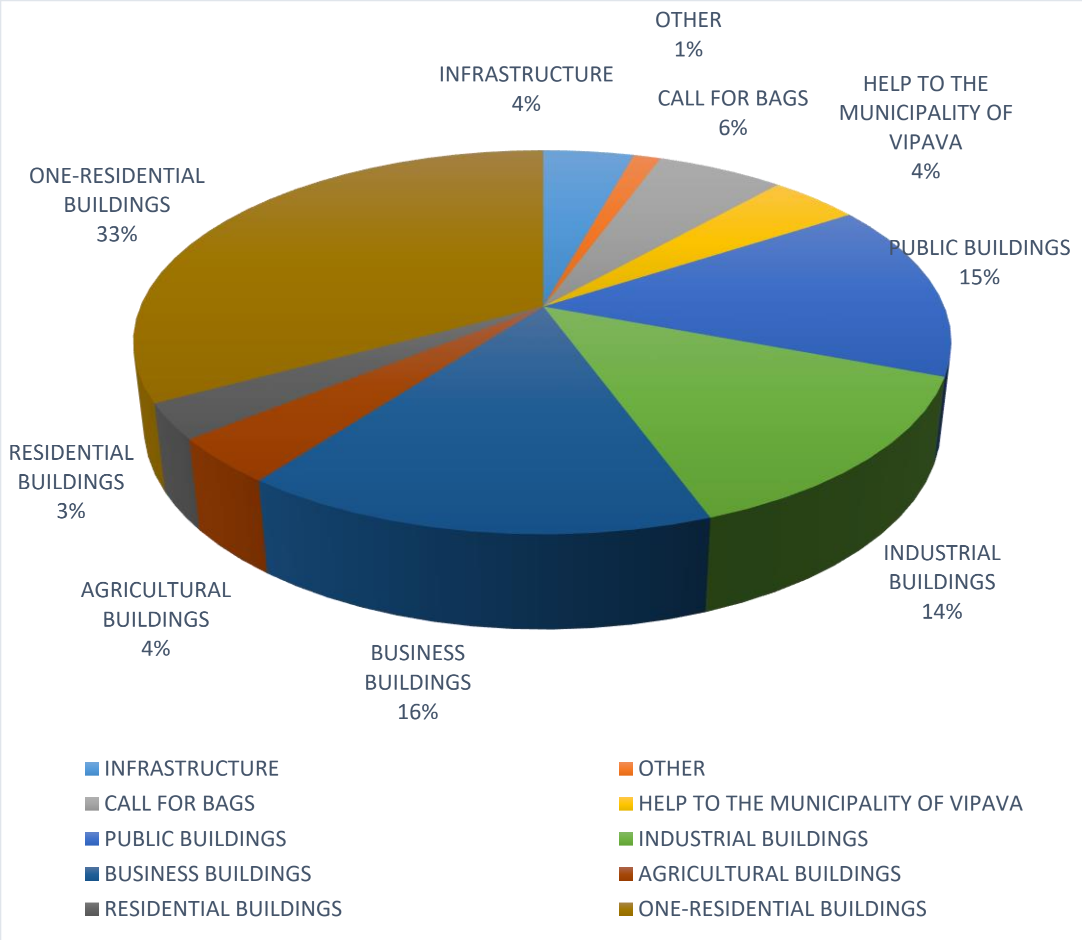

Figure 5: Comparison of calls depending on the type of the object[32]

32 Ibid.

2.6. Assessment of local and national institution's constraints in three aspects:

2.6.1. Territorial planning

The local as well as national spatial plan should be flexible and include the potential natural and other risks.[33] A trend of longer periods of strong winds and wind deviations could continue. These tendencies, should meet the spatial planning. Thus, spatial planning should encourage spatial solutions and activities for long-term preservation of landscape identity, natural values, etc. In addition, they should be appropriately promoted.[34]

In the Municipality of Ajdovščina the spatial plan is currently being updated. In the framework of its elaboration a need for a unified recommendations on construction typology resilient to high wind or wind gusts based on studies of statics has been identified. In addition, inclusion of previous long-term experiences in high wind areas and eventual deviations should influence the settlement recommendations in order to minimalize the high wind damage. Thus, considering meteorological data and previous high wind events experience in spatial planning is proposed.[35]

Figure 6: Spatial location of the Municipality of Ajdovščina[36]

2.6.2. Infrastructure preparedness

At the local as well as national Slovenian level, there is a shortage of urban infrastructure planning regulation due to the risk of high wind. Thus, it would be beneficial to adopt the

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33 Strategija prostorskega razvoja Občine Ajdovščina, Analiza stanja in teženj, Studio 3 d.o.o., november 2005, Ajdovščina (Strategy of spatial development of the Municipality of Ajdovščina).

34 Ibid.

35 Ibid.

36 http://gis.iobcina.si/gisapp/Default.aspx?a=ajdovscina

infrastructure planning to the high wind needs, also in order to minimize all the maintenance costs.

Furthermore, in the Vipava valley, there is a shortage of appropriated recommendation designed especially for transit during high wind events. There is a need for road closure protocols adapted especially for high wind in Vipava valley. Transit infrastructure lines should recognize the high wind hazard.

Figure 7: High wind transit consequences.

2.6.3. Disaster preparedness

In Slovenia, for successful protection, rescue, relief, prevention, mitigation and disaster recovery against wind risk, there is a need to update recommendation for prevention and civil protection adapted solely to high wind. There are no local and national Protection and Rescue Plans designed especially for high wind. When high wind intervention is necessary, the fire–fighting department guard should be enhanced too, due to fire hazard. Nevertheless, it is essential to give priority to people safety and implement the necessary evacuations.[37]

Figure 8: Fire – fighters in Ajdovščina

37 Občina Ajdovščina: Ocena ogroženosti pred naravnimi in drugimi nesrečami v občini Ajdovščina, Ajdovščina julij 2014. (Municipality of Ajdovščina: Risk Assessment against natural and other disasters, July 2014).

3. Identification of responsible institutions in the territorial planning, infrastructure and disaster preparedness in Croatia

Local and national institutions responsible for territorial planning, infrastructure and disaster preparedness in Croatia are listed in Figure 11.

Table 2: Responsible local and national institutions in Croatia

	1. National		2. Local	
Territorial planning	Ministry of Construction and Physical Planning	Department for Territorial Planning, Legal Affairs and the European Union Programmes Croatian Institute for Territorial Development	County, Municipality, City	Department of Building and Urban Development.
Infrastructure	Ministry of Maritime Affairs, Transport and Infrastructure Ministry of Construction and Physical Planning.		County, Municipality, City	Department of Utility Affairs, Municipal Infrastructure and Environmental Protection
Disaster preparedness	Ministry of interior affairs	National Protection and Rescue Directorate, Croatian platform for the reduction catastrophes risk,	County, Municipality, City	Local departments of National Protection and Rescue Directorate Local and regional Headquarters for protection and rescue

3.1. Territorial planning

Territorial planning is used to regulate purposeful organizations, the use and purpose of territory, and the conditions for the setup, improvement and protection of the territory that belongs to the country, counties, cities and municipalities.

Depending on various levels, different institutions are in charge of territorial planning in Croatia. On national level, the institution in charge is the Ministry of Construction and Physical Planning. On county level, the institution in charge is the Department of Building and Urban Development.

The Law on Territorial Planning[38] states that the department for territorial county planning can also construct territorial plans for cities and municipalities and urban plans that are significant to the country or county. It can also perform expert analytical work in the field of physical planning, if requested by the Ministry or the Mayor.

Territorial plans are adopted at national, regional and local levels.

National level territorial plans are:

- national plan for territorial development,
- territorial plan for national parks,
- territorial plan for nature parks,
- other territorial plans with special features whose adopting obligation is prescribed by the national plan for territorial development,
- urban plan for the organization of separate construction area outside the settlement for the economical and/or public use of national importance (we will refer to this from now on as *urban development plan of national importance*).

Region level territorial plans are:

- territorial plant for counties,
- territorial plan of the City of Zagreb,
- urban plan for the organization of separate construction area outside the settlement for the economical and/or public use of county importance (we will refer to this from now on as *urban development plan of county importance*).

Local level territorial plans are:

- territorial plan for city or municipality development,
- general urban plan and development urban plan, except for the development plan from sections 2 and 3 of this paper.

38 Source: http://narodne-novine.nn.hr/clanci/sluzbeni/2013_12_153_3220.html

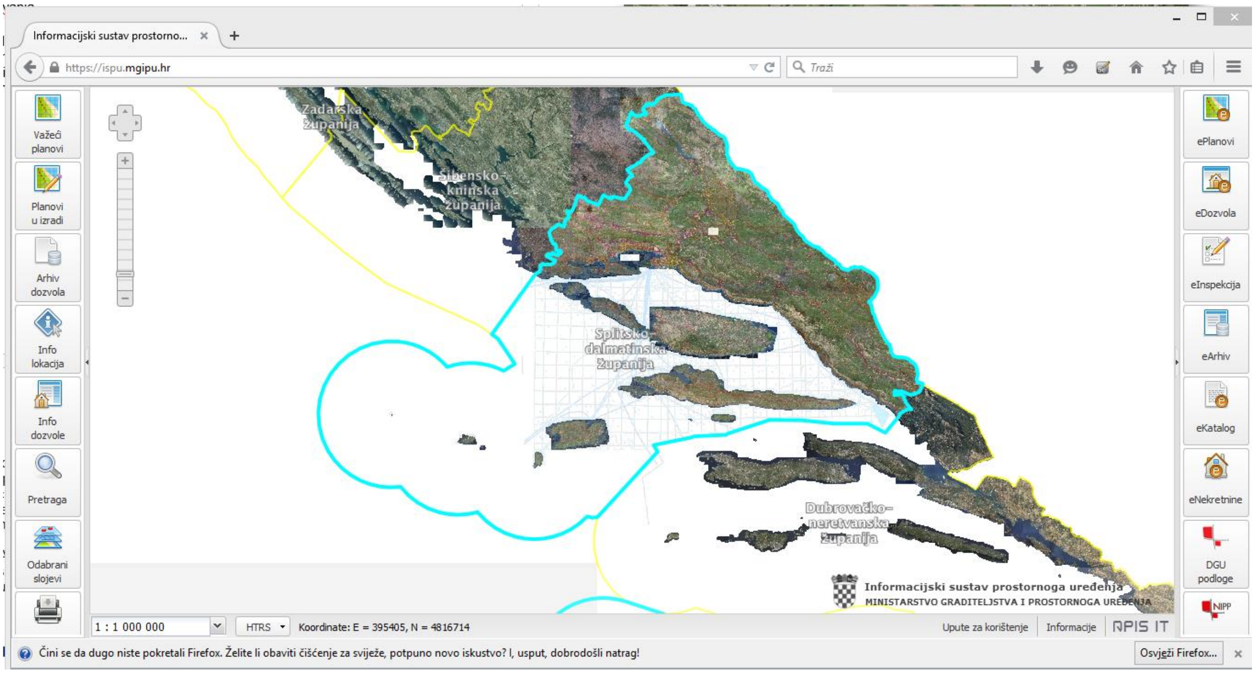


Figure 9: Split-Dalmatia County territorial plan information system

3.2. Infrastructure preparedness

Infrastructure implicates utilities, transport, energy, water, marine, communications, electronic communications and other facilities intended for the management of other types of natural and created resources.

In Croatia, the Ministry of Maritime Affairs, Transport and Infrastructure is responsible for road and rail infrastructure. Other critical infrastructure is responsibility of the Ministry of Construction and Physical Planning.

Urban development plan of national importance prescribes the conditions of implementation of all interventions in the area within its scope, and conditions of implementation of infrastructure outside the area for which it brings urban plan for the needs of the area.

Urban development plan of county importance prescribes the conditions of implementation of all interventions in the area within its scope and conditions of implementation of infrastructure outside the area for which it brings urban plan for the needs of the area.

Territorial plan of the city or municipality proscribes corridors for infrastructure significant for the city or municipality.

Department of Municipal Affairs, Municipal Infrastructure and Environmental Protection operates on a county level.

3.3. Disaster preparedness

On the national level the Ministry of Interior Affairs and National Protection and Rescue Directorate is responsible for disaster preparedness, while Croatian Counties and Cities Disaster Risk Reduction Platform is responsible for territorial planning on a local level.

National Protection and Rescue Directorate duties include:

- performs administrative and professional tasks related to the establishment of a system of citizen protection and rescue, material goods and other resources in accidents (natural and technical major accidents and disasters, etc.),
- conducts education (basic education for firefighting activities, training and perfecting of protection and rescue operational forces and other types of education for the protection and rescue participants),
- establishes a system of insurance of the correctness of protection and rescue technique during exploitation,
- manages operational forces and coordinates the activity of other participants in the activities of protection and rescue,
- monitors the implementation of the prescribed measures,
- carries out mobilization for the purposes of protection and rescue system in emergency situations and performs duties of civil protection,
- performs administrative and professional tasks in the area of firefighting,
- participates in the implementation of preventive measures for protection against fire and explosions, and in the rescue of people and property,
- performs the duties of notification and operates a unique alert system,
- prepares and conducts international contracts from the field of protection and rescue, and it prepares and conducts international cooperation with competent authorities of other countries and of international organizations in the field of protection and rescue.

4. Identification of local institution's roles and activities in Croatia

4.1. Territorial planning

The body responsible for territorial planning in Split-Dalmatia county is the Department of Building and Urban Development.

The Administrative Department for Building and Urban Development is carrying out administrative and other professional tasks in the field of physical planning and construction, and produces reports, the technical basis, proposals and draft documents from the scope of the governing body.

Territorial plans are delivered by county council.

4.2. Infrastructure preparedness

Department of Utility Affairs, Municipal Infrastructure and Environmental Protection (in Croatian: *Upravni odjel za komunalne poslove, komunalnu infrastrukturu i zaštitu okoliša*) performs administrative and other professional tasks in the field of public utilities, infrastructure and environmental protection, and prepares reports, expert basis, proposals and draft documents of the scope of the administrative body, in order to improve environmental protection and so that the municipal and infrastructural development of the county can improve and be more balanced.

Urban development plan of county importance shall prescribe the conditions of implementation of all interventions in the area within its scope and conditions of implementation of infrastructure outside the area for which it brings urban plan for the needs of the area.

Territorial Plan of the city or municipality proscribes corridors for infrastructure significant for the city or municipality.

4.3. Disaster preparedness

Disaster preparedness encompasses local risk assessments and local protection and rescue plans. Amongst other things, those plans define who is responsible for different things when it comes to protection and rescue plans.

Institutions and units whose duties concern disaster preparedness include:

- Local departments of National Protection and Rescue Directorate,
- Volunteer firefighting department,
- Firefighters,
- National Hydrometeorological Agency issues warnings,
- Croatian Counties and Cities Disaster Risk Reduction Platform.

4.4. Identification of national institution's roles and activities in the:

4.4.1. Territorial planning

According to Law on Territorial Planning, territorial plans are delivered on national, regional and local level.

Territorial plans are:

- National plan of territorial development,
- Territorial plan for special features,
- Urban plan of national importance,
- County regional plan,
- Territorial Plan of the City of Zagreb,
- Urban plan of importance of county,
- Territorial development plan for the city or municipality,
- Urban master plan,
- Urban development plan.

The Ministry responsible for territorial planning on national level is the Ministry of Construction and Physical Planning. The ministry is established in several departments, and the department dealing with territorial planning is the Department for Territorial Planning, Legal Affairs and the European Union Programmes.

In 2014, Croatian Institute for Territorial Development is established. The newly established public institution took over the duties and employees of the Institute for Territorial Planning from the Ministry of Construction and Physical Planning, which stopped working on December 31st, 2013.

The Institute for Territorial Development consists of three main services:

- service for national level territorial planning documents - responsible for territorial development strategies on the national level,
- service for territorial planning information system and territorial situation monitoring,
- service for International Cooperation and legal and technical affairs.

4.4.2. Infrastructure preparedness

The Ministry of Maritime Affairs, Transport and Infrastructure is responsible for road and rail infrastructure in Croatia. Other critical infrastructure is the responsibility of the Ministry of Construction and Physical Planning.

According to Law on Territorial Planning, infrastructure includes utilities, transport, energy, water, marine, communications, electronic communications and other facilities intended for the management of other types of created and natural resources.

Urban development plan of national importance shall prescribe the conditions of implementation of all interventions in the area within its scope and conditions of implementation of infrastructure outside the area for which it brings urban plan for the needs of the area.

4.4.3. Disaster preparedness

Disaster preparedness encompasses national risk assessments and national protection and rescue plans. Amongst other things, those plans define who is responsible for different things when it comes to protection and rescue plans.

Institutions and units whose duties concern disaster preparedness include:

- The Ministry of Interior Affairs,
- National Protection and Rescue Directorate,
- Croatian platform for the reduction catastrophes risk,
- National Hydrometeorological Agency.

4.5. Interaction between the local and/or national institution's roles and activities

4.5.1. Before the wind

Local and regional governments (cities and counties) provide risk assessments and the plans of protection and rescue before the wind occurs. Amongst other things, these plans determine the extent of elementary disasters and their possible consequences, which are later used in the assessment of elementary disasters and in risk assessments. Additionaly, National Hydrometeorological Agency deals with wind measurements and issues warnings on national and regional level.

4.5.2. During the wind

In case of the strong wind forecast, National Hydrometeorological Agency warns the National Protection and Rescue Directorate. National Protection and Rescue Directorate executes the rescue with the help of the firefighters. Military is engaged if necessary.

When it comes to environmental disasters, all citizens between the ages of 18 and 60 (men) and 18 and 55 (women) are obligated to participate in protection against elementary disasters. Single parents that have a child that is up to 7 years old do not have to participate in this protection if during the protection the guarding and care for their child is not secured. Pregnant women also do not have to participate in this protection against elementary disasters.[39]

39 *http://www.zakon.hr/z/540/Zakon-o-za%C5%A1titi-od-elementarnih-nepogoda*

4.5.3. After the wind

The announcement of local elementary disaster can be made by the Mayor alone or it can be suggested to the Mayor by the Head of the Police Department. The Government of the Republic of Croatia can also declare elementary disaster or a direct danger of its occurrence, and it can do so alone or by following the suggestion given to it by the Minister of Internal Affairs. The Government of the Republic of Croatia can declare an elementary disaster or a direct danger of its occurrence on the area of two or more counties or on a national level.[40]

Damage to infrastructure, buildings, and roads that happened as a result of strong winds must be solved by the owners or concessionaires.

4.6. Assessment of local and national institution's constraints in three aspects:

4.6.1. Territorial planning

According to Strategy of territorial development (in draft version) 41 , territorial development must take into account nature protection and biodiversity conservation, protection of natural resources and the environment, prevention of damage, climate change, disaster risk reduction and waste management in case of industrial accidents.

Extreme weather conditions due to global warming, such as heavy rain, heat waves and gusts of wind with destructive force strongly influence people and space. In addition to directly threaten the life and quality of life of people, floods, droughts, forest fires, melting glaciers and sea level rise, as the most common consequences of this phenomenon, significantly reshape territory and have a devastating effect on individual ecosystems, landscapes and built structures and cause major economic and material damage.

There are two aspects of the response to the risks and consequences of climate change effects: acting in the present conditions of climate variability and response to future climate change. It is important to take into account that there are no exact mathematical models that could predict with certainty the actual weather and the resultant sequence of climate change, but scientific studies warning of global trends examined possible scenarios.

40 http://www.zakon.hr/z/540/Zakon-o-za%C5%A1titi-od-elementarnih-nepogoda
[41] Source: http://www.mgipu.hr/doc/StrategijaPR/SPRRH_Nacrt_KP_18092015.pdf

4.6.2. Infrastructure preparedness

In Croatia, there is no regulation concerning infrastructure planning with respect to high winds. Currently there are no regulations concerning planning of roads concerning avoiding wind gusts. Skilled planners are incorporating their knowledge to avoid high wind risk zones but usually traffic needs, land ownership and tackling land obstacles are more demanding challenges in road planning. Location of bridges are part of road and railway plans. Usually, high winds are taken into consideration while planning but sometime other aspects supersede those.

Wind loading regarding to harbors have two main issues. First is security of personnel and vessels guarded during high winds. Second questions are maintaining structural strength of all elements of harbor constructions under direct wind loading and indirect loading from wind generated waves.

Marines are planned taking into account two main wind direction that can affect vessels, but are still vulnerable on other wind directions.

Figure 10: High wind over the bridge

4.6.3. Disaster preparedness

Local and regional protection and rescue plans proscribe obligations of institutions in case of disasters. The obligations of local, regional and national institutions depend on extent of the disaster, but there is no strict lien where other institution takes control. Sometimes local institution starts the rescue operation and at some time regional or national institution overtakes the control of operation.

Local, regional and voluntary firefighting units with help of other institutions, such as red cross, Croatian mountain rescue service carry out rescue operations.

Roads, cable lines and other infrastructure preparedness and is in the scope of the utility services (Road maintaining company, Power Supply Company, Water supply company, Telecom operators ….).

Figure 11 Split firefighters [42]

[42] Source : http://www.jutarnji.hr/split--na-smotri-vatrogasaca-predstavljeni-novi-kanaderi/802608/?foto=4

5. Identification of Responsible Institutions in Territorial Planning, Infrastructure and Civil Protection in Germany

This report deals with the specific roles and activities of different institutions on the national and local level before, during and after storm events. The focus is on institutions responsible for spatial planning, for infrastructure, and for civil protection, as these are able to essentially influence the vulnerability of an area towards storms. The German case study addresses summer storm *Ela* that occurred during the Whit weekend 2014 in North-Rhine Westphalia and especially the City of Essen (see also C2/C4).

The report is structured as follows: First, all responsible institutions as well as their roles and activities are identified on the national and local level. Subsequently, interactions of national and local institutions before, during and after summer storm *Ela* are described. Last, constraints on both levels are assessed and recommendations are drawn.

Beforehand, Tab. 3 gives an overview of the responsible institutions in Germany (national level) and the City of Essen (local level) in the fields of spatial planning, infrastructure and civil protection. Detailed information on each institution, their actions, responsibilities and constraints will be given in the following subchapters.

Table 3: Responsible National and Local Institutions in Germany

	National Level		**Local Level (City of Essen)**
Spatial Planning	Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (‘*Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit*‘, **BMUB**)	Federal Office for Building and Regional Planning (‘*Bundesamt für Bauwesen und Raumordnung*‘, **BBR**) Including: Federal Institute for Research on Building, Urban Affairs and Spatial Development (‘*Bundesamt für Bauwesen und Raumordnung*‘, **BBSR**)	Department of Spatial Planning and Building Regulations (‘*Amt für Stadtplanung und Bauordnung*’) within the Portfolio Environment and Building (‘*Geschäftsbereich für Umwelt und Bauen*’) assisted by the Department of geo-information, measuring and cadaster (‘*Amt für Geoinformation, Vermessung und Kataster*‘)
Infra-structure[43]	Federal Ministry of Transport and Digital Infrastructure (‘*Bundesministerium für Verkehr und digitale Infrastruktur*‘, **BMVI**)	Federal Highway Research Insitute (‘*Bundesanstalt für Straßenwesen*‘, **BASt**) and Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway (‘*Bundesnetzagentur*‘, **BNetzA**) as an auhtority of the Federal Ministry for Economic Affairs and Energy (‘*Bundesministerium für Verkehr und digitale Infrastruktur*‘, **BMWi**)	Department of Roads and Transport (‘*Amt für Straßen und Verkehr*‘) and Department of Spatial Planning and Building Regulations (‘*Amt für Stadtplanung und Bauordnung*’) within the Portfolio Environment and Building (‘*Geschäftsbereich für Umwelt und Bauen*’) assisted by the Department of geo-information, measuring and cadaster (‘*Amt für Geoinformation, Vermessung und Kataster*‘)

[43] As the BMUB (BBR/BBSR) is responsible for spatial planning on the national level, also infrastructure and disaster relevant decisions are taken within the preparation of land-use plans. As explained in subchapter 4, the designation of different land uses within the land-use plans are a suitable instrument for risk management.

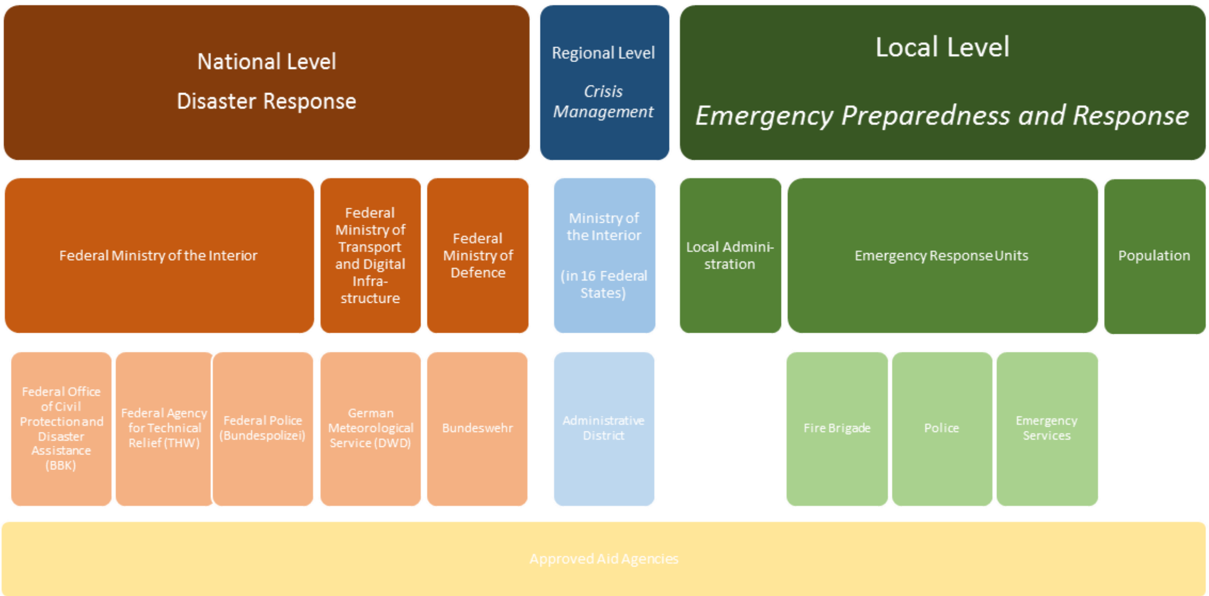
Civil Protection	Federal Ministry of the Interior (‘*Bundesministerium des Inneren*’, **BMI**)	Federal Office for Civil Protection and Disaster Response (‘*Bundesamt für Bevölkerungsschutz und* Katastrophenhilfe’, **BBK**) and Federal Agency for Technical Relief (‘*Bundesanstalt Technisches Hilfswerk*‘, **THW**)	City Administration / Mayor Emergency Response Units • Fire Brigade(s) • Police • Emergency Services Population

Source: Website BASt 2016; Website BBK 2016; Website BBR 2016; Website BBSR 2016; Website BMI 2016a; Website BMUB 2016; Website BMVI 2016a; Website BMWi 2016; Website BNetzA 2016a; Website Stadt Essen 2016; Website THW 2016.

In this report special attention is drawn to civil protection and disaster preparedness. In Germany “[t]he term ‘civil protection’[44] (*Bevölkerungsschutz*) refers to all emergency management tasks and measures taken by federal, state and local governments.” (Website BMI 2016b)

The following Fig. 12 shows the detailed structure of civil protection in Germany. All relevant institutions will be described in the following subchapters.

Figure 12: Civil protection in Germany on all administrative levels



Source: own depiction.

[44] “The term ‘civil protection’ reflects this cross-cutting approach; the traditional term ‘civil defense’ (which is narrower and related to defense tasks) is no longer used. The term ‘disaster response’ refers to another priority of the Federal Government's task of guaranteeing civil security: providing support to crisis management in the federal states in case of major disasters of all types, particularly support in information-sharing, coordination, managing scarce resources and conducting crisis management exercises.“ (Website BMI 2016c)

6. Identification of National Institutions' Roles and Activities in Germany

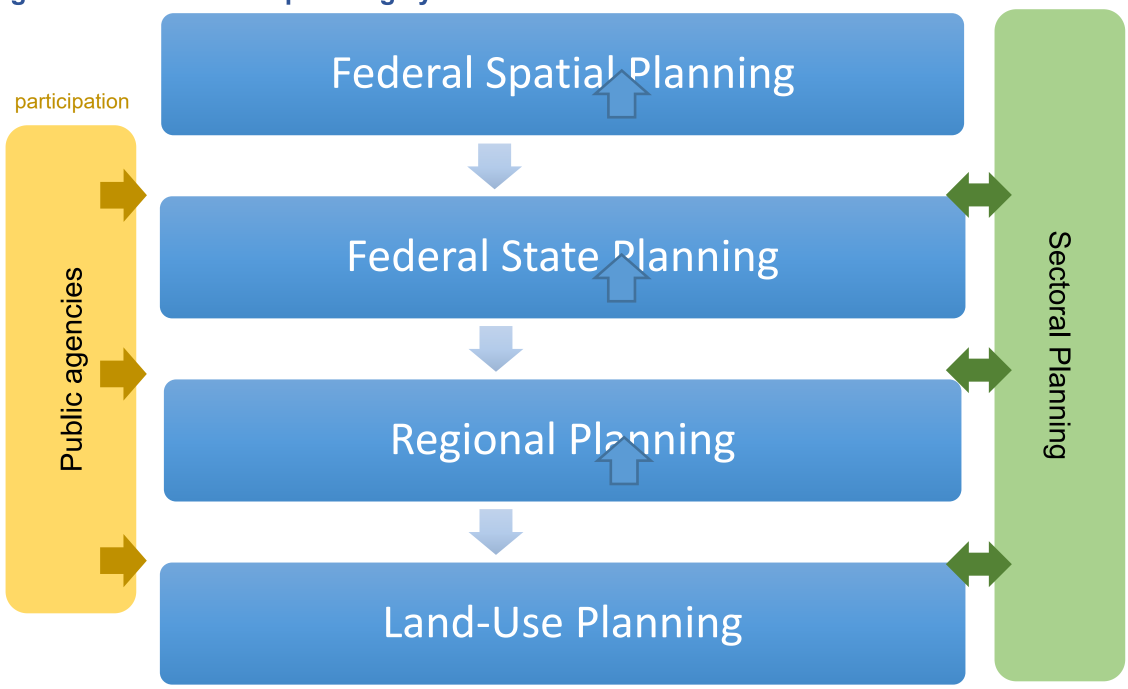
6.1. Spatial Planning

In order to understand the institution's roles and activities in spatial planning, the German planning system is shortly outlined before presenting specific institution.

Spatial planning in Germany takes places at three levels: the national level (federal spatial planning), the regional level (divided into federal state planning and regional planning) and the local level (land-use planning). Each level of spatial planning in Germany is assigned with certain legal and organizational tasks but all levels stay interconnected, following the so called counter-current principle (*Gegenstromprinzip*).

At the national level spatial planning is focused on the development of guiding and basic principles. Furthermore, national spatial planning forms the legal framework for the regional planning and gives superordinate standards. The regional level of spatial planning, consisting of both federal state planning and regional planning, is responsible for specifying the national principles. Within regional plans these national principles are spatially realized and land-use categories distributed for a broader area, consisting of several municipalities. Both land-uses and planning aims are further elaborated on the local level of spatial planning in Germany. The municipalities are responsible for the zoning classification and have the right of self-government. (Cf. Website ARL 2016) Fig. 13 shows all components of the German planning system and their interaction. Subsequently all relevant institutions on the national level and their roles are explained.

Figure 13: The German planning system



Source: own depiction following Website ARL 2016; own translation.

Since December 2013, the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (**BMUB**) is responsible for spatial planning in Germany. Key responsibilities of the BMUB in the field of spatial planning are on overall urban development, housing and building activities and the development and the retention of rural infrastructure. Furthermore, the ministry prepares legislation, sharpens existing legal frameworks and transposes EU directives into national law. For this purpose the BMUB is a member of numerous international organizations (e.g. UN, OECD, WTO) and coordinates several inter-ministerial national working groups and committees as e.g. the German Building Ministers Conference. The BMUB is also responsible for the German public building law. (Cf. Website BMUB 2016)
As concluded on the BMUB homepage, the ministry is "tasked with creating the conditions for good housing standards and intact cities and with raising the quality of structural engineering, building technology and construction materials in Germany […] [as] cornerstones of high quality of life and a pleasant social climate" (Website BMUB 2016).

Contracted with the BMUB is The Federal Office for Building and Regional Planning (**BBR**). The BBR provides sectoral and scientific consultation regarding spatial planning to the BMUB. About 1,200 employees of the BBR (1st service office) belong to the operational division of the BMUB. (Cf. Website BBR 2016) The research institution of the BBR is the Federal Institute for Research on Building, Urban Affairs and Spatial Development (**BBSR**), again under the portfolio of the BMUB. The BBSR especially advises the German government with sectoral and scientific "consultation in the political fields of spatial planning, urban development, housing and building" (Website BBSR 2016).

6.2. Infrastructure

In Germany, infrastructure planning is primarily carried out by the Federal Ministry of Transport and Digital Infrastructure (**BMVI**). The BMVI is responsible for road construction, land transport, aviation, digital infrastructure and shipping.
Besides the BMVI, the Ministry for Economic Affairs and Energy (**BMWi**) is party involved in infrastructure-related business as one of its authorities – the Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway (**BNetzA**) – is responsible for technical and communication infrastructure. All institutions are introduced separately in the following.

The **BMVI** is divided into nine directorates with about 1,300 employees. For infrastructure planning and maintenance, six of the nine directorates are of major importance. There are five directorates, which directly deal with infrastructure concerns (digital infrastructure, aviation, waterways and shipping, land transport, road construction) and one directorate coordinating strategic policies. The last mentioned is the Policy Issues Directorate-General, which surveys infrastructure demands and is responsible for an appropriate planning. It is also responsible for supervising infrastructure projects (such as road construction) regarding time schedule and budget. The Policy Issues Directorate-General is moreover responsible for developing mobility strategies that are environment-friendly and climate-friendly. For this purpose the Policy Issues Directorate-General develops the Federal Transport Infrastructure Plan and the Mobility and Fuel Strategy. Furthermore it promotes local projects, encouraging cycling, electric mobility and noise mitigation. As stated on the website, other key priorities of the directorate include "toll services, research funding, freight transport and logistics, spatial planning, demographic change and EU policy issues". (Cf. Website BMVI 2016a)

The responsibilities of the five directorates dealing with infrastructure concerns can be seen in Tab. 4.

Table 4: BMVI directorates responsible for infrastructure planning and maintenance

Directorate	Responsibilities

Digital Society Directorate-General	• roll-out of digital infrastructure:
	  • broadband roll-out
	  • radio spectrum policy
	  • Network Alliance
	
	• digitalization of society and transport:
	  • automated driving
	  • telematics
	  • IT-based systems

Aviation Directorate-General	• national and international aviation and aviation policy matters
	• airports
	• safety in air transport
	
	in close cooperation with:
	  • Federal Aviation Office (LBA)
	  • Federal Supervisory Authority for Air Navigation Services (BAF)
	  • German Federal Bureau of Aircraft Accident Investigation (BFU)
	  • German Air Navigation Services (DFS)

Waterways and Shipping Directorate-General	• maintenance and upgrading of waterways (23,000 km2 of maritime waterways; 7,350 km of inland waterways) • participation in international institutions, e.g. on shipping law, law of the sea

Land Transport Directorate-General	• political, legal, technical questions regarding rail and road transport, e.g.
	  • obtaining a driving license
	  • road user behavior
	  • registration of vehicles
	• development of regulatory framework for rail passenger transport, e.g.
	  • Road Safety Programme
	• investment in rail infrastructure

Road Construction Directorate-General	• maintenance of the structural integrity of the road network of the Federal Government (12,800 km of federal motorways and approximately 40,000 km of federal highways)
	  • strengthening bridges
	  • improving/upgrading existing roads
	  • construction of new roads
	• usage of public funds

Source: Website BMVI 2016a.

Scientific expertise and decision support in technical and transport policy issues to the BMVI is provided by the Federal Highway Research Institute (**BASt**). One main task of the BASt is the planning, coordination and performance of research projects of the BMVI. The BASt therefore is “the practice-oriented, technical-scientific research institute of the German Government in the field of road engineering” (Website BASt 2016).

The BASt is furthermore responsible for a road-related improvement of safety, environmental compatibility, efficiency and performance. It is also involved in the preparation of regulations and standards and a member of the network of national and European cutting-edge research institutes in the field of road engineering. (Cf. Website BASt 2016)

Another important institution in the field of infrastructure planning and maintenance is the Federal Network Agency for Electricity, Gas, Telecommunications, Post and Railway (**BNetzA**) as one of six authorities of the Federal Ministry for Economic Affairs and Energy (**BMWi**). The BNetzA is mainly responsible for technical infrastructure and communication infrastructure. Its key responsibility is to guarantee liberalisation, deregulation and non-discriminatory access to markets for telecommunication, post, rail and energy. (Cf. Website BNetzA 2016a)
The main instrument of the BNetzA is the Network Development Plan, which indicates the nationwide need for expansion of extra-high voltage lines (cf. Website BNetzA 2016b).

Last but not least, some infrastructure relevant decisions are taken within the BMUB (BBR/BBSR) when framing the preparation procedures of preparatory and binding land-use plans for the regional and local level. The designation of different land-use categories and functions of land-uses is one of the most important instruments for risk management as e.g. flood prone areas may be kept free from development.

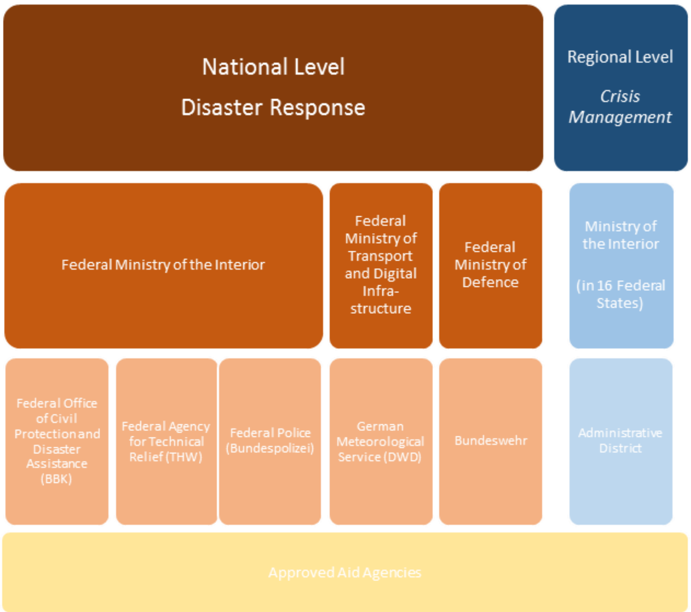
6.3. Civil Protection

In Germany, civil protection belongs to be constitutional responsibilities of the 16 federal states (*Länder*). Within specific laws of the *Länder* responsibilities are split up between the municipalities, the counties and the federal state. Wind related hazards are understood as natural hazards in Germany, which makes the North-Rhine Westphalian 'law on fire safety, rescue and emergency services' (*Gesetz über den Brandschutz, die Hilfeleistung und den Katastrophenschutz*, BHKG) the most important legal basis for civil protection on the level of the *Länder* and the City of Essen (cf. §1 BHKG).

In case of large-scale disasters and emergencies the federal state comes into play, coordinating the response activities of the *Länder*. The Federal Government supplies the *Länder* with information, the management of scarce resources and the conduction of crisis management exercises. Furthermore, the federal state financially supports the necessary investments of the counties and municipalities in buildings and technical infrastructure of emergency response.
Emergency management – including disaster preparedness and response – is up the counties and country free cities (like the City of Essen). They have to prepare disaster prevention plans and must guarantee for the necessary technical equipment and personnel. Municipalities on the other hand are responsible for fire protection and management and are asked to set up local fire prevention plans. All levels closely collaborate with relief organizations and fire brigades. (Cf. BMI 2016b, BMI 2016c)

The structure of institutions in civil protection on the national and regional level in Germany can be seen in Fig. 14. Subsequently all relevant institutions are introduced.

Figure 14: Civil protection on national and regional level in Germany



Source: own depiction.

On the national level, the Federal Ministry of the Interior (**BMI**) is the main responsible institution for civil protection in Germany. The BMI and its executive agencies have several fields of action, ranging from civil protection to security and integration. (Cf. Website BMI 2016a) Within the field of civil protection, crisis management is of special importance, embracing disaster preparedness. Crisis management is defined by the BMI as “all measures to prevent, prepare for, identify, manage and follow up after crises” (Website BMI 2016b). For this purpose the BMI has a Communications, Command and Control Centre, which is the contact point for all matters of internal security, and national (as well as international) civil protection at ministerial level. From this Control Centre, information is shared among federal and state security authorities and executive agencies. (Cf. Website BMI 2016b)

The superior federal authorities reporting to the Federal Ministry of the Interior regarding civil security preparedness, civil protection and disaster response are the Federal Office of Civil Protection and Disaster Response (**BBK**) and the Federal Agency for Technical Relief (**THW**) (cf. Website BMI 2016c). Furthermore, the Federal Police (*Bundespolizei*) is under the command of the BMI.

The **BBK** went into operation in 2004 as a reaction to 9/11 and also the massive flooding in summer 2002 in Germany (cf. Website BMI 2016b). It sees itself as a national service center for institutions and authorities at all administrative levels, as well as for organizations working in civil protection (cf. Website BBK).

The BBK has several responsibilities:

- Planning and preparing civil protection measures (emergency preparedness and contingence planning), especially
    - acting as a central point of contact for the *Länder*,
    - drawing up and developing planning, protection and preparedness policies in the field of civil protection,
    - implementing the policy jointly developed with the federal states to provide equipment and training for disaster management units and institutions,
    - intensifying cooperation with the military and police forces.

- Planning and preparing cooperation between the Federal Government and the *Länder* in case of specific threats, especially
  - providing administrative support for the Federal Government and Länder Interministerial Coordination Centre for Large-Scale Emergencies and Hazards,
  - maintaining information and coordination services by operating and developing the German Joint Information and Situation Centre (GMLZ) and the German Emergency Preparedness Information System (deNIS),
  - coordinating and managing administrative, medical and psycho-social aftercare for victims of disasters or terrorist attacks abroad and their relatives, known by its German acronym NOAH, after their return to Germany.
- Critical infrastructures, especially helping develop the National Strategy to Protect Critical Infrastructure and supporting the Federal Ministry of the Interior's coordinating function in inter-ministerial cooperation and cooperation with the federal states.
- Basic and advanced training for decision-makers and top executives from the field of civil security preparedness, including civil protection and disaster response in the Academy for Crisis Management, Emergency Planning and Civil Protection (AKNZ).
- Protecting public health by developing and optimizing inter-ministerial framework plans and plans by federal states to prevent health risks and strengthen medical and counter-epidemic management in civil protection.
- Warning and informing the public, especially
  - extending the integrated warning system including its core element of satellite-based warnings via radio and TV,
  - developing plans for comprehensive public information including risk and crisis communication.
- Strengthening civic self-help and self-protection, especially
  - promoting medical first-aid training for the public,
  - supporting municipalities in their self-protection responsibilities.
- Research and development, especially
  - establishing the BBK as the national contact point for managing non-police security research,
  - initiating and accompanying research and development projects in all fields of crisis management,
  - intensifying gathering of academic and applied expertise in cooperation with the Commission on the Protection of the Civilian Population in case of Major Disasters and in time of war at the Federal Ministry of the Interior.
- International cooperation in civil protection, especially
  - planning and implementing the EU Civil Protection Mechanism,
  - raising the BBK's profile in international organizations through cooperation in working groups and networking,
  - organizing experts for international events and projects. (Cf. Website BBK 2016; Website BMI 2016c)

The Federal Agency for Technical Relief (**THW**) provides technical relief according to the Act on the Federal Agency for Technical Relief (*THW-Gesetz*). This comprises the management of disasters, public emergencies and large-scale accidents. The THW operates at the request of the authorities responsible for threat prevention at all administrative levels and might also operate abroad on behalf of the Federal Government. All operations take place in accordance with the Federal Civil Protection and Disaster Relief Act. (Cf. Website BMI 2016d)

As the BMI states, the THW “is a cornerstone of civil protection in Germany and helps in case of natural disasters and accidents” (Website BMI 2016d). The THW exists for more than 60 years and has currently 668 local THW units, all operated by 99 % volunteers. They provide technical relief, e.g. in case of a storm event and clear streets from fallen branches or pump out flooded basements. (Cf. Website BMI 2016d)

On the federal German level there are two more ministries (indirectly) involved in civil protection. The first is the BMVI, already described in subchapter 2.2 as the main responsible ministry for infrastructure planning and preparedness. The BMVI is involved in civil protection as one executive agency of the ministry is the German Meteorological Service (**DWD**). The DWD provides weather forecasting and warnings, which are a major component of disaster preparedness. (Cf. §4 (3) DWDG; Website BMVI 2016b) Further information on the DWD and its responsibilities are explained in subchapter 4.1.

The other ministry indirectly involved in civil protection and disaster preparedness is the Federal Ministry of Defence (**BMVg**).The BMVg is responsible for military defense and all matters concerning the Armed Forces (*Bundeswehr*). In case of large-scale disasters and emergencies, the *Bundeswehr* may be requested for support. (Cf. Website BMVg 2016)

6.4. Identification of Local Institutions' Roles and Activities in the:

6.4.1. Spatial Planning

On the local level it is the Department of Spatial Planning and Building Regulations (*Amt für Stadtplanung und Bauordnung*), which is responsible for spatial planning in the City of Essen. The Department of Spatial Planning and Building Regulations is established within the Portfolio Environment and Building (*Geschäftsbereich für Umwelt und Bauen*) and is, as already mentioned in chapter 2.1, responsible for the preparation and implementation of binding land-use plans. The department also covers aspects of transport planning. (Cf. Website Essen 2016a)

The cities in the Ruhr Area have an exception in their preparatory land-use plans. Usually cities and municipalities prepare and implement separate preparatory land-use plans. In order to improve the cooperation and to steer the development of land in a more sustainable way, the cities in the densely populated Ruhr Area decided to develop a collective land-use plan, also known as a 'regional preparatory land-use plan' (own translation; *Regionaler Flächennutzungsplan*). For the City of Essen it is again the Department of Spatial Planning and Building Regulations contributing to this regional preparatory land-use plan. (Cf. Website Städteregion Ruhr 2016)

Especially for the development and implementation of land-use plans there needs to be a close cooperation between all departments of a city administration. During the day-to-day business there are two departments which are of special importance for the successful maintenance of the spatial planning department. The first is the Department of Geo-Information, Measuring and Cadaster (*Amt für Geoinformation, Vermessung und Kataster*), which is responsible for the management of data. In the German case study of the Wind Risk Prevention Project the Department of Geo-Information, Measuring and Cadaster is the main contact to the City of Essen. The second important department is the Department of Urban Renewal and land-use management (own translation; *Amt für Stadterneuerung und Bodenmanagement*), which is e.g. responsible for the inquiry of standard land values and rent indices. (Cf. Website Essen 2016b, Website Essen 2016c)

6.4.2. Infrastructure Preparedness

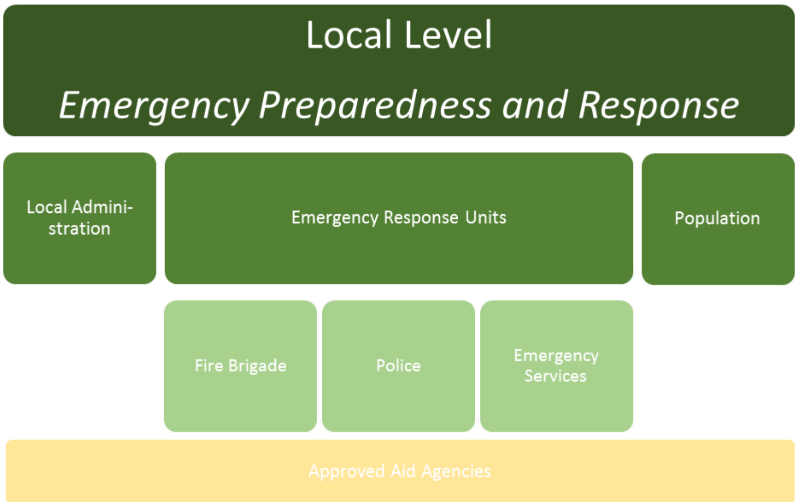
In the field of infrastructure, there are different city departments and enterprises responsible for different fields of infrastructure. In the field of road infrastructure the City of Essen has a Department for Roads and Transport (*Amt für Straßen und Verkehr*). The department is responsible for all measures regarding road construction, road works, routing, signage (road signposts) and traffic lights. (Cf. Website Essen 2016d)
However, regarding risks from high wind and storms like summer storm *Ela* the responsibility of infrastructure preparedness does not lie that much within the field of road construction but rather within the maintenance of city trees. The responsible institution is called '*Grün und Gruga*' and is comparable to an urban green space planning office. Grün und Gruga is responsible for tree care, as well as the development and planning of municipal urban green spaces. Moreover the maintenance of forests, cemeteries and the *Grugapark* are within the responsibilities of Grün und Gruga. (Cf. Website Essen 2016e)

6.4.3. Civil Protection

As stated before, in Germany civil protection belongs to be constitutional responsibilities of the *Länder*. In specific laws each federal state (*Land*) divides these responsibilities between the municipalities and the counties.

Emergency management, including disaster preparedness and response, is up the counties and country free cities (like the City of Essen). They prepare disaster prevention plans and guarantee for the necessary technical equipment and personnel. On the municipal level, fire protection and management are carried out and local fire prevention plans are set up. The structure is depicted in Fig. 15.

Figure 15: Civil Protection at the local level in Germany



Source: own depiction.

As can be seen in Fig. 15, there are three main groups of actors relevant in local emergency preparedness and response. The **local administration,** respectively the **country administrator or major of a country free city** is responsible for the constitution and administration of an action committee and a mission control (cf. §§ 33ff. BHKG). The mission control is provided by the respective country or country free city and is responsible for the operative-tactical risk management. It coordinates action forces, resources and measures to be conducted. (Cf. §34 BHKG) Furthermore the mission control is responsible for the coordination of **fire brigades, ambulance corps and emergency services**, which form the action committee (cf. §34 (1) BHKG). The action committee of fire brigade (*Feuerwehrstab*) is supported by **approved aid agencies** like the German Red Cross, if requested.

Besides regular fire service, municipal volunteer fire brigades can be requested to help in operations concerning storms. In case of wind related hazards the fire brigades are responsible for supplying with constantly trained and educated operational personnel as well as resources, such as chainsaws (cf. §3 (1), (4) BHKG). Thereby, civil protection and a fast removal of damages to critical infrastructures by logging trees can be secured. (Cf. §11 Abs. 4 BGKH) In case of severe damages, fire brigade units from other counties can be requested, as far as these are not occupied with own, prior tasks (cf. §39 (1) BHKG).

The last group of actors is formed by the adult citizens of Germany. The (adult) population is committed to give aid in form of resources or manpower, if instructed so by the fire brigade.

Property owners are furthermore under duty to implement safety precautions (*Verkehrssicherungspflicht*) on their property. (Cf. §43 (1-3) BHKG).

6.5. Interaction between Local and National Institutions' Roles and Activities

6.5.1. Before the storm event

Before a storm event, the main interaction takes place between the German Meteorological Service and several national, regional and local institutions. As stated earlier, the German Meteorological Service is legally responsible for publishing weather alerts whenever public safety and order are endangered (cf. §4 (3) DWDG). These weather alerts base on the analysis and assessment of weather modelling, which are conducted and interpreted by meteorologists of the DWD (cf. DWD 2013: 3).

The main German warning management system is a satellite-based warning system called 'SatWas'. It is also operated by the DWD and is the official weather alert platform for the federal government of Germany, the *Länder* (federal states) and the official public-sector broadcaster (TV and radio). (Cf. Website BBK BUND 2015a) Furthermore the DWD has a warning system especially designed for Germany's emergency response units, which is called 'fire brigade warning system FeWIS' (*Feuerwehr-Warnsystem, FeWIS*). Addressees of FeWIS are fire brigades, the THW, the federal police, the Federal State Ministries of the Interior and aid agencies like the German Red Cross.

In a three-level warning system, all important institutions of all levels are notified. Warnings in the first level are given by the early warning system 48-120 hours (maximum five days) before of a possible event. These early warning are spatially unspecified and therefore relevant for the whole country. The second level of warning takes place 12-24 hours before an event. During this warning level, warning reports and advance information are distributed; again spatially unspecific. In the third warning level, detailed and official weather alerts are published on the spatial basis of counties/administrative districts. Warnings of level three can only be generated 12 hours or less ahead of a possible event. (Cf. DWD 2013: 13)

The emergency response units (fire brigades, THW, Federal Ministries of the Interior, police and others) moreover receive special information 48 hours ahead of a likely event on its possible magnitude and extent. These advance information for emergency response units are updated five times a day. (Cf. DWD 2013: 11)

6.5.2. During a Storm Event – Emergency Response

It can be stated that all administrative levels are somehow involved in the emergency management process in case of a large-scale wind disaster in Germany. The Federal Government for example supplies the *Länder* with information and financial support. The *Länder* pass both information and money on to the counties and municipalities; weighting the status of the storm's impact. Furthermore approved aid agencies can be requested by any administrative level in order to support the emergency response process. (Cf. BMI 2016b, BMI 2016c)

Nevertheless, emergency management lies within the responsibility of the counties and country free cities (like the City of Essen). Therefore, concrete emergency response actions are always carried out on the local level and therefore it is the local level where the most interaction and cooperation take place. These interactions are not necessarily restricted to one country free city, as e.g. fire brigade units may be requested from neighbour cities. (cf. §39 (1) BHKG)

6.5.3. After a Storm Event – Recovery, Prevention, Mitigation

Immediately after a storm event, institutions other than the emergency response forces are deployed in order to estimate and to remove damages. This phase is the starting point of a recovery process. In very severe cases, the Armed Forces (*Bundeswehr*) may be requested in order to secure safety and order.

The recovery phase after a storm might require years of time. Interactions can mainly be found within the local level as exemplified by summer storm *Ela*. Until today the institution responsible for urban green spaces in Essen, *Grün und Gruga*, is busy removing damages and taking care of new planting.

6.6. Assessment of Local and National Institutions' Constraints

6.6.1. Spatial Planning

The German planning system is built on the counter-current principle (*Gegenstromprinzip*), meaning that each level has its own responsibilities but that actions and measures are harmonized throughout the national, regional and local level. The overall system is well established but can only function as long as all levels are maintaining a good cooperation.

The preparatory and binding land-use plans that are developed and implemented on the local level are a planning instrument of major importance when it comes to adapting to wind risks. Accordingly it would be desirable to implement building recommendations and regulations concerning storm directly in local land-use plans. Currently wind loads are only considered in the construction of buildings. It might as well be an option to consider storms and other extreme events for other planning objects (such as trees) and in other disciplines, such as urban green or emergency management.

6.6.2. Infrastructure Preparedness

In infrastructure planning and preparedness it may generally be stated that it would be beneficial to assess the vulnerability of all different infrastructure systems towards wind risks and, if necessary, implement prevention measures. As summer storm *Ela* showed, infrastructure systems are endangered rather indirectly, e.g. due to trees falling onto roads. For this purpose, communication and cooperation between different institutions and actors should be intensified.

It could be problematic that some infrastructure systems are maintained by private companies, as e.g. in the energy supply sector. Recommendations might therefore be required from national or even international levels.

6.6.3. Civil Protection

In the field of civil protection, summer storm *Ela* showed that in all phases – warning management before an event, emergency response during an event and recovery after an event – worked very well. Nevertheless there are always ideas for improvement, as the fire brigade for example faced the problem of owning too few chainsaws. From the perspective of maintenance and care of urban green spaces and city trees, financial support by the Federal Government should be prolonged, in order to overcome the long-term damages and clearance operations.

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European Civil Protection

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WIND RISK

Task C – Risk/Vulnerability assessment

Action C.8: Civil initiative roles and obstacles in providing help at wind disaster events

For the Wind Risk prevention project

University of Ljubljana
Technical University of Dortmund
University of Split
Municipality of Ajdovščina

Actions C.8 - Civil initiative roles and obstacles in

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1. Identification of Civil initiatives at wind disaster events in Slovenia

In the Republic of Slovenia, the Civil Protection (CP) is organized as specific and diverse units for protection, rescue and relief. CP units and forces involve:

- professionals (The Slovenian Professional Fire Fighters' Association, Emergency Medical Service, Public Veterinary Services, Public Social Care Services, Service for protection and rescue in the case of ecological and other disasters at sea and Forensic Unit of the Forensic Institute at the Medical Faculty, etc.);
- voluntary (Various public services, Slovenian Fire Fighting Association, Slovenian Mountain Rescue Service, Slovenian Cave Rescue Service, Slovenia Federation of Divers, Slovenian Canine Association, Slovenian Federation of Association of Rescue Dog Handlers, Slovenian Scout Association, Slovenian Association of Catholic Scouts, Association of Slovenian Radio Amateurs, Slovenian Red Cross, Caritas of Slovenia, etc.);
- other civil protection types of units and services (National Rapid Response Unit, NBC Protection and Decontamination Units, Technical Rescue Unit, Urban Search and Rescue Unit, Explosive Ordnance Disposal Unit, Support services, etc.);[1]
- research institutions and
- in case of insufficiency of the above mentioned forces also the Slovenian Army and the Slovenian Police can take actions.

According to the European Commission, Humanitarian Aid & Civil Protection official site: "These units and services involve around 5% of the total population of Slovenia, the majority of which carry out tasks voluntarily without payment or as a part of their national service."[2]

The above mentioned CP units are all part of the management system for protection against natural and other disasters, which includes a whole range of activities, such us prevention, alertness, protection against risks, rescue and relief operations during disasters, provision of basic living conditions after disasters and reconstruction measures, etc...[3]

In the Republic of Slovenia the national-security system is composed of three pillars or subsystems, these are Defence, Internal security and Protection against natural and other disasters subsystem. Moreover, the Slovenian Civil Protection is organized at three territorial levels, namely local, regional and national level. Each level of civil protection has its own above mentioned diverse units and functionality, also operating and interacting with each other. Furthermore, also commercial companies, institutions performing hospital activity, organizations with over 100 employees, institutions managing dangerous substances or infrastructure systems and other organisations are obliged to carry out CP responsibilities.[4]

Within the present Wind Risk Action C.8 report, we will assess the roles and obstacles of each Slovenian Civil protection level and thus prepare the basis for the evaluation of its efficiency, from our point of view. Furthermore, also EU Civil Protection will be presented.

1 Source: EC Vademecum – civil protection, available at: http://erccportal.jrc.ec.europa.eu/vademecum/si/2-si-1.html

2 Source: EC Vademecum – civil protection, available at: http://ec.europa.eu/echo/files/civil_protection/vademecum/si/2-si-1.html#lega

3 Available at: http://www.sos112.si/eng/page.php?src=sv1.htm,

4 Available at: http://www.sos112.si/slo/page.php?src=cz1.htm,

We have to stress that the present report was made out of directly accessible and readily available data and other relevant materials.

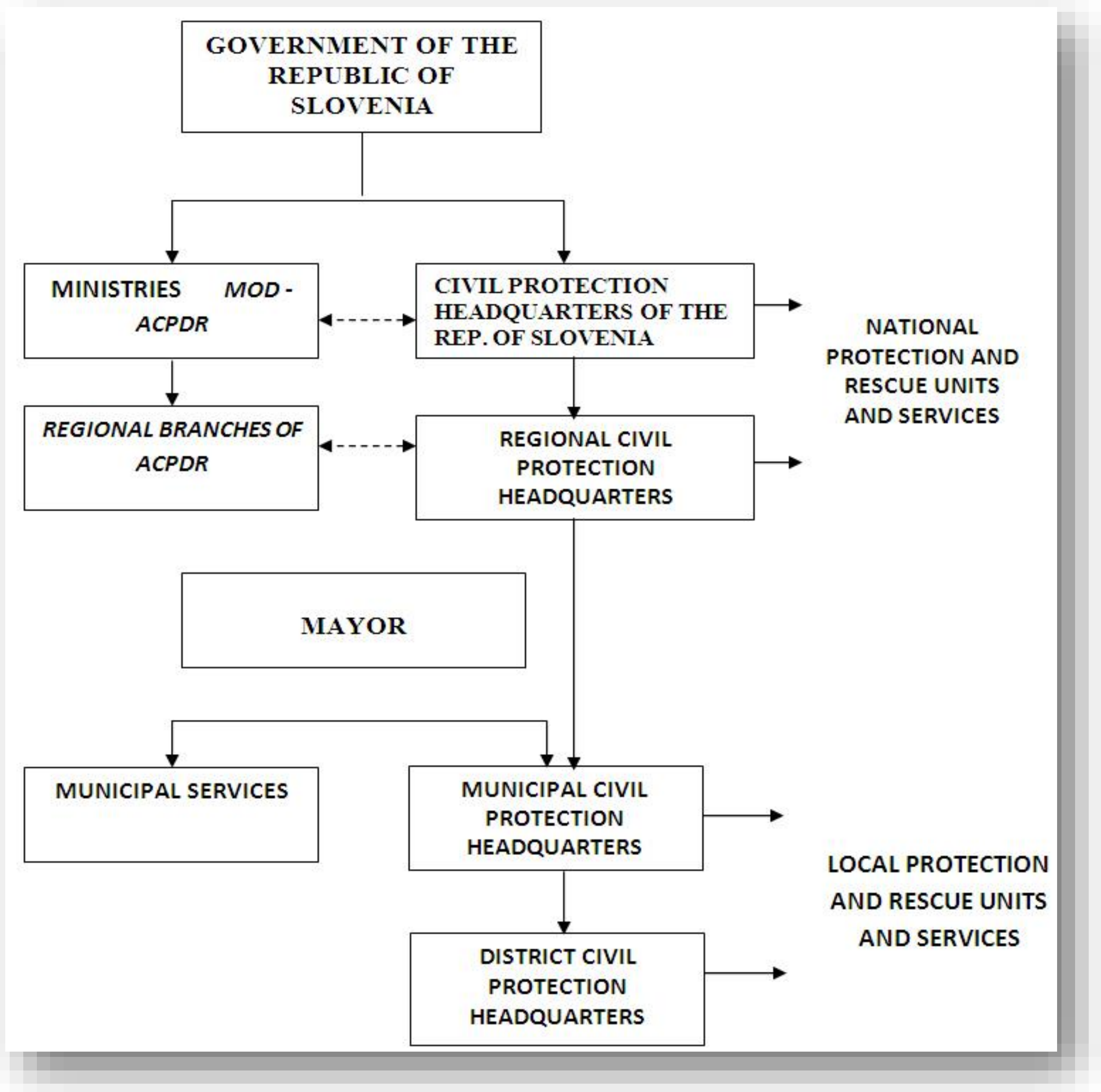

Figure 1: Slovenian Civil Protection Organisational chart[5]

5 Source: EC Vademecum – civil protection, available at: http://ec.europa.eu/echo/files/civil_protection/vademecum/si/2-si-1.html#over, The national Administration of the Republic of Slovenia for Civil Protection and Disaster Relief (ACPDR)

Slovenian national general documentation, legislation and other regulations, which deals with the organization of Slovenian Civil Protection,[6] is:

- The Doctrine on Protection, Rescue and Relief, issued pursued to Article 93 on the Law on Protection Against Natural and Other Disasters, 30/5/2002;
- Act on Protection Against Natural and Other Disasters (Official Gazette of the Republic of Slovenia (OJRS) no. 56/01-official consolidated text no. 97/10);
- Material Obligation Act (OJRS, no. 87/01);
- Regulation on the content and drawing up the protection and rescue plans (OJRS, no. 24/2012);
- Fire Protection Act (OJ RS, 71/93, amended in 2007, OJ RS, 3/2007);
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- Decree on the Organization, Equipment and Training of Protection and Aid Forces (OJRS, no. 22/99, 99/99, 102/00, 33/02 in 106/02);
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- Regulation on the Conditions which must be met by Educational Institutions Providing Training in Protection Against Natural and Other Disasters (OJRS, 16/96 and 31/97);
- Regulation of Fire Order (OJRS, 52/07) – Ministry of Defence[7] and
- Other.

6 Available at: http://www.sos112.si/slo/page.php?src=cz1.htm

7 Source: EC Vademecum – civil protection, available at: http://ec.europa.eu/echo/files/civil_protection/vademecum/si/2-si-1.html#over

1.1. Identification of <u>local</u> Civil initiatives at wind disaster events

In the Republic of Slovenia the local Civil Protection service is organized in those 212 municipalities that have over 3.000 inhabitants. The Municipality of Ajdovščina has more than 19.000 inhabitants and is spread over a territory of 245 km^2. Thus, the Municipality of Ajdovščina manages its own fully developed and well operational local CP Service independently.[8]

Figure 2: Local Civil protection units at wind risk intervention[9]

Municipal CP Service, includes **managing** and **operational** bodies. The Municipal **managing** bodies for protection against disasters are:

- The Mayor is the responsible authority and is the head of the protection, rescue, relief and recovery operations. He provides preparations for the protection against natural and other disasters, adopts emergency response plans, determines municipal protection rescue and relief forces, provides measures for the prevention and mitigation of consequences of natural and other disasters, manages protection, rescue, relief and recovery from natural and other disasters and provides notifications for inhabitants.[10] Furthermore, he appoints the CP Commander as the operational and professional head of all these operations.
- The Municipal Council prepares and implements regulations for the purposes of the protection against disasters.
- The municipal administration bodies carry out tasks according to their field of work and their competences.

8 Source: EC Vademecum – civil protection, available at: http://ec.europa.eu/echo/files/civil_protection/vademecum/si/2-si-1.html#over

9 Source: Municipality of Ajdovščina, 10/2/2012

10 Source: EC Vademecum – civil protection, available at: http://ec.europa.eu/echo/files/civil_protection/vademecum/si/2-si-1.html#lega

- Municipal and supervisory committees.[11]

The Municipal **operational** bodies are those, which actually run and implement the protection, rescue and relief operations. They are carrying out the majority of the CP operational subsystems, which are:

- CP Commander is the operational and technical head of the disaster protection, rescue and relief operations. Currently, in the Municipality of Ajdovščina CP Commander is also involved in Wind Risk project. He reports directly to the Mayor.
- If CP Commander is absent, CP Deputy Commander holds all his powers and reports directly to the Mayor.
- CP Headquarters provide expert assistance in managing and perform other operational and technical tasks related to disaster protection, rescue and relief.
- Head of Intervention is usually the Commander of the firefighting unit in charge of the area where the disaster has occurred, unless otherwise specified in Protection and Rescue Plans or by the CP Commander.[12]

1.1.1. Before the wind disaster event

The Municipality of Ajdovščina is known for its strong wind bora which is extremely fast and dangerous especially in autumn and winter time. That is why the Municipality must be prepared to act appropriately before the wind disaster event occurs and therefore must adopt curtain measures. Namely, The Mayor and the Municipal Council adopts and implements regulations related to the protection against natural and other disasters in the municipality territory, which include also high wind risk. Furthermore, the municipal administration bodies prepare the documentation dealing with efficient protection and rescue activities.[13] For example:

- risk assessment document: **Natural and Other Risk Assessment in the Municipality of Ajdovščina**[14], which is presented in the Wind Risk Action C2 and includes high wind risk;
- action documents: for the cases of natural and other risks that pose the greatest threat the **Protection and Rescue Plans documents**[15] are developed. The specific Protection and Rescue Plans document dealing exclusively with high wind risk is currently lacking;
- procedure document: for the event of a disaster a document called **Plan for Mobilization and Communication of Protection and Rescue Providers**[16] is developed, defining response and action activities in the event of any disaster and;
- regular rescue trainings are carried out.

11 Source: Municipality of Ajdovščina: Protection and Rescue Plans, July 2014

12 Source: Municipality of Ajdovščina: Protection and Rescue Plans, July 2014

13 Source: Municipality of Ajdovščina: Protection and Rescue Plans, July 2014

14 Source: Municipality of Ajdovščina: Natural and Other Risk Assessment in the Municipality of Ajdovščina, July 2014

15 Source: Municipality of Ajdovščina: Protection and Rescue Plans, July 2014

16 Source: Municipality of Ajdovščina: Plan for Mobilization and Communication of Protection and Rescue Providers, julij 2014.

1.1.2. During the wind disaster event

During the wind disaster event the Municipal Council implements regulations and the Municipal bodies, including civil protection headquarters, carries out actions according to the protection against natural and other disasters program in the municipality territory. For example:

- First, the Regional Notification Centre alarms the responsible persons on behalf of the Municipality of Ajdovščina (CP Commander and Mayor).
- The CP Commander or the Head of Intervention assesses the situation in the affected area and provides a brief first report.
- After the first report, the bodies analyse the situation, the potential development and outcome of the disaster.
- The CP Commander manages the response and decides when to activate the bodies for the operational and professional leadership of protection, rescue and relief.
- As soon as the Protection and Rescue Plan is implemented, services and units with available resources can successfully intervene and take appropriate actions.
- During interventions, the municipal administration bodies provide support to the CP operational bodies in implementation of protection, rescue and relief measures. [17]

Figure 3: Bora consequences - overturned vehicles[18]

Figure 4

17 Source: Municipality of Ajdovščina: Protection and Rescue Plans, July 2014

18 Source: Municipality of Ajdovščina, 11/3/2015

1.1.3. After the wind disaster event

The Municipal bodies carry out a detailed survey of the wind disaster event (report) including recommendation of intervention works. Mayor leads the disaster relief in the municipalities and together with the Municipal Council, decides about the use of municipal funds. The Republic of Slovenia Civil Protection and Disaster Relief Administration decides, based on the level of the damage, when and if the national damage assessment begins.[19]

Figure 4: Roof restoration after Bora event[20]

19 Source: http://www.sos112.si/slo/

20 Source: Municipality of Ajdovščina: 11/3/2015

1.2. Identification of Civil initiative roles in providing help on the regional level

The current Slovenian management system of protection against natural and other disasters consists of 13 regional Civil Protection and Disaster Relief offices, operating throughout Slovenia. Each of these 13 offices has its own governing body, units and services which can independently operate within their own territory. Municipality of Ajdovščina area belongs to the regional CP office of the Republic of Slovenia for Civil Protection and Disaster Relief in Nova Gorica.[21]

Each regional CP office also has a Regional Emergency Notification Centre (13 in total), connected to the Emergency Notification Centre of the Republic of Slovenia, that performs a 24-hour duty service. The centre responds to the 112 European emergency call number which has been adopted by Slovenia in 1997.[22] In the case of an emergency, activation of all protection and rescue CP units and/or distribution of assets from the Logistic Centres, is followed. Furthermore, after major disasters, regional disaster damage assessment committees are formulated and coordinated by national Administration for Civil Protection and Disaster Relief.[23]

Figure 5: Damaged traffic sign on the regional motorway as a consequence of bora wind[24]

21 Available at: http://www.sos112.si/eng/clanek.php?catid=27&id=2095

22 Source: EC Vademecum – civil protection, available at: http://ec.europa.eu/echo/files/civil_protection/vademecum/si/2-si-4.html

23 Available at: http://www.sos112.si/eng/

24 Source: Mirko Šterman: Podobe vetra, 2013.

1.3. Identification of Civil initiative roles in providing help on the national level

In the Republic of Slovenia, the National Assembly and the Government are involved in the disaster management system i.e. protection, rescue and relief activities at the national level. They provide guidelines for organisation, preparation and implementation of protection measures. They adopt National Programme and Annual Plan for Protection Against Natural and Other Disasters, national emergency response plans and other related documents and supervise their implementation. Among other tasks they provide and manage national funds for the recovery after effects of major natural and other disasters. [25]

In addition, the Government directs, coordinates and supervises the CP activities of ministries, since each ministry is responsible for the implementation of measures to prevent natural and other disasters, and to prevent the consequences of such disasters in areas within their competence. The Act on Protection against Natural and Other Disasters already regulates also inter-ministerial coordination, but various ministers adopt additional regulations and instructions, which regulate CP activities.[26]

The national Administration of the Republic of Slovenia for Civil Protection and Disaster Relief (ACPDR) is a national authority involved in the administrative and technical professional duties regarding the national disaster management system. ACPDR is divided into six internal organizational units (four sectors and two services) based in Ljubljana and it represent a constituent body of the Ministry of Defence.[27]

Figure 6: Slovenian CP logo[28]

ACPDR prepares all legal documents that regulate the work of the disaster management system in Slovenia. Moreover, ACPDR is involved in inter-ministerial statistics, humanitarian law and water regulation, as well as the preparation of databases on spatial

25 Source: EC Vademecum – civil protection, available at: http://ec.europa.eu/echo/files/civil_protection/vademecum/si/2-si-1.html#over

26 Source: EC Vademecum – civil protection, available at: http://ec.europa.eu/echo/files/civil_protection/vademecum/si/2-si-1.html#lega

27 Available at: http://www.sos112.si/eng/, 30.11.2015.

28 Source: https://www.google.si/search?q=civilna+za%C5%A1%C4%8Dita&biw=1219&bih=814&source=lnms&tbm=isch&sa=X&sqi=2&ved=0ahUKEwjM4drS_eTJAhWCLhoKHapdCIoQ_AUIBigB#tbm=isch&q=civilna+za%C5%A1%C4%8Dita+logo

planning and the establishment of a geo-informational system. In addition, ACPDR provides administrative support to the Commander of the Republic of Slovenia and his headquarters, who are directly accountable to the Government. ACPDR cooperates between national civil protection authorities and operational organisations and implements international protection and relief activities. The ACPDR also coordinates rescue and humanitarian assistance on behalf of the Republic of Slovenia in the event of major disasters abroad.[29]

Furthermore, it provides financial resources for the rescue services.[30] According to the ACPDR official site, the annual Slovenian tax due to natural and other disasters, on average amounts to more than 2 % GDP.[31]

1.3.1. Before the wind disaster event

As the ACPDR is responsible for operational preparedness of the civil protection system, it prepares and harmonizes regulations and regulatory acts. Furthermore, it organises and equips national civil protection units and services, maintains material assets within the national Logistic Centres and provides guidelines for the development and readiness of all public rescue services. [32]

In addition, ACPDR prepares and adopts documents as the National Programme of Protection Against Natural and Other Disasters preparation, Risk and threat assessments and National emergency response plans. It organises monitoring, notification and warning system and communication system. It directs and coordinates preventive measures of all public rescue services within national jurisdiction. It organises, equips and trains national civil protection units, which fall under national jurisdiction. It coordinates different kind of Preparedness actions, educations and trainings. It provides working conditions for the National Civil Protection Commander and Civil Protection Headquarters. And it establishes and maintains National reserves. [33]

1.3.2. During the wind disaster event

ACPDR is responsible for adequate response to any major disaster events. Thus, also in the case of the major wind national disaster event, ACPDR monitors, announces the threat, alerts, gives instructions for action and coordinates rescue and relief operations. According to the ACPDR official site[34], the Civil Protection Commander of the Republic of Slovenia manages the response. He is assisted by the Civil Protection Headquarters comprising members of various ministries, experts from different fields and heads of different protection

29 Available at: http://www.sos112.si/eng/,

30 Source: EC Vademecum – civil protection, available at:: http://ec.europa.eu/echo/files/civil_protection/vademecum/si/2-si-1.html#over

31 Available at: http://www.sos112.si/eng/,

32 Available at: http://www.sos112.si/eng/,

33 Source: EC Vademecum – civil protection, available at: http://ec.europa.eu/echo/files/civil_protection/vademecum/si/2-si-1.html#over

34 Available at: http://www.sos112.si/eng/, 30.11.2015.

and rescue units. ACPDR is also obliged to co-finance activities relating to public rescue services at the national level. [35]

The ACPDR is responsible for the interoperation of the Slovenian autonomous communication and information system for protection, rescue and relief with other international systems. International intervention is regulated by political (bilateral or regional) agreements.[36] It comprises the Emergency Notification Centre of the Republic of Slovenia, which intervenes in the management of the information flow, whenever a state coordination is required, as well as the 13 regional notification centres operating 24 hours a day.[37]

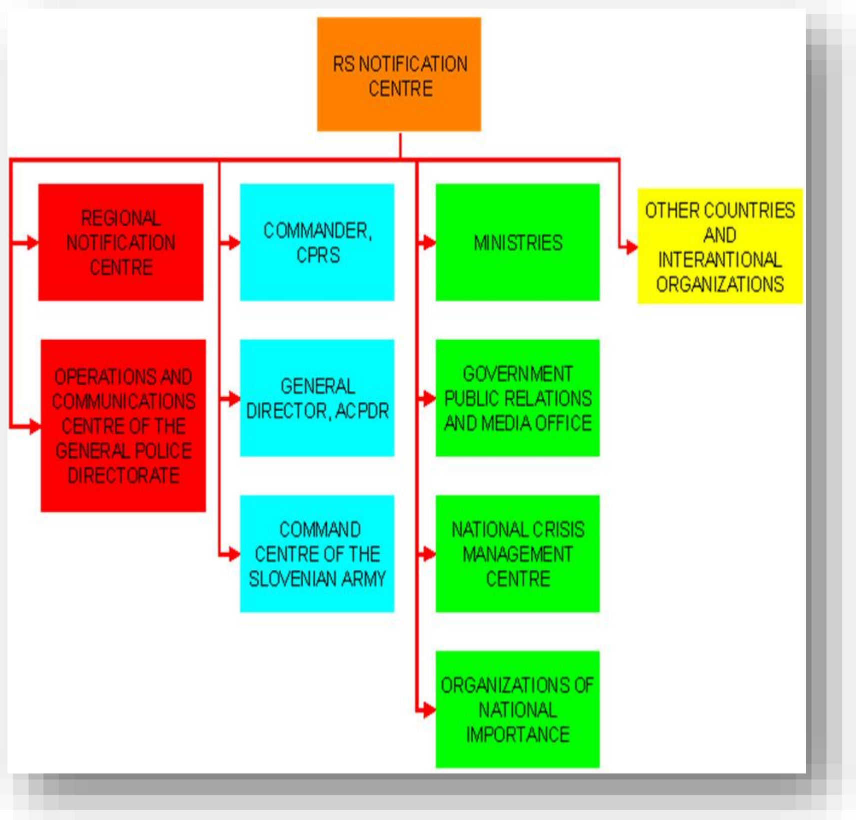

Figure 7: Lines of communication[38]

35 Source: EC Vademecum – civil protection, available at: http://ec.europa.eu/echo/files/civil_protection/vademecum/si/2-si-1.html#over

36 Source: EC Vademecum – civil protection, available at: http://ec.europa.eu/echo/files/civil_protection/vademecum/si/2-si-1.html#lega

37 Available at: http://www.sos112.si/eng/page.php?src=sv1.htm

38 Source: EC Vademecum – civil protection, available at: http://ec.europa.eu/echo/files/civil_protection/vademecum/si/2-si-1.html#over

1.3.3. After the wind disaster event

Provision of basic living conditions after disasters is also one of the fundamental tasks of the (national) disaster management system. Adoption of the reconstruction measures to be carried out by competent ministries is planned, while the government coordinates their activities. [39]

National and regional damage assessment commissions estimate the damage and prepare proposals to ameliorate disaster impacts. Victims gather evidence of the damage they have suffered and submit evidences to the commission for evaluation and approval. estimates property damage and other consequences of accidents, based on the methodology prescribed. [40]

39 Available at: http://www.sos112.si/eng/, 30.11.2015.

40 Source: EC Vademecum – civil protection, available at: http://ec.europa.eu/echo/files/civil_protection/vademecum/si/2-si-1.html#over

1.4. Identification of Civil initiative roles in providing help on the EU level

Directorate General for Humanitarian Aid and Civil Protection (DG ECHO) is the European Commission (EC) authority responsible for European Union (EU) and according to its official web site[41], DG ECHO offers assistance in the aim to save lives affected by natural disasters and man-made crisis. Furthermore, DG ECHO facilitates cooperation and implementation of prevention measures and tools between international civil protection authorities and services across Europe based on the Treaty of Lisbon. It improves the quality and accessibility to disaster information, raises public awareness on disaster management, develops guidelines on risk assessment and hazard mapping, encourages research to promote disaster resilience, etc. For the period 2014 – 2020, EU CP activities has a budget of € 326,5 million.[42]

Figure 8: Humanitarian Aid and Civil Protection logo[43]

Figure 9: European Civil Protection logo[44]

41 Source: http://ec.europa.eu/echo/who/about-echo_en

42 Source: http://ec.europa.eu/echo/who/about-echo_en

43 Source: EC Vademecum – civil protection, available at: http://ec.europa.eu/echo/what/civil-protection/mechanism_en

44 Source: EC Vademecum – civil protection, available at::http://ec.europa.eu/echo/what/civil-protection/mechanism_en

1.4.1. Before the wind disaster event

According to the DG ECHO official site[45], in 2001 the European Civil Protection Mechanism (EUCPM) was created in order to foster coordination of national civil protection authorities across Europe.[46] Furthermore, the EUCPM includes diverse planning and alarming tools, such us:

- The Emergency Response Centre (ERC) operating 24 hours/day;
- The Common Emergency and Information System (CECIS) as a web based alert and notification application;
- A training programme aiming to improve the co-ordination of CP interventions;
- Finances prevention, preparedness and response activities, such as our WIND RISK project[47] and;
- Early warning and monitoring systems: European Flood Alert System (EFAS), European Forest Fire Information System (EFFIS), The Global Disaster Alerts and Coordination System (GDACS), European Mediterranean Seismological Centre (EMSC), Intergovernmental Oceanographic Commission (IOC-UNESCO)…[48]

1.4.2. During the wind disaster event

According to the DG ECHO official site, EUCPM monitors, receives and respond to requests for assistance through the Emergency Response Coordination Centre. By collecting and analysing real-time information on disasters, it ensures immediate, coordinated and pre-planned response efforts and facilitate the delivery of CP assistance in a variety of disasters to the victims.[49]

1.4.3. After the wind disaster event:

According to the DG ECHO official site, the EC provides assistance also in the aftermath of the natural disasters. This involves financial aid, technical expertise, longer-term development assistance and investment in research and evacuation means. Furthermore, EC facilitates the overall effective transport and logistics coordination and promotes the innovative approaches to narrow the growing gap between humanitarian needs and response.[50]

45 Source: http://ec.europa.eu/echo/who/about-echo_en

46 Source: http://ec.europa.eu/echo/what/civil-protection_en

47 Source: Wind Risk Prevention Project, Acronym: Wind RISK, ECHO/SUB/2014/695276

48 Source: http://ec.europa.eu/echo/who/about-echo_en

49 Source: http://ec.europa.eu/echo/who/about-echo_en

50 Source: http://ec.europa.eu/echo/who/about-echo_en

1.5. Identification of Civil initiative obstacles in providing help at wind disaster events

Several obstacles in providing help at wind disaster events are identified on the local, regional, national as well as on the EU level.

The Municipality of Ajdovščina identified a need for new updated knowledge on typical local Bora wind in order to plan improved preparedness measures adapted to unique features of the local area. The main issue represents an inadequate comprehension of all kinds of wind characteristics. Thus, a new high frequency wind measuring unit (UT), accurate definition of high wind force, speed, bursts, etc. and its characteristic, would represent a base for further research and in the long term improve understanding of the wind. Based on UT, more effective actions could be made, such as:

- introduction of an updated and more efficient method for better assessment of the high wind vulnerability, also in regard to climate change;
- improvement of existing municipality policies, financial instruments and disaster risk reduction actions;
- preparation and adaptation of local CP preparedness and emergency plans, namely High Wind Risk Assessment and Protection and Rescue Plan documents;
- introduction of an updated approach and recommendations dealing with early warning system and supporting CP decisions involving:
  - population (movement limitations, public building closure, etc.);
  - infrastructure construction and material recommendations;
  - transportation/transit (road closure);
  - better building constructions and material recommendations;
  - forests management;
- better assessment of the impact of high wind in combination with hail, snow and sleet, during local weather phenomena;
- improved territorial and infrastructure planning;
- engagement of decision-making in natural disaster risks managing;
- minimalizing the socio-economic costs and
- other.

To sum up, the Municipality of Ajdovščina is in need of actions dealing with the improvement of the links between relevant actors and policies (prevention-preparedness-response-recovery). Thus, resulting in better municipal preparedness from high wind risks. It is also believed that the same needs could be applied to other similar EU regions.

Figure 10: Local Civil Protection during the wind risk event[51]

Furthermore, as the problems regarding high wind are the same on the regional level as well as on the local level, the need for improving the above presented obstacles on regional and national level would be helpful too. Moreover, on the Slovenian national level, there is a lack of high wind Risk Assessment and Protection and Rescue Plan documentation adapted specifically to the wind phenomena.

At the EU level and beyond, a lack of better cooperation and compliance between (EU) countries suffering from high wind risk and wind gusts and exchange of good practices, is identified. Even more, there is a need for more studies dealing with high wind hazard and evaluations of its damage. Public awareness of high wind and wind gusts should be raised and knowledge and understanding should be deepened and expanded. As a result and as a consequence of climate change, improved national and EU preparedness regarding high wind risk should be expected.

51 Source: Municipality of Ajdovščina, 6/2/2012

2. Civil initiative roles and obstacles in providing help at wind disaster events in Croatia

The law on civil protection system in Croatia is delivered in July 2015. This law regulates civil protection system on local, regional and state level. This Law regulates the civil protection system as organizing participants, task forces and citizens for the protection and rescue of people, animals, material and cultural resources and the environment in major accidents and disasters and eliminating the consequences of terrorism and war destruction.

Measures and activities in the system of civil protection carried out by participants (Croatian government, the central government body in charge of civil defense, government bodies and other state bodies, the Croatian Armed Forces and the police and the local and regional (regional) governments) and operational power system of civil protection (headquarters of civil protection, fire-fighting operations forces, the Croatian Red Cross, Croatian mountain rescue service, organizations, units and commissioners of civil protection, coordinators at the site and legal persons in the system of civil protection).

The system of civil protection is being developed on the existing capacities of emergency services with the addition of competent and ready capabilities to a higher level of organization, legal persons, associations of citizens and the citizens themselves. Law on Civil Protection System committed to conceptual harmonization and standardization with the state on the territory of the EU, so that the protection and rescue in major accidents and disasters are defined as a function of the system of civil protection.

The basic principle of law is that each operational civil protection forces alone carried out the obligations prescribed by this Act and other regulations within its mandate, develops, trains and uses its own operational capacity and coordinate operational activities with other participants in a complete system. Croatian prime minister and the executive body of local and regional (regional) governments are directly responsible and authorized to major accidents and disasters guided system of civil protection, and for the purpose of coordinating the activities of the system is established Headquarters of Civil Protection, as well as professional - operational body at all levels. The Republic of Croatia will establish the extra-budgetary fund civil protection based on a special law, to ensure financial resources for the protection and rescue in major accidents and disasters, and the extra-budgetary fund of civil protection can be established by local and regional (regional) governments to ensure financial resources for the protection and rescue in major accidents.[52]

[52] http://www.duzs.hr/news.aspx?newsID=22724&pageID=203

3. Identification of Civil initiatives at wind disaster events in Croatia

Measures and activities in the system of civil protection are carried out by following participants:

- Croatian Government
- Central state administration body in charge of civil protection
- Government bodies and other state bodies
- The Croatian Armed Forces and Police
- Local and regional (regional) governments.

Measures and activities in the system of civil protection are carried out by following operational participants:

- the headquarters of civil protection
- operational firefighting forces
- operational forces of the Croatian Red Cross
- the operational forces of the Croatian Mountain Rescue Service Association
- troops and commissioners of civil protection
- coordinators at the site
- legal persons in the system of civil protection.

3.1. Identification of local/regional Civil initiatives at wind disaster events

3.1.1. Before the wind disaster event

Regional and local protection and rescue plans are delivered on regional (county) and local (municipality) level.

All intervention and operational units must undergo proper education and training.

Wind measurement and forecasting is done by state hydrological meteorological service. In case of high wind forecast/measurement, warning is issued to State protection and rescue doctorate DUZS and publicly announced in local media.

3.1.2. During the wind disaster event

Emergency service of Split and Dalmatia county are:

- Regional department of State protection and rescue doctorate (DUZS) and service 112
- Firefighting troops (county firefighting unit, public firefighting unit, voluntary firefighting departments)
- Red cross
- Mountain rescue service

Besides emergency services, in case of hazardous event, every citizen is obligated to provide help.

All injuries, damages and other incidents in case of disaster event are reported to central office for providing help – centre 112. The operator in centre sends appropriate unit

State protection and rescue doctorate (DUZS) [53] intervention units Are State Firefighting Intervention Units and State Civil Protection Intervention Units.

State Civil Protection intervention unit of (DIP CZ) is established as the operating power for the specialized tasks of protection and rescue:

- In ruin
- In water
- in radiological, chemical, biological and nuclear protection events
- logistical tasks of population care

Split department of State Civil Protection intervention unit is consisted of:

- A team for ruins rescue (30 members + 3 rescue dogs)
- A ream for water rescue (36 memebers)
- A team for radiological, chemical, biological and nuclear protection (29 members)
- Logistics team (29 members)

[53] http://www.duzs.hr/

Sequence number	Forces		Tasks
Regular forces in Split-Dalmatia County			
1.	County Public firefighting unit		Carry out measurements for technical intervention, rescue from the water pumping water and removing flotsam.
2.	County voluntary firefighting unit		
3.	Building companies		Work on the sanation of flood consequences on request of the Headquarters.
4.	Utility (communal) companies		
5.	HEP-electric power company		Ensure a continuous supply of power and energy and mitigate the consequences of flooding the electro-energy plants.
6.	Water supply companies		Ensuring a regular supply of drinking water, working on the rehabilitation of damaged and / or destroyed water infrastructure
7.	Clinical Hospital CentreSplit		Provide health care of seriously injured and ill.
8.	County Medical center		Provide emergency medical assistance to the injured and ill.
If necesary, folowing forces are required as a support			
No.	Forces	No. of executors	Tasks
1.	Protection and rescue Headquarters	22	Plans, organizes, commands, co-ordinates and supervises the implementation of protection and rescue tasks.
2.	Commandmment of county civil protection	18	Plans, organizes, commands,, coordinates and supervises the implementation of the protection and rescue tasks.
3.	Special civil protection unit for logistic	99	Specialist Unit of Civil Protection County are activated as additional forces to protection and rescue forces.
4.	Troops of special and general purpose for local government unit		The city / municipality Specialist Unit of Civil Protection County are activated as additional forces to protection and rescue forces.
5.	Civic associations engaged in protection and rescue (County red cross, hunting clubs, diving companies...)		

Table 1 Obligations of forces in case of hazardous event[54]

[54] Protection and rescue plan of Split and Dalmatia County

Figure 11. State Civil Protection intervention unit training [55]

3.1.3. After the wind disaster event

Facilities (roads, power cables, water supply infrastructure buildings) are maintained by the legal persons responsible for managing the facility. In case of natural disaster event, financial aid is approved by the state.

[55] Source: http://www.duzs.hr/news.aspx?newsID=22982&pageID=147

3.2. Identification of Civil initiative roles in providing help on the national level

3.2.1. Before the wind disaster event

Croatian hydrological and meteorological service[56] is official meteorological agency responsible for weather information measuring, forecasting and warnings in case of potentially hazardous weather forecast. A part of DHMZ s activity is MeteoAlarm[57]

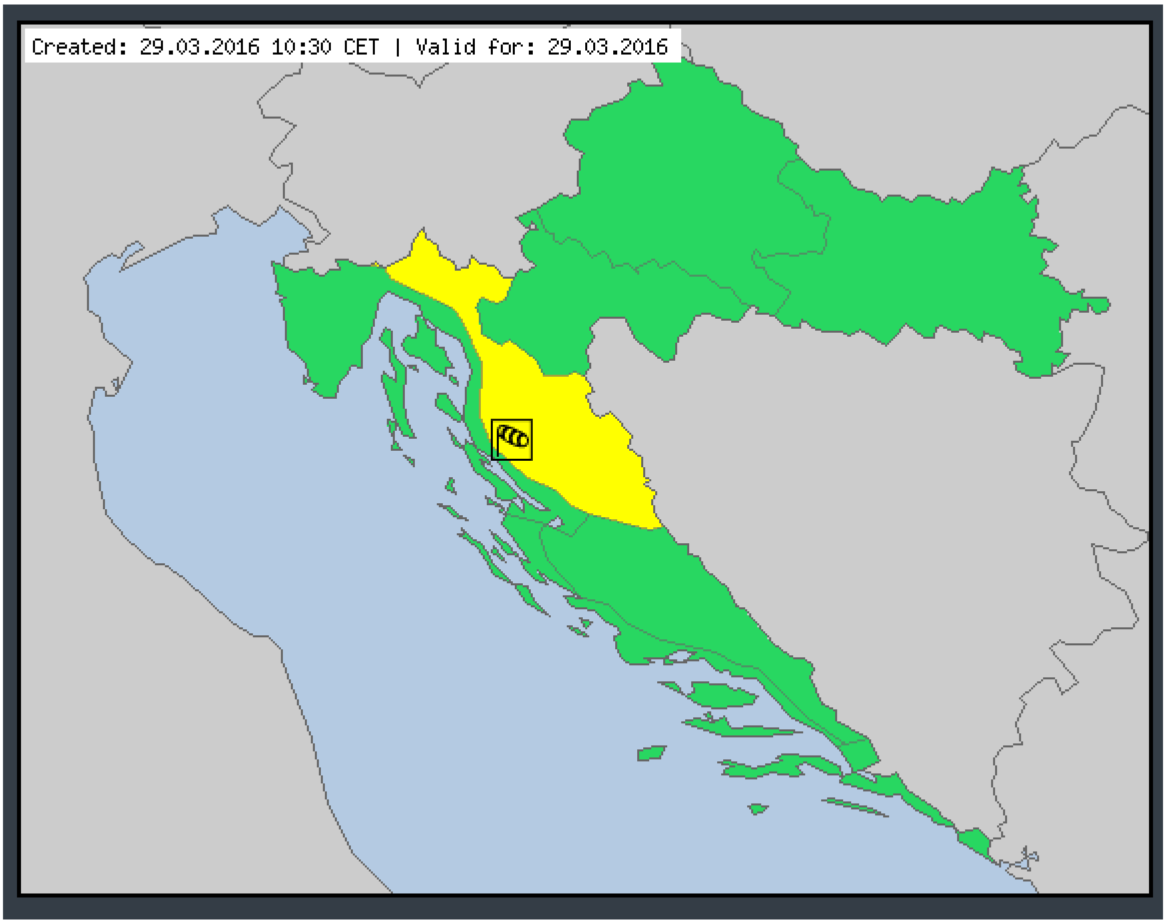

Figure 12. Meteo Alarm yellow warning for wind in Gospić region

Besides DHMZ, there are several meteorological amateur associations, among whom the most active is Crometeo[58] . Crometeo gathers people interested in weather forecasting and analysis and publishes unofficial weather forecasts and analysis.

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[56] http://meteo.hr/
[57] http://www.meteoalarm.eu/index2.php?lang=hr_HR&country=HR
[58] http://crometeo.hr/

Protection and rescue plan for area of Republic of Croatia is delivered by Croatian government[59]. The plan includes measured of protection and rescue from hazards of other natural causes and this includes extreme wind.

3.2.2. During the wind disaster event

In case of strong wind forecast, DHMZ gives warning to DUZS and reports warning to media. Help is provided by local emergency services, but in case the extent of disaster exceeds the limits of municipality/region, state forces can be included in providing help.

State protection and rescue doctorate (DUZS) [60] intervention units are: State Firefighting Intervention Units and State Civil Protection Intervention Units.

State Civil Protection intervention unit of (DIP CZ) is established as the operating power for the specialized tasks of protection and rescue:

- In ruin
- In water
- in radiological, chemical, biological and nuclear protection events
- logistical tasks of population care

Croatian Mountain Rescue Service (Hrvatska gorska služba spašavanja - HGSS) [61]is a national, voluntary, professional, humanitarian associations of public interest whose main objectives are the prevention of accidents, rescue and first aid in the mountains and other inaccessible areas and in exceptional circumstances where in rescue and relief work requiring special skills and use technical equipment for rescue in the mountains in order to preserve human life, health and property.

In its activities HGSS cooperate with government bodies and bodies of local and regional / regional governments, institutions, the Croatian Armed Forces, health care institutions and social welfare institutions, Croatian Mountaineering Association and other legal and natural persons in the field of culture, physical culture and sports , tourism, environmental protection, traffic. It also works closely with the public institutions and competent authorities for nature protection in the field of protection and conservation of mountain nature and environmental protection.

The areas of work of Mountain Rescue Service are often urban communities and other non-mountainous areas. Its activities include rescue at heights and high buildings in case of earthquakes, weather and other disasters, rescue in accidents in case of bad weather conditions with the use of specific expertise and technical rescue equipment, organizing

[59] http://narodne-novine.nn.hr/clanci/sluzbeni/2010_08_96_2707.html
[60] http://www.duzs.hr/
[61] http://www.gss.hr/hgss/o-sluzbi/

the transport of injured and sick persons and the issue of preventive and educational materials regarding the safety of persons and property.

Saving for all rescued is completely free of charge.

Croatian Red Cross[62] is integral part of the protection and rescue system of the Republic of Croatia. Representatives of the Croatian Red Cross are members of crises management bodies on national, county and city level. Croatian Red Cross participates in all the activities linked to crises, during all phases – from preparedness activities to response and recovery phase.

Croatian Red Cross implements preparedness activities and responds in case of disasters and other emergencies. It prepares disaster response units on local and national level and informs citizens of all ages about correct procedures and behaviour in emergencies. All the needed equipment is procured and stockpiled in the Central warehouse in Zagreb and in regional warehouses.

Disaster preparedness activities include trainings for disaster response units that are organized on the city and county level. Every member adopts basic knowledge in first aid, psychosocial support, security and self-protection and communication. After initial education, they can specialize in one of the areas: first aid (advanced training), assessment, tracing, shelter, water and sanitation.

3.2.3. After the wind disaster event

In case of material damage natural disaster can be pronounced. In that case material damage can be refunded from state budget.

Natural disaster can be proclaimed on state, county, municipality and City level. When natural disaster causes significant damages, city/municipality can request proclamation of natural disaster. Depending on the extend of the area affected by the disaster (state, county or city), State/County/Municipality/City committee for assessment of damage caused by natural disaster meets and investigates. As outcome, the committee makes final proposal to the Major to, or not to declare natural disaster.

In case of natural disaster, damage mitigation financial aid is given by committee for the assessment of damage.

[62] http://www.hck.hr/en/category/-disaster-preparedness-and-response-63

3.3. Identification of Civil initiative obstacles in providing help at wind disaster events

Several obstacles can be identified in civil initiative help providing at wind disaster events. All civil forces included in providing help in wind disaster event are also included in any other disaster event that can happen in state and region, and so far there are no specialized departments dealing with wind risk help providing and vulnerability reduction. Wind is mainly researched and analyzed from the aspect of energy potential, and not as hazard.

The main obstacles in providing help is lack of education of operative personnel regarding wind behavior and resulting risks for population, transit, buildings, infrastructure and forests. The personnel is mainly relying on personal experience and intuition in the absence of official recommendations.

Better and official recommendations for transport and infrastructure operation during the high wind events should be proclaimed, instead of relying on the operator's decision.

Risk assessment and protection and rescue plans treat wind as natural risk and do not take into account the frequency and damages caused by wind related events. Better official cost analysis should give better insight into the cost structure from the wind related events and give the

Cooperation of different operational teams and institutions is improved by introduction of central number for incidents 112. Better definition of obligations and responsibilities should improve cooperation in help providing even more.

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WIND RISK

Task D – Action plan

Action D.1: Spatial Planning Recommendations Aiming at Reducing Vulnerabilities

For the Wind Risk prevention project

University of Ljubljana
Technical University of Dortmund
University of Split
Municipality of Ajdovščina

Chapter D.1 – Spatial Planning Recommendations Aiming at Reducing Vulnerabilities

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1. Introduction: Reducing Vulnerability towards Storms through Spatial Planning?

As spatial planning decides about future land uses and city structures, the discipline recognizably influences the vulnerability of areas. The aim of this Wind Risk Report D.1 therefore is to discuss how vulnerabilities can be reduced from a spatial planning perspective. In comparison to other Wind Risk Reports, D.1 does not target the development of single on-site measures. Instead D.1 aims at developing an approach on how location-based vulnerabilities may be identified and treated by systematic, comparable spatial planning approaches.

One key procedure within spatial planning is environmental assessment. Environmental assessment aims at ensuring that before any (planning) decision on projects, plans or programs are taken, possible environmental implications are considered (cf. Website EC 2016a). As EU Directives 2011/92/EU[1] and 2001/42/EC[2] form the legal bases for environmental assessment, both a systematic and comparable approach is provided for.

The focus of this report is therefore on the connection between spatial planning and environmental assessment. In chapter 2, the EU Directives on Environmental Assessment are introduced. The above-mentioned Directives shall be addressed and their assessment procedures outlined in detail. Furthermore, the recent amendment of Directives 2011/92/EU will be introduced, which, for the first time, explicitly addresses climate change as well as risks from accidents and/or disasters (Annex IV) as substantial topics of environmental assessment. Moreover, a comparison of similarities and differences between Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) will be given.

In chapter 3, the connections between spatial planning and environmental assessment are introduced for each Wind Risk partner country, namely Germany, Slovenia and Croatia. For each country, the national spatial planning system is described and laws and regulations on environmental assessment are given.

Chapter 3 provides the basis for chapter 4, in which a discussion is conducted on the question if spatial planning is capable of reducing vulnerability through environmental assessment. In this chapter, opportunities and restrictions of environmental assessment as a systematic, comparable spatial planning approach are identified. Moreover, recommendations are given from a spatial planning perspective on how the (location-based and therefore spatially varying) vulnerability towards storms may be reduced.

Chapter 5 gives a summary of the finding and concludes on the guiding research question for this report, which is:

- *Is Spatial Planning Capable of Reducing Vulnerability through Environmental Assessment?*

[1] Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment
[2] Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment

2. Environmental Assessment in the EU

This chapter presents an in-depth description of the Environmental Assessment Directives 2011/92/EU (EIA Directive) and 2011/42/EC (SEA Directive). Special attention is drawn to the latest amendment of the EIA Directive (2014/52/EU), which comprises an assessment of risks from accidents or disasters (Annex IV).

2.1. Environmental Impact Assessment Directive 2011/92/EU

2.1.1. Development of the EIA Directive

Environmental Impact Assessment (EIA) was first introduced in 1985 in the EIA Directive 85/337/EEC. It was established with the purpose of considering both positive and negative potential environmental impacts prior to the implementation of public or private projects. (Cf. Website EC 2016b)

The Annexes of the Directive define whether a project mandatorily requires an EIA (Annex I projects) or whether a screening procedure needs to be conducted in order to estimate the necessity of an EIA.
Projects listed in Annex I are considered to always have significant impact on the environment. These embrace for example airports (with a runway length greater than 2,100 m), long-distance motorways, long-distance railway lines, waste water treatment plants (greater than 150,000 person equivalents), installations for the disposal of non-hazardous waste (greater than 100 tons per day) and installations for the disposal of hazardous waste (regardless of the size).
Projects listed in Annex II are considered to possibly have an impact on the environment, which is why the national authorities decide in a case-to-case screening procedure on whether an EIA is needed. The criteria for the examination of Annex II projects are anchored in Annex III of the Directive. Annex II projects are for example flood-relief works and urban development projects. (Cf. Directive 2011/92/EU)

The presently legally binding Directive 2011/92/EU consists of the initial Directive from 1985 and three amendments. The first amendment of the initial Directive was conducted in 1997 with the aim of widening the scope of projects covered (Directive 97/11/EC). With the first amendment, both the number of projects for mandatory EIA (Annex I) as well as screening procedure projects (Annex II) was increased and new screening criteria (Annex III) established. The primary inducement for amending 85/337/EEC was the adoption of the UN ECE Espoo Convention.
The second amendment took place in 2003 due to the Aarhus Convention and the new resolution on public participation. Directive 2003/35/EC therefore detached Directive 97/11/EC and aimed at aligning the provisions “on public participation in decision-making processes and an access to justice in environmental matters.” (Website EC 2016b)
The third amendment was conducted in the year 2009 in which the Annexes were updated again. EIA Directive 2009/31/EC was newly considering projects in the field of transport and both capturing and storage of carbon dioxide (CO_2). (Cf. Website EC 2016b)

2.1.2. Structure and Contents of Directive 2011/92/EU

The first segment of Directive 2011/92/EU explains the essential contents of the Directive, before concrete articles are named. The first segment e.g. justifies the codification of the Directive *"[it] has been substantially amended several times" (1)* and states the legitimation for the existence of the Directive *"Union policy on the environment is based on the precautionary principle and on the principles that preventive action should be taken, that environmental damage should, as a priority, be rectified at source and that the polluter should pay. Effects on the environment should be taken into account at the earliest possible stage in all the technical planning and decision-making processes." (2)* In a later context, the legally protected goods embraced in the Directive are named: *The effects of a project on the environment should be assed in order to take account of concerns to protect human health, to contribute by means of a better environment to the quality of life, to ensure maintenance of the diversity of species and to maintain the reproductive capacity of the ecosystem as a basic resource for life. (14)*

Furthermore, the difference between Annex I and Annex II projects and the role of Member States in setting thresholds and the project developers are explained *(8-13)*. Also the topics of transboundary cooperation *(15)* and public participation *(16-21)* are included. Regarding public participation it is stated that by taking into account opinions and concerns of the public, the aims of *"increasing the accountability and transparency of the decision-making process and contributing to public awareness of environmental issues and support for the decisions taken." (16)* are enforced.

Subsequently, the second segment contains the legally binding articles and paragraphs. The prior described structure is now transferred to articles, starting with the legitimation. *"Member states shall adopt all measures necessary to ensure that, before consent is given, projects likely to have significant effects on the environment by virtue, inter alia, of their nature, size or location are made subject to a requirement for development consent and an assessment with regard to their effects. […] The environmental impact assessment may be integrated into the existing procedures for consent to projects in the Member States, or, failing this, into other procedures or into procedures to be established to comply with the aims of this Directive." (Art. 2 1-2)* Subsequently the protected goods are anchored in Article 3: *"The environmental impact assessment shall identify, describe and assess in an appropriate manner, in the light of each individual case and in accordance with Articles 4 to 12, the direct and indirect effects of a project on the following factors: (a) human beings, fauna and flora; (b) soil, water, air, climate and the landscape; (c) material assets and the cultural heritage; (d) the interaction between the factors referred to in points (a), (b) and (c)."* Article 4 then contains the differentiation between Annex I projects (mandatory EIA) and Annex II projects (scoping): *"(1) Subject to Article 2(4), projects listen in Annex I shall be made subject to an assessment in accordance with Articles 5 to 10. (2) Subject to Article 2(4), for projects listed in Annex II, Member States shall determine whether the project shall be made subject to an assessment in accordance with Articles 5 to 10. Member states shall make that determination through: (a) a case-by-base examination; or (b) thresholds or criteria set by the Member State. Member States may decide to apply both procedures referred to in points (a) and (b). (3) When a case-by-case examination is carried out or thresholds or criteria are set for the purpose of paragraph 2, the relevant selection criteria set out in Annex III shall be taken into account."*

The exact EIA procedure is outlined in Tab 1, referring to Articles 5 to 9 of the Directive.

Last, the Annexes contain specific project for which an EIA is mandatory (Annex I), project, for which the competent authority needs to screen whether an EIA is needed (Annex II) and the selection criteria needed for screening projects (Annex III). Furthermore, Annex IV contains information referred to in Article 5(1) on the detailed description of the project. In addition, Annex V contains a list of the successive amendments, the dates until which these amendments needed to be transposed into national law and a table of correlation between the Articles of Directive 85/337/EEC and Directive 2011/92/EU.

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2.1.3. EIA Procedure

Tab. 1: EIA procedure according to Directive 2011/92/EU

Art. & Parag.	Subject	Addressees	Procedure
Art. 5 (1-4)	Information on the project are to be provided, evaluated and commented on. This information are at least: • *a description of the project comprising information on the site, design and size of the project;* • *a description of the measures envisaged in order to avoid, reduce and, if possible, remedy significant adverse effects;* • *the data required to identify and assess the main effects which the project is likely to have on the environment* • *an outline of the main alternatives studied by the developer and an indication of the main reasons for his choice, taking into account the environmental effects;* • *a non-technical summary of the information referred to in points (a) to (d). (Art. 5(3))*	• Developer	supplies information on the project in an appropriate form
		• Member State	evaluates the information given by the developer; ask the competent authority for an opinion on the information supplied
		• Competent authority	gives an opinion on the information to be supplied by the developer after consulting the developer and other authorities (Art. 6(1))
Art. 6 (1-6)	Participation procedures for authorities with environmental responsibilities (1) and the public (2). Early decision-making information for the public have to be: • *the request for development consent;* • *the fact that the project is subject to an EIA procedure and, where relevant, that Article 7 applies;* • *details on the competent authorities responsible for taking the decision, those from which information can be obtained, those to which comments or questions can be submitted, and details of the time schedule for transmitting comments or questions;* • *the nature of possible decision or, where there is one, the draft decision;* • *an indication of the availability of the information gathered pursuant to Article 5;* • *an indication of the times and places at which, and the means by which, the relevant information will be made available;* • *details of the arrangements for public participation made pursuant to paragraph 5 of this Article. (Art. 6(2))* Later information to be made available to the public concerned are: • *any information gathered pursuant to Article 5;* • *in accordance with national legislation, the main reports and advice issued to the competent authority or authorities at the time when the public concerned is informed in accordance with paragraph 2 of this Article;* • *[…] information other than that referred to in paragraph 2 of this Article which is relevant for the decision in accordance with Article 8 of this Directive and which only becomes available after the time the public concerned was informed […]. (Art. 6(3))*	• authorities with environ-mental responsi-bilities	express their opinion on the information supplied by the developer
		• Member State	designates the authorities to be consulted (either in general or on a case-by-case basis); ensures that information are made available to the public; defines the detailed arrangements for informing the public
		• Competent authority	forwards the information supplied by the developer to the other environmental authorities to be consulted
		• The public	is informed as soon as possible, latest when information can reasonably be provided
		• The public concerned	has early (before the request for development consent is taken) and effective opportunities to participate in the environmental decision-making procedures via comments and opinions

Art. 7 (1-5)	Participation procedures in case other Member States possibly being affected by a project in one Member State: • *a description of the project, together with any available information on its possible transboundary impact;* • *information on the nature of the decision which may be taken. (Art. 7(1))*	• Member State	inform other Member States possibly affected by a project and give reasonable time in which participation requests may be expressed; enter consultations on the potential transboundary effects of the project
		• Potentially affected other Member States	receives information on the project and may request the wish to participate in the decision-making process; arrange the information received and inform environmental authorities and the public concerned; enter consultations on the potential transboundary effects of the project
		• Potentially affected environ-mental authorities and public in other Member State	forwards the opinion to the Member State in whose territory the project is intended to be carried out before development consent for the project is granted
Art. 8	Consideration of the consultations and all information gathered (pursuant to Articles 5-7) in the development consent procedure.	• Competent authority	considers all information and consultations
Art. 9 (1-2)	Information of the public on the decision of the development consent: • *the content of the decision and any conditions attached thereto;* • *having examined the concerns and opinions expressed by the public concerned, the mains reasons and considerations on which the decision is based, including information about the public participation process;* • *a description, where necessary, of the main measures to avoid, reduce and, if possible, offset the major adverse effects. (Art. 9(1))*	• Competent authority	informs the public on the decision of the development consent; informs any Member State which as been consulted according to Article 7; forwards all information referred to in paragraph 1 of this Article
		• Consulted Member State	ensures that the received information is made available to the public concerned in their own territory

Source: own depiction following Directive 2011/92/EU, Articles 5-9.

2.2. Amended Environmental Impact Assessment Directive 2014/52/EU

2.2.1. Development of EIA Directive 2014/52/EU

In May 2014 Directive 2011/92/EU was amended by EIA Directive 2014/52/EU. The major aims of the amendment were to reduce the overall administrative burden, to make “business decisions on public and private investments more sound, more predictable and sustainable in the long term” and to better include topics that have emerged since the initial Directive, like “resource efficiency, climate change and disaster prevention” (Website EC 2016c).

The European Commission sums up the main amendments as follows:

- “Member States now have a mandate to simplify their different environmental assessment procedures.
- Timeframes are introduced for the different stages of environmental assessments: screening decisions should be taken within 90 days (although extensions are possible) and public consultations should last at least 30 days. Members States also need to ensure that final decisions are taken within a ‘reasonable period of time’.
- The screening procedure, determining whether an EIA is required, is simplified. Decisions must be duly motivated in the light of the updated screening criteria.
- EIA reports are to be made more understandable for the public, especially as regards assessments of the current state of the environment and alternatives to the proposal in question.
- The quality and the content of the reports will be improved. Competent authorities will also need to prove their objectivity to avoid conflicts of interest.
- The grounds for development consent decisions must be clear and more transparent for the public. Member States may also set timeframes for the validity of any reasoned conclusions or opinions issued as part of the EIA procedure.
- If projects do entail significant adverse effects on the environment, developers will be obliged to do the necessary to avoid, prevent or reduce such effects. These projects will need to be monitored using procedures determined by the Member States. Existing monitoring arrangements may be used to avoid duplication of monitoring and unnecessary costs.” (Website EC 2016c)

The amendment needs to be transported into national law until 16 May 2017 (cf. Website EUC 2016c).

2.2.2. Structure and Contents of Directive 2014/52/EU

The first segment of EIA Directive 2014/52/EU outlines the major changes of the Directive in comparison to Directive 2011/92/EU and gives reason, why an amendment is needed: *“It is necessary to amend Directive 2011/92/EU in order to strengthen the quality of the environmental impact assessment procedure, align that procedure with the principles of smart regulation and enhance coherence and synergies with other Union legislation policies, as well as strategies and policies developed by Member States in areas of national competence. (3) […] Directive 2011/92/EU should also be revised in a way that ensures that environmental protection is improved, resource efficiency increased and sustainable growth supported in the Union. To this end, the procedures it lays down should be simplified and harmonised.” (6)* Another important topic that was included in the amendment of the EIA Directive is the economic and social significance of good land management, including soil. Plans and programs shall therefore become more appropriate regarding the topics of land take, sealing, erosion and compaction. These insights were the outcome of the United Nations Conference on Sustainable Development held in Rio de Janeiro in June 2012. (Cf. Directive 2014/52/EU (9))

Most importantly for the Wind Risk Prevention Project is the following reason for the amendment of the EIA Directive: *“Over the last decade, environmental issues, such as resource efficiency and sustainability, biodiversity protection, climate change, and risks of accidents and disasters, have become more important in policy making. They should therefore also constitute important elements in the assessment and decision-making processes.” (7)* This statement is specified in the following segments 13-15, which, in order to ensure a correct understanding, will be quoted directly:

- *"Climate change will continue to cause damage to the environment and compromise economic development. In this regard, it is appropriate to assess the impact of projects on climate (for example greenhouse gas emissions) and their vulnerability to climate change." (13)*
- *"[…] to ensure that the implementation, review and further development of Union initiatives, take into consideration disaster risk prevention and management concerns as well as the United Nations Hyogo Framework for Action Programme […], which stresses the need to put in place procedures for assessment of the disaster risk implications of major infrastructure projects." (14)*
- *"In order to ensure a high level of protection of the environment, precautionary actions need to be taken for certain projects which, because auf their vulnerability to major accidents, and/or natural disasters (such as flooding, sea level rise, or earthquakes) are likely to have significant adverse effects on the environment. For such projects, it is important to consider their vulnerability (exposure and resilience) to major accidents and/or disasters, the risk of those accidents and/or disasters occurring and the implications for the likelihood of significant adverse effects on the environment. […]" (15)*

It is striking that for the first time climate change, disaster risk management and accidents as well as disasters found entrance to the EIA Directive. According to statement 13 it is not sufficient anymore to describe the possible significant effects of projects on climatic factors as in Articles 3 and 5 of Directive 2011/92/EU (cf. Directive 2011/92/EU 3 (b); 5 (1))[3], but an assessment of the vulnerability of planned structures and objects towards climate change becomes necessary.
Furthermore, the inclusion of the Hyogo Framework enables a consideration of disaster risk prevention and management, especially for infrastructure projects. By including this statement 14, the gap between risks prevention and planning is bridged.
Last, statement 15 enforces precautionary actions regarding accidents and/or disasters in the habit of risks analyses. First, the vulnerability of projects towards major accidents and/or natural disasters needs to be assessed by investigating exposure and resilience of the projects. Second, the risk of occurrence for these accidents and/or disasters needs to be estimated. Third, implications for the likelihood of significant adverse effects on the environment need to be described.

From statement 30 onwards, the environmental impact assessment report is introduced. This report is to be written by the developer of a project and to be commented by the competent authority during the phase of scoping. It contains all information delivered previously under Article 5 (1) Directive 2011/92/EU and Annex IV. *"The environmental impact assessment report […] should include a description of reasonable alternatives […], including […] an outline of the likely evolution of the current state of the environment without implementation of the project (baseline scenario) […]." (31)*

Subsequently, the second segment contains the legally binding articles and paragraphs. E.g. the environmental impact assessment report in now embedded in Article 1. Especially interesting is the replacement of Article 3 in favor of an enlarged list of protected goods and of a second paragraph, which says: *"The effects referred to in paragraph 1 on the factors set out there in shall include the expected effects deriving from vulnerability of the project to risks of major accidents and/or disasters that are relevant to the project concerned."* (Directive 2014/52/EU Article 3(2))
Amendments of Articles 5 to 9, which describe the exact EIA procedure, are described in detail in the following subchapter.

Again, the third part of Directive 2015/52/EU consists of the amended Annexes. An Annex II.A is inserted on information referred to in Article 4(4), referring to the list of information the project developer has to provide. Former Annexes III and IV are being

[3] "A description of the aspects on the environment likely to be significantly affected by the proposed project, including, in particular, […] climatic factors […]." (Directive 2011/92/EU, Annex IV, Information referred to in Article 5(1)

replaced by a new Annex III on the selection of scoping criteria referred to in Article 4(3). Annex IV provides information on the environmental impact assessment report and refers to the amended Article 5(1).

2.2.3. Changes in EIA procedure

As it is of special interest for the Wind Risk Prevention Project, in the following the amendments concerning changes in the EIA procedure are investigated. Changes are marked in red letters.

Tab. 2: Changes in EIA procedure according to Directive 2014/52/EU

Art. & Parag.	**Changes in subject**	**Addressees**	**Procedure**
Art. 5 (1-3, 4)	Information on the environmental impact assessment report (paragraph 1). The report shall at least have the following contents: • *a description of the project comprising information on the site, design, size and other relevant features of the project;* • *a description of the likely significant effects of the project on the environment;* • *a description of the features of the projects and/or measures envisaged in order to avoid, prevent or reduce and, if possible, offset likely significant adverse effects on the environment;* • *a description of the reasonable alternatives studied by the developer, which are relevant to the project and its specific characteristics, and an indication of the main reasons for the option chosen, taking into account the effects of the project on the environment;* • *a non-technical summary of the information referred to in points (a) to (d); and* • *any additional information specified in Annex IV relevant to the specific characteristics of a particular project or type of project and to the environmental features likely to be affected.*	• Developer	supplies information on the project in the form of an environmental impact assessment report; is responsible for a good quality of the report
		• Member State	evaluates the information given by the developer; ask the competent authority for an opinion on the information supplied
		• Competent authority	gives an opinion on the information of the environmental impact assessment report after consulting the developer and other authorities (Art. 6(1)); needs to exhibit sufficient expertise to examine the report
Art. 6 (1-2, 3-4, 5-6, 7)	Participation procedures for authorities with environmental responsibilities (1) and the public (2). Early decision-making information for the public have to be: • *the request for development consent;* • *the fact that the project is subject to an EIA procedure and, where relevant, that Article 7 applies;* • *details on the competent authorities responsible for taking the decision, those from which information can be obtained, those to which comments or questions can be submitted, and details of the time schedule for transmitting comments or questions;* • *the nature of possible decision or, where there is one, the draft decision;* • *an indication of the availability of the information gathered pursuant to Article 5;* • *an indication of the times and places at which, and the means by which, the relevant information will be made available;* • *details of the arrangements for public participation made pursuant to paragraph 5 of this Article. (Art. 6(2))* Later information to be made available to the public concerned are:	• authorities with environ-mental responsi-bilities	express their opinion on the information supplied by the developer
		• Member State	designates the authorities to be consulted (either in general or on a case-by-case basis); ensures that information are made available to the environmental authorities and the public (1-2); defines the detailed arrangements for informing the public, taking the necessary measures to ensure that the relevant information is electronically accessible

	• *any information gathered pursuant to Article 5;* • *in accordance with national legislation, the main reports and advice issued to the competent authority or authorities at the time when the public concerned is informed in accordance with paragraph 2 of this Article;* • *[…] information other than that referred to in paragraph 2 of this Article which is relevant for the decision in accordance with Article 8 of this Directive and which only becomes available after the time the public concerned was informed […]. (Art. 6(3))* *Article 6(7): The time-frames for consulting the public concerned on the environmental impact assessment report referred to in Article 5(1) shall not be shorter than 30 days.*	• Competent authority	forwards the information supplied by the developer to the other environmental authorities to be consulted
		• The public	is informed as soon as possible, latest when information can reasonably be provided
		• The public concerned	has early (before the request for development consent is taken) and effective opportunities to participate in the environmental decision-making procedures via comments and opinions
Art. 7 (1-3, 4-5)	Participation procedures in case other Member States possibly being affected by a project in one Member State: • *a description of the project, together with any available information on its possible transboundary impact;* • *information on the nature of the decision which may be taken. (Art. 7(1))*	• Member State	inform other Member States possibly affected by a project and give reasonable time in which participation requests may be expressed; enter consultations on the potential transboundary effects of the project
		• Potentially affected other Member States	receives information on the project and may request the wish to participate in the decision-making process; arrange the information received and inform environmental authorities and the public concerned; enter consultations on the potential transboundary effects of the project; agree on a reasonable time frame
		• Potentially affected environ-mental authorities and public in other Member State	forwards the opinion to the Member State in whose territory the project is intended to be carried out before development consent for the project is granted
Art. 8	The results of consultations and the information gathered (pursuant to Articles 5-7) shall be duly taken into account in the development consent procedure.	• Competent authority	considers all information and consultations
Art. 8a (1-6)	(1) Least information incorporated in the decision of granting a development: • *The reasoned conclusion referred to in Article 1(2)(g)(iv);* • *Any environmental conditions attached to the decision, a description of any features of the project and/or measures envisaged to avoid, prevent or reduce and, if possible, offset significant adverse effects on the environment as well as, where appropriate, monitoring measures;* OR (2) Reasons for refusal of development (4) monitoring parameters	• Member State	ensures that the measures envisaged to avoid, prevent or reduce significant adverse effects are implemented by the developer; determines the procedures regarding the monitoring
		• Competent authority	takes decisions on the environmental impact assessment report within reasonable time; has to make sure that information on Article 3 are still up to date when granting development consent

Art. 9 (1, 2)	Information of the public on the decision to grant or refuse development consent: • *the content of the decision and any conditions attached thereto;* • ~~*having examined the concerns and opinions expressed by the public concerned,*~~ *the mains reasons and considerations on which the decision is based, including information about the public participation process. This also includes the summary of the results of the consultations and the information gathered pursuant to Articles 5 to 7 and how those results have been incorporated or otherwise addressed, in particular the comments received form the affected Member State referred to in Article 7;* ~~• *a description, where necessary, of the main measures to avoid, reduce and, if possible, offset the major adverse effects.*~~	• Competent authority	promptly informs the public on the decision of the development consent taking into account information from Article 8a; informs any Member State which as been consulted according to Article 7; forwards all information referred to in paragraph 1 of this Article
		• Consulted Member State	ensures that the received information is made available to the public concerned in their own territory
Art. 9a	“Member States shall ensure that the competent authority or authorities perform the duties arising from this Directive in an objective manner and do not find themselves in a situation giving rise to a conflict of interest. Where the competent authority is also the developer, Member States shall at least implement, within their organisation of administrative competences, an appropriate separation between conflicting functions when performing the duties arising from this Directive.”	• Member State	ensure that the competent authority/ies are not in a conflict of interest

Source: own depiction, following EIA Directive 2014/52/EU, Articles 5-9a.

2.3. Strategic Environmental Assessment Directive 2001/42/EC

2.3.1. Development of SEA Directive 2011/42/EC

The SEA Directive came into force in 2001 and needed to be transposed into national law by July 2004. In comparison to the EIA, the SEA applies to plans and programs rather than to individual projects. Furthermore, there is no list of plans and programs for which the SEA applies but the demand that any plan or program setting the framework for future development needs an SEA.

The SEA is mandatory for plans and programs prepared in the sectors of “agriculture, forestry, fisheries, energy, industry, transport, waste management, water management, telecommunications, tourism, town and country planning or land use”. (Website EC 2015d) Furthermore an SEA has to be conducted if determined so under the Habitats Directive.

Important to note is that the SEA Directive does not refer to policies and that plans and programs “must be prepared or adopted by an authority (at national, regional or local level) and be required by legislative, regulatory or administrative provisions” (Website EC 2016d).

Similar to the EIA there is the screening procedure for projects, which possibly have environmental effects. A set of criteria of the screening procedure is anchored in Annex II. (Cf. Website EC 2016d) The detailed structure and contents as well as the SEA procedure are described in the following subchapters.

2.3.2. Structure and Contents of Directive 2001/42/EC

The first segment of SEA Directive 2001/42/EC outlines the inducement for implementing a directive on strategic environmental assessment: *“Environmental assessment is an important tool for integrating environmental considerations into the preparation and adoption of certain plans and* *programmes which are likely to have significant effects on the environment in the Member States, because it ensures that such effects of implementing plans and programmes are taken into account during their preparation and before their adoption. (4) The adoption of environmental assessment procedures at the planning and programming level should benefit undertakings by proving a more consistent framework in which to operate by the inclusion of the relevant environmental information into decision making. The inclusion of a wider set of factors in decision making should contribute to more sustainable and effective solutions. (5) […] Action is therefore required at Community level to lay down a minimum environmental assessment framework, which would set out the broad principles of the environmental assessment system and leave the details to the Member States, having regard to the principle of subsidiarity. […]" (8)*

The close linkage of the EIA and the SEA becomes apparent in statement (10). Therein it is stated that an SEA is mandatory for all plans and programs referring to projects listed in the EIA Directive. Furthermore, other prerequisites for plans and programs of mandatorily being subject to SEA are anchored: *"All plans and programmes which are prepared for a number of sectors and which set a framework for future development consent of projects listed in Annexes I and II to Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment, and all plans and programmes which have been determined to require assessment pursuant to Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild flora and fauna, are likely to have significant effects on the environment, and should as a rule be made subject to systematic environmental assessment. […]" (10)* A scoping-like procedure needs to be applied if plans or programs set the framework for future development but may not have significant effects on the environment. In this case, Member States need to determine whether an assessment of environmental effects is necessary. For this purpose, relevant criteria are anchored in the SEA Directive. (Cf. Directive 2001/42/EC (11, 12); Article 3(3-6)) From an SEA excluded are plans and programs, which solely serve national defense or civil emergency purposes as well as financial or budget plans and programs (cf. Directive 2001/42/EC Article 3(8)).

Similar to the amended EIA Directive 2014/52/EU, a report needs to be created if significant environmental effects are to be expected. This environmental report identifies, describes and evaluates the possible effects on the environments and gives reasonable alternatives. (Cf. Directive 2001/42/EC (14)) Again similar to the EIA Directive is the information, participation and consultation process of the public, other authorities and other potentially affected Member States (cf. Directive 2001/42/EC (15-18))

As well as in the EIA Directives, the second and third segment of the SEA Directive consist of the concrete Articles and the Annexes. First, in Article 2, definitions are given. Following the definition for 'plans and programs' these comprise both newly prepared plans and programs as well as modifications to them. Furthermore, these have to be *"subject to preparation and/or adoption by an authority at national, regional or local level or which are prepared by an authority for adoption, through a legislative procedure by Parliament or Government, and which are required by legislative, regulatory of administrative provisions" (Article 2(a)).* In Article 3 the scope of the Directive is defined. Therein is stated that any plan or program likely having a significant environmental effect according to Articles 4 to 9 needs to be subject to an environmental assessment. In detail this applies to plans and programs prepared for *"agriculture, forestry, fisheries, energy, industry, transport, waste management, water management, telecommunications, tourism, town and country planning or land use and which set the framework for future development […]"(Article 2(2)(a)).*

The exact SEA procedure and monitoring is anchored in Articles 5-10 which are subject to the following subchapter. In Annex I, a list of information to be provided within the environmental report (referred to in Article 5(1)) is given. Annex II contains the criteria for determining the likely significance of effects referred to in Article 3, the scoping-like process of estimating the necessity for an SEA.

2.3.3. SEA Procedure

Tab. 3: SEA procedure according to Directive 2011/42/EC

<table>
<tr><th>Art. & Parag.</th><th>Subject</th><th>Addressees</th><th>Procedure</th></tr>
<tr><td rowspan="2">Art. 5
(1-4)</td><td rowspan="2">Development of an environmental report for plans and programs according to Art. 3(1). Report identifies, describes and evaluates the likely significant effects on the environment and reasonable alternatives. Least information to be given (according to Annex I):
• an outline of the contents, main objectives of the plan or programme and relationship with other relevant plans and programmes;
• the relevant aspects of the current state of the environment and the likely evolution thereof without implementation of the plan or programme;
• the environmental characteristics of areas likely to be significantly affected;
• any existing environmental problems which are relevant to the plan or programme […];
• the environmental protection objectives, established at international, Community or Member State level […];
• the likely significant effects (including secondary, cumulative, synergistic, short, medium and long-term permanent and temporary, positive and negative effects) on the environment, including on issues such as biodiversity, population, human health, fauna, flora soil, water, air, climatic factors, material assets, cultural heritage including architectural and archaeological heritage, landscape and the interrelationship between the above factors;
• the measures envisaged to prevent, reduce and as fully as possible offset any significant adverse effects on the environment of implementing the plan or programme;
• an outline of the reasons for selecting the alternatives dealt with, and a description of how the assessment was undertaken including any difficulties (such as technical deficiencies or lack of know-how) encountered in compiling the required information;
• a description of the measures envisaged concerning monitoring in accordance with Article 10;
• a non-technical summary of the information provided under the above headings.
Other authorities according to Art. 6(3) shall be consulted when deciding on the level of detail of information in the environmental report.</td><td>• Authority introducing plan or program</td><td>supplies an environmental report according to Art. 5(1) and Annex I on the likely significant effects, taking into account other levels of decision-making and other Community legislation</td></tr>
<tr><td>• other authorities (accord. to Art. 6(3))</td><td>give an opinion on the sufficiency of the level of detail of the supplied information</td></tr>
<tr><td>Art. 6
(1-5)</td><td>Information and consultation procedures for authorities with environmental responsibilities and the public: both receive the draft plan or program as well as the environmental report in an early stage, so that an effective opportunity within an appropriate time frame is given to express their</td><td>• authorities with environmental responsibilities</td><td>receive the draft plan or program;
express their opinion on the draft plan or program as well as on the environmental report in an appropriate time frame</td></tr>
</table>

	opinion.	• Member State	designates the authorities to be consulted; identifies the concerned public, the interested public, non-governmental organizations, e.g. those promoting environmental protection and others; determines the detailed arrangements for the information and consultation of the public
		• The public	receive the draft plan or program; express their opinion on the draft plan or program as well as on the environmental report in an appropriate time frame
Art. 7 (1-3)	Transboundary information and consultation procedures in case other Member States are possibly being affected by the plan or program.	• Member State	informs other Member States possibly affected by the plan or program before its adoption or submission to the legislative procedure; forwards a copy of the draft plan or program as well as the environmental report; gives reasonable time in which consultation requests may be expressed; enters consultations on the potential transboundary effects of the project
		• Potentially affected other Member States	receives draft plan or program as well as environmental report; may request the wish to be consulted or may be asked to do so and then agree on a reasonable time frame of the duration of the consultation; agrees on detailed arrangements to ensure that authorities and concerned public are being informed and have enough time to forward their opinion
		• Potentially affected environ-mental authorities and public in other Member States	forward their opinion
Art. 8	Consideration of the environmental report, the national and transboundary consultations and all information gathered (pursuant to Articles 5-7) in the preparation of the plan or program, before its adoption or submission to the legislative procedure.	• Competent authority	considers all information and consultations

Art. 9 (1-2)	Information of the authorities, the public and any Member State consulted on the adopted plan or program. The following information need to be made available: • *the plan or program as adopted;* • *a statement summarising how environmental considerations have been integrated into the plan or programme and how the environmental report prepared (Art. 5), the opinions expressed (Art. 6) and the results of consultations entered into (Art. 7) have been taken into account in accordance with Article 8 and the reasons for choosing the plan or programme as adopted, in the light of the other reasonable alternatives dealt with;* • *the measures decided concerning monitoring according to Article 10.*	• Competent authority	informs authorities, the public and any Member State consulted on the adopted plan or program
		• Member State	Determines the detailed arrangements concerning the information
Art. 10 (1-2)	Monitoring of significant environmental effects of the implementation of plans and programs in order to identify at an early stage unforeseen adverse effects, and to be able to undertake appropriate remedial action.	• Member State	is responsible for monitoring

Source: own depiction, following Directive 2011/42/EC, Articles 5-10.

2.4. Comparison of EIA and SEA

2.4.1. Similarities between EIA and SEA

As can be seen in Tables 1-3, the EIA and SEA procedure have many similarities. In the EIA (since 2014), environmental impact assessment report needs to be prepared by the project developer, describing the project and its potential significant environmental effects. In the SEA, the equivalent is the environmental report, which needs to be prepared, also identifying possible significant effects on the environment due to the plan or program. Both reports also have to present:

- the likely development without the implementation of the project or plan/program,
- reasonable alternatives to the intended planning and
- a description of the features of the project respectively plan/program and/or measures envisaged in order to avoid, prevent or reduce and, if possible, offset likely significant adverse effects on the environment;

In both procedures, relevant authorities, the public and other Member States possibly affected are informed and consulted early in the procedures. In the EIA, the environmental impact assessment report needs to be provided as soon as possible. In the SEA the draft version of a plan/program and the environmental report need to be provided.

Before the final decision on a project, respectively the adoption of a plan or program, the results of the consultations of the public, environmental authorities and other Member States are to be considered in both environmental assessment procedures. After the decision respectively adoption, all groups involved are to be informed on the final outcome and, in the case of the EIA, equipped with further information. Furthermore, in case of significant environmental effects of a project, plan or program, a monitoring needs to be set up and regularly assessed by the Member States.

2.4.2. Differences between EIA and SEA

Besides these similarities between EIA and SEA procedures, there also are some differences. First, the in the SEA environmental authorities are required to be consulted in the screening-like process (Art. 3(6)) and are therefore, in comparison to the EIA, involved in the decision on whether or not an SEA needs to be conducted for a plan or program. Yet, the amendment of the EIA Directive also gained further involvement of other relevant authorities. In Article 5(3)(b) is for example anchored that other environmental authorities can be requested for their expertise before the competent authority gives an opinion on the environmental impact assessment report. If requested so by the developer, the competent authority even needs to consult other relevant authorities before giving an opinion on the scope and level of detail of the information to be included by the developer in the environmental impact assessment report (Directive 2014/52/EU, Article 5(2)). Nonetheless, a major difference is that other authorities are already included in the screening-like process of the SEA while other authorities are earliest consulted after the screening is completed and the decision that an EIA is necessary is already taken.

Until the amendment of the EIA Directive, another major difference existed in the scoping procedures of EIA and SEA. In the latter, the content and extent of scoping matters for the environmental report is obligatorily determined in Annex I, consisting of ten comprehensive aspects to be included. Under the Directive 2011/92/EU the EIA did not have any form of report but rather a list of information to be supplied in “an adequate form” according to Article 5(1) and Annex IV. Since the amendment and the entering into force of EIA Directive 2014/52/EU an environmental impact assessment report needs to be developed, also embracing comprehensive criteria. One major difference still existing between EIA Directive 2014/52/EU and SEA Directive 2001/42/EC is that the assessment of reasonable alternatives is studied by the project developer in the EIA (see Annex IV(2)), while in the SEA a transparent decision process is demanded, including the requirement of outlining any difficulties that may have arisen in the assessment of the alternatives (see Annex I(h)).

Another major difference that existed until the amendment of the EIA Directive is that there were no monitoring arrangements provided in the EIA, while the SEA determines a monitoring “of the significant environmental effects of the implementation of plans and programmes in order, *inter alia*, to identify at an early stage unforeseen adverse effects, and to be able to undertake appropriate remedial action” (Article 10(1)). Since EIA Directive 2014/52/EU entered into force, the Member States are responsible for determining monitoring procedures “of significant adverse effects on the environment” (Article 8a(4)). It stays unclear though, who is responsible for conducting the monitoring.

3. Connecting Spatial Planning and Environmental Assessment in Germany, Slovenia and Croatia

The EU Directives on Environmental Assessment shall ensure that projects, plans and programs "likely to have significant effects on the environment are made subject to an environmental assessment, prior to their approval or authorization." (Website EC 2016a) Therefore, the EIA and SEA Directives are inevitably linked with the instruments and tasks of spatial planning.
As both Directives originate of the European Parliament and of the Council, they are binding and need to be transferred to national law. While the SEA Directive has been established in all EU Member States since 2004 and is daily spatial planning practice, the amended EIA Directive 2014/52/EU will need to be implemented by May 2017.

The following two questions shall be investigated in this chapter:

- How are the EU Directives on Environmental Assessment implemented in national law in the three Wind Risk partner countries Germany, Slovenia and Croatia?
- In how far are spatial planning and Environmental Assessment connected in each partner country?

3.1. Spatial Planning and Environmental Assessment in Germany

In Germany, the environmental assessment and spatial planning are closely interwoven. Besides the anchorage of Strategic Environmental Assessment of plans and programs in the Law on Environmental Impact Assessment (*Umweltverträglichkeitsprüfungsgesetz*, UVPG), also the Federal Building Code (*Baugesetzbuch*, BauGB) contains regulations on environmental assessment. According to § 1 (6) No. 7 BauGB, the interests of environmental protection, including nature protection and landscape preservation, are to be considered whenever developing a land-use plan.

Detailed information on the connection between environmental assessment and spatial planning are given in the following subchapters. First, the German spatial planning system is briefly introduced in order to get an understanding of the administrative structure (see chapter 3.1.1). Subsequently, German laws and regulations on environmental assessment are enlarged, focusing on the connection of environmental assessment and German planning law (see chapter 3.1.2).

3.1.1. The German Spatial Planning System

In Germany, spatial planning is divided into comprehensive spatial planning and sectoral planning (cf. Website ARL 2016). While the latter develops sectoral plans for sectoral disciplines, e.g. water management, comprehensive spatial planning acts cross-sectoral. Both, comprehensive and sectoral spatial planning is oriented according to the administrative structure of Germany and therefore takes place on the national level, the regional level (consisting of both Federal States and regions) and the municipalities. (Cf. Greiving et al. 2016: 186f.; Turowski 2005) Fig. 1 illustrates the structure of spatial planning in Germany and gives examples for each spatial level.

Fig. 1: Spatial Planning Structure in Germany

Spatial level	Spatially relevant planning			
	Comprehensive		Sectoral (Transport, water, geology, emergency response, etc)	
Europe	Spatial planning	European spatial development (no binding character)	Societal planning	Environmental policies, TEN, CAP
National level	Spatial planning	Spatial development planning	Societal planning	eg, National transport network plan
Federal state	Spatial planning	Regional planning (partly land-use related)	Societal planning	eg, River basin authorities in charge of management plans, partly land-use planning and management related
Municipality (all planning on this level can be subsumed together under the term *"urban planning and management"*)	Spatial planning	Local land-use planning	Societal planning	eg, Waste and sewage planning, public transport planning, municipalities are in charge of (land-use management)

Source: Greiving et al. 2016: 187.

There are two laws on comprehensive spatial planning that are to be considered in this chapter's context; the Federal Spatial Planning Act (*Raumordnungsgesetz, ROG*) and the Federal Building Code (*Baugesetzbuch*, BauGB).

The ROG applies to the national and the regional level of spatial planning in Germany. It contains principles and aims of comprehensive spatial planning. While principles of spatial planning are statements on the future spatial development without legally binding character[4], aims of spatial planning incorporate binding standards that have to be considered by all spatial planning authorities and need to be included as designations in regional plans (cf. § 3 I 2 ROG). On the regional level, Spatial Planning Acts are implemented for each federal state (except for the city stated Berlin, Bremen and Hamburg). According to the Federal Spatial Planning Acts, spatial structure plans are to be prepared on the level of regions. According to § 8 ROG, spatial structure plans need to contain information on the structure of settlements, open space and the location of infrastructure and their paths. (Cf. Greiving et al. 2016: 187f.; Hendler 2012)

The BauGB applies to the municipal level. It provides for preparatory and binding land-use plans. (Cf. § 1 BauGB) Preparatory land-use plans contain the distribution of land uses for the entire municipal territory and are the spatial prerequisite for the development of binding land-use plans. The latter are developed and implemented for concrete parts of the city and are binding for both authorities and the public. (Cf. Greiving et al. 2016: 188) The BauGB provides for an environmental assessment in the field of urban land-use planning, which is introduced under subchapter 3.1.2.

[4] According to § 3 I 3 ROG, their legally binding force is restricted to an obligatory consideration. This means that the principles have to be considered throughout the planning process but can be outweighed by other – in certain situations, more important – concerns.

3.1.2. Laws and Regulations on Environmental Assessment in Germany

EIA and SEA according to Umweltverträglichkeitsprüfungsgesetz, UVPG

In Germany, EIA and SEA are implemented jointly in the *Umweltverträglichkeits-prüfungsgesetz* (UVPG, directly translated as 'law on environmental assessment'), commonly referred to as '*Umweltprüfungen*' (meaning 'environmental assessments'). The UVPG therefore is the national implementation of both EIA and SEA EU Directive. (Cf. UVPG; Website UBA 2016)

The UVPG is structured as follows:

In part I, general regulations for environmental assessments are explained, including definitions and scope of the law. Part II contains the EIA, structured into two segments. Segment 1 contains the prerequisites for an EIA and segment 2 contains the procedural steps of an EIA. A closer description of the contents can be taken from Tab. 4 below.

In part III, the SEA is anchored, also structured into the two segments on the prerequisites (segment 1) and the procedural steps of an SEA (segment 2). Furthermore, Part IV of the UVPG contains special procedural steps for both EIA and SEA, embracing e.g. airports, but also spatial structure plans as well as land-use plans. Part V contains regulations for specific cables and pipelines, e.g. high-voltage lines or gas pipelines. In part VI, concluding regulations and four annexes are included. (Cf. UVPG)

Tab. 4: EIA and SEA procedures according to UVPG in Germany

**Contents in blue colour present national contents that exceed the EIA or SEA Directives*

Art. & Parag.	Subject	Comparison to EIA / SEA Directive
§3 (a-f)	Description of the screening procedure and on different possibilities: • general screening if an EIA is necessary for a project (§3a) • screening through individual preliminary examination (§3c) • screening for projects with research or trial character of maximum two years (§3f) • list of projects with mandatory EIAs due to criteria on type, size and/or capacity included in Annex I (§3b) • necessity to conduct an EIA in case a project, which was approved with a mandatory EIA, is expanded (§3e)	EIA (2011) Annexes I and II
§4	*"This law is applied, if legal regulations of the Federation or the Federal States do no specify the environmental assessment or if the regulations do not correspond this law. Legal regulations with advanced requirements stay untouched."*	/
§5	Instruction of the developer on prospectively required documents • the developer of a project may in advance of any procedure ask the competent authority for consulting, especially regarding the prospectively required documents according to § 6. (1) • the competent authority offers a review on the scope and content of the required documents with both the developer as well as other authorities according to § 7. (1) • the competent authority may moreover offer consulting to the developer beyond the above mentioned review, if appropriate for the process.	/
§6	Contents of the documents on the project, to be supplied by the developer. § 6(3) • *a description of the project comprising information on the site, design and size of the project, as well as demand of ground; (1)* • *a description of the measures envisaged in order to avoid, reduce and, if possible, remedy significant adverse effects, as well as compensating measures in case of prior interference with nature which cannot be remedied; (2)* • *an overview on the expected adverse effects on the environment with respect to common level of knowledge and approved inspection method; (3)* • *a description of the environment and its components within the scope of the project, as well as information on the population in the project's scope as far as essential and appropriate towards the developer; (4)* • *an outline of the main alternatives studied by the developer and an indication of*	EIA 2011 Art. 5

	the main reasons for his choice, taking into account the environmental effects; • *a non-technical summary of the information.* § 6(4) • *description of the most important characteristics of the applied technical procedures;* • *description of the type and scope of expectable emissions, waste, ratio of waste water, the usage and design of water, soil, nature and landscape as well as other consequences of the project which may have adverse environmental impacts;* • *references to problems, which may have occurred during gathering of these information, e.g. technical gaps or lack of knowledge;*	
§7	Participation procedures for other authorities • the competent authority informs other authorities with environment-related field of responsibilities and supplies them with the information according to § 6.	EIA 2014 Art. 6
§8	Transboundary information and consultation of authorities • in case that the scope of the project touches protected goods in another Member State or that another Member States asks for it, appropriate information need to be provided. The consultation time frame of the consulted authorities is to be determined. In case participation is found appropriate, the authorities of the affected Member State has to be provided with all information according to § 6. (1) • the decision on the approval or refusal of the project shall be provided, including the reasoning. (3)	EIA 2014 Art. 7
§9 (1-3)	Participation of the public • the public is to be informed on the environmental effects of the project and sufficient time shall be given to the concerned public in order to participate in the decision-making process; • in case the submitted documents according to § 6 change during the process, but no additional or other severe environmental effects arise, public participation may be abstained from. (1) • The following information shall be provided to the public: o *the request for development consent;* o *the fact that the project is subject to an EIA procedure according to § 3a and, where relevant, that Articles 8 and 9a apply;* o *details on the competent authorities responsible for taking the decision, those from which information can be obtained, those to which comments or questions can be submitted, and details of the time schedule for transmitting comments or questions;* o *the nature of possible decision ~~or, where there is one, the draft decision~~;* o *an indication on which information have been submitted pursuant to Article 6;* o *an indication of the times and places at which, and the means by which, the relevant information will be made available;* o *further details of the arrangements for public participation. (1a)* • at least the following documents need to be made available to the public: o *any information gathered pursuant to Article 6;* o *the main reports and advice issued to the competent authority or authorities at the time when the public concerned is informed. (1b)* In preliminary public participation the public shall to be informed that: • the procedure will be made public according to § 9(1a); • according to § 9(1b) the required documents are open for searching within an appropriate time frame; • the concerned public will have the opportunity to participate; • the public will be informed on the decision, including the content and explanation to the decision. (3)	EIA 2014 Art. 6
§9a	In case a project might have significant environmental effects on another Member State, the public in that state should get the opportunity to participate in the process according to § 9 (1-1b) or (3). The competent authority should work towards: • announcing the project in the other Member State; • a clarification on which authority and in which form the public may submit statements; • it is clarified that any statement submitted after a certain time frame cannot be considered; • that the decision on the approval or refusal of the project will be made public to the concerned public and that both content and explanation are made available. (1)	EIA 2011 Art. 7

§9b (1-3)	In case of a project in another Member State that has significant effects on Germany, the competent German authority beseechs the other state for information on the project, especially a description of the project and the transboundary environmental effects. If transboundary participation is appropriate, the competent authority beseechs the other state for participation and communicates time frames.	/
§10	*"Legal regulations on secrecy and data security (privacy) remain untouched."*	/
§11	Comprising illustration of environmental effects • the competent authority considers the consultations and all information gathered (pursuant to §§6-8 and §§9 and 9a) in the development consent procedure.	EIA 2011 & 2014 Art. 8
§12	Assessment of environmental effects and consideration of the result in the decision • the competent authority assesses the environmental effects of the projects according to the illustration from § 11 and considers the assessment in the final decision.	EIA 2014 Art. 8a
§13	Preliminary notices and/or partial license are only to be approved after the environmental impact assessment, which shall focus on the recognizable environmental effects at that level of planning process.	/
§14	In case the project needs the approval from several federal state authorities, the federal state authorities shall nominate one leading authority for §§ 3a, 5, 8(1, 3), 9 and 11. Further responsibilities according to §§ 6,7 and 9 may be assigned to that authority.	/
§14a (1-2)	The competent authority shall screen if there is a necessity for a SEA. (1) The screening result is to be made available to the public. In case the SEA is not necessary, the main reasons are to be made public. (2)	SEA 2001 Art. 3
§14b (1-4)	A SEA is mandatory for plans and programs according to Annex III No. 1 and 2. (1) Other plans and programs only require a SEA if they form the framework for projects according to Annex I and which are likely to have significant environmental effects (to be estimated in a preliminary examination). (2) If a preliminary examination is required, the criteria attached in Annex IV are to be used. Authorities mentioned in § 14h are to be included in the preliminary examination process. (4)	SEA 2001 Art. 3
§14c	A SEA is mandatory in case an assessment is required according to the § 36 Federal Nature Conservation Act (*Bundesnaturschutzgesetz,* BNatSchG).	/
§14d	In case of minor changes in plans and programs, a SEA is only required if a preliminary examination reveals possible significant environmental effects. §§ 13 and 13a BauGB and § 9(2) ROG stay untouched.	SEA 2001 Art. 3(3)
§14e	*"This law is to be applied, if legal regulations of the Federation or the Federal States do no specify the SEA or if the regulations do not correspond this law. Legal regulations with advanced requirements stay untouched."*	/
§14f (1-4)	• The competent authority determines the scope of SEA, including the environmental report. (1) • The environmental report shall contain information to be gathered with appropriate effort, regards the state of knowledge, […] content and detail of the plan or program as well as its position in the decision process. (2) • In case of a multistage planning and approval process, multiple examinations shall be prevented. For subsequent examinations, SEA shall concentrate on additional or other significant environmental effects as well as on required updating. (3) • Other authorities touched by the plan or program are to be included in the process of determining the scope of the environmental report. The competent authority offers a review on the scope and content of the required documents with other authorities. (4)	SEA 2001 Art. 5

§14g (1-4)	The competent authority creates an environmental report early in the process. Therein, probable significant environmental effect due to the implementation of a plan or program are described and reasonable alternatives identified, described and assessed. (1) The environmental report should at least provide the following information: • *an outline of the contents, main objectives of the plan or program and relationship with other relevant plans and programs;* • *the aims of environmental protection applying to the plan or program as well as an acknowledgement on how these aims were regarded;* • *the relevant aspects of the current state of the environment and the likely evolution thereof without implementation of the plan or program;* • *any existing environmental problems which are relevant to the plan or program […];* • *the environmental characteristics of areas likely to be significantly affected;* • *the measures envisaged to prevent, reduce and as fully as possible offset any significant adverse effects on the environment of implementing the plan or program;* • *an outline of the reasons for selecting the alternatives dealt with, and a description of how the assessment was undertaken including any difficulties (such as technical deficiencies or lack of know-how) encountered in compiling the required information;* • *a description of the measures envisaged concerning monitoring;* • *a non-technical summary of the information provided under the above headings. (2)*	SEA 2001 Art. 3(1), 5
§14h	Information and consultation procedures for authorities with environmental responsibilities: they receive the draft plan or program as well as the environmental report in an early stage, so that an effective opportunity within an appropriate time frame (of at least one month) is given to express their opinion.	SEA 2001 Art. 6
§14i (1-3)	• Regarding public participation, § 9(1-1b) apply. (1) • The draft plan or program, as well as the environmental report and other relevant documents are to be made publically available in an early stage and for at least one month. (2) • The concerned public may vent the draft plan or program and environmental report. A suitable time frame of at least one month is to be set by the competent authority. (3)	SEA 2001 Art. 6
§14j (1-3)	• For transboundary participation of authorities § 8 applies. Regarding the information of authorities in another Member State, a copy of the draft plan or program as well as the environmental report has to be supplied. The competent authority determines an appropriate time frame for consultation. In case of approval of the plan or program, the competent authority informs the authority in the other Member State and provides the information according to § 14l. (1) • For transboundary participation of the public in another Member State, § 9a applies. The public of the other Member State may participate in the process according to § 14i. (2) • For the participation of German authorities and the public in case of a plan or program in another Member State with potential significant effects on Germany, § 9b applies. (3)	SEA 2001 Art. 7
§14k (1-2)	• Consideration of the environmental report, the national and transboundary consultations and all information gathered (pursuant to §§14h-j) in the preparation of the plan or program. (1) • The result of the SEA is to be considered in the adoption or adjustment of a plan or program. (2)	SEA 2001 Art. 8
§14l (1-2)	Information of the authorities, the public and any Member State consulted is necessary if the plan or program is adopted. A refusal may be made public. (1) The following information need to be made available in case of an adoption: • *information that the plan or program is adopted;* • *a statement summarizing how environmental considerations have been integrated into the plan or program and how the environmental report prepared, the opinions expressed and the results of consultations entered into have been taken into account and the reasons for choosing the plan or program as adopted, in the light of the other reasonable alternatives dealt with;* • *the measures decided concerning monitoring according to § 14m.*	SEA 2001 Art. 9
§14m (1-5)	• Monitoring of significant environmental effects of the implementation of plans and programs in order to identify at an early stage unforeseen adverse effects, and to be able to undertake appropriate remedial action. Monitoring measures are to be included in the environmental report. (1) • if not arranged differently according to legal regulations of the Federation or the	SEA 2001 Art. 10

	Federal States, the monitoring is task of the authority competent for SEA. (2) • Other authorities shall receive all environmental information, if requested. (3) • Monitoring results are to be made available for the public according to the regulations of the Federation or the Federal States via the gateway on environmental information and to be considered in case of amendments of a plan or program. (4) • Established mechanisms of monitoring as well as data and information resources may be used for fulfilling § 14m(1). (5)	
§14n	The SEA may be combined with other examinations on the investigation or assessments of environmental effects.	SEA 2001 Art. 4(3)
§16	Spatial structure plans, regional planning procedures: • the ROG or either federal state law contains the specific procedures for EIA in case of projects under the *Raumordnungsverfahren* ('regional planning procedure') (§15(1) ROG) (1) • the environmental assessment <u>may</u> be restricted to additional or severe environmental effects for subsequent approval procedures (2) • In case SEA is mandatory for a spatial structure plan, both environmental assessment and monitoring are conducted according to ROG (4)	/
§17	Establishment of land-use plans • in case land-use plans are implemented, amended or complemented, the environmental assessment takes place according to the BauGB. Furthermore, there is no need for a SEA in case the environmental assessment according to BauGB fulfills all requirements of a SEA according to UVPG. (1) • in case a SEA is mandatory for a land-use plan, both environmental assessment and monitoring are conducted according to BauGB (2) • the environmental assessment <u>shall</u> be restricted to additional or severe environmental effects for subsequent approval procedures (3)	/

Source: own depiction following UVPG §§3-14 and §§16-17.

There are some special characteristics about the German implementation of the EIA and SEA directive. Besides that they are jointly implemented in one law (UVPG), as can be seen in §§ 16-17 UVPG the planning laws ROG and BauGB contain environmental assessment paragraphs which have priority regarding environmental assessment of spatial planning documents. The reason for this special characteristic is that, historically, the German legislative had already made particular land-use plans subject to environmental assessment procedures before the EU SEA Directive was implemented. The inducement was the consideration that environmental effects of a project are mainly dependent on a project's location and that the decision on potential locations for projects (with possible environmental effects) should be taken on the level of plans and not on the (subsequent) level of individual projects. Therefore, the German legislative secured the opportunity to assess potential environmental effects by finding the most suitable location for potentially hazardous projects even before any discussion on the realization of concrete individual projects within EIA procedures.

Therefore, special attention needs to be drawn to the Federal Spatial Planning Act (ROG) and the Federal Building Act (BauGB) and the therein-anchored paragraphs on environmental assessment (see following subchapters).

Environmental Assessment according to Federal Spatial Planning Act

The ROG contains two paragraphs particularly relevant for environmental assessment, § 9 on environmental assessment for spatial structure plans (*Raumordnungspläne*) and § 15 on regional planning procedures (*Raumordnungsverfahren*). The major difference between §§ 9 and 15 is that § 9 applies to plans and programs and therefore is within the scope of SEA, while § 15 applies to individual project and covers the scope of EIA.
In the following, both articles are translated and interpreted.

§ 9 ROG on Environmental Assessment

(1) When establishing spatial structure plans according to § 8 ROG an environmental assessment needs to be conducted by the competent authority, identifying the expected significant effects of the spatial structure plan on

- *humans, including human health, animals, plants and biologic diversity,*
- *soil, water, air, climate and landscape,*
- *cultural heritage and other material goods, as well as*
- *the interaction between the aforementioned protective goods*

and describing and assessing these effects in an environmental report; the environmental report contains information according to Annex I.
The scope of investigation of the environmental assessment […] and the environmental report is to be determined; public authorities touched by the environmental effects of a spatial structure plan in their environmental or health-related field of responsibility are to be involved. The environmental assessment relates to the contemporary state of knowledge and generally accepted inspection methods being appropriate proportionally to the content and level of detail of the spatial structure plan.

(2) In case of marginal changes of spatial structure plans, it may be abstained from an environmental assessment, as far as an approximate examination with respects to the criteria anchored in Annex II determined that there presumably are no significant effects on the environment. This examination is to be conducted under participation of the public authorities touched by the environmental effects of a spatial structure plan in their field of responsibility. If it is determined that there are no significant environmental effects to be expected, the considerations leading to this result are to be incorporated in the reasoning of the plan.

(3) The environmental assessment while the establishment of a spatial structure plan shall be restricted to the additional or other significant environmental effects, if other plans or programs that already were subject to an environmental assessment according to Annex I embrace parts of or the whole planning area. The environmental assessment may be combined with other examinations on the identification or assessment of environmental effects.

(4) The significant environmental effects due to the implementation of the spatial structure plans are to be monitored by the competent authority according to the Federal State planning laws […] on the basis of monitoring measures anchored in the comprising explanation according to § 11(3) ROG; especially in order to investigate unexpected adverse effects in an early stage and to be able to adopt relief measures. Public authorities touched in their fields of responsibility inform the competent authority according to sentence 1, if, according to their insights the implementation of a spatial structure plan has significant, especially unexpected adverse effects on the environment.

§ 9 ROG show many similarities with both the EU SEA Directive as well as the German UVPG. The listed protective goods as in (1) are the exact same as in the UVPG and the necessity for an environmental report is also included as in both SEA Directive and UVPG. One major difference is, that the contents to be included in the environmental report are anchored in the Annex of the ROG but are directly mentioned in § 14g UVPG. However, Annex I of § 14g UVPG are very similar in their content.

Furthermore, the information, consultation and participation of other relevant authorities are stated in § 9(2 and 4) ROG. In comparison to the EIA Directive and the UVPG, the explanations on participation processes are rather unspecific, though, and no concrete time frames are mentioned. Also public and transboundary information, consultation and participation are not included in the ROG.

Another similarity between the ROG and the UVPG is that marginal changes of the spatial structure plans do not require a separate environmental assessment if no further significant effects on the environment are to be expected. § 9 ROG also addresses the monitoring of spatial structure plans similar to § 14m UVPG but less detailed. One major difference is, that monitoring measures are not be described in the environmental report, as designated in the UVPG, but are rather to be developed for every individual spatial structure plan.

§ 15 on Regional Planning Procedures (*Raumordnungsverfahren*)

(1) The regional planning authority of every Federal State examines in a special procedure the spatial compatibility of plans and measures relevant to regional planning according to § 1 Regional Planning Act. Herein, spatially relevant effects of plans or measures are to be examined under regional criteria; especially die cohesion with the requirements of the regional planning are to be investigated. […] The conduction of a regional planning procedure may be abstained from, if the examination of the spatial compatibility is secured otherwise.

(2) The developer of a spatially relevant plan or measure supplies the regional planning authority with all documents on the procedure, which are necessary for an assessment of the spatially significant effects of the project. In case of spatially relevant plans and measures of defense, the Federal Ministry of Defense […] decides; in case of spatially relevant plans and measures of civil protection, the competent authority decides on the nature and scope of information on the plan or measure.

(3) Public authorities touched in their field of responsibility are to be involved. In case of spatially relevant plans and measures, which may have significant effects on other Member State, participation procedures are to be conducted according to the Regional Planning Act, basing on the principles of reciprocity and equality. The public can be involved in the conduction of a regional planning procedure. In case of spatially relevant plans and measures according to (2) sentence 2, the decision on the scope of public participation is to be taken together with the therein-mentioned authorities.

(4) The decision on the necessity of a regional planning procedure is to be taken within a period of four weeks after the submission of the requited documents. The regional planning procedure is to be completed within six month after the submission of the required documents.

(5) In case of spatially relevant plans and measures of Federal authorities or other public authorities on behalf of the Federation as well as of legal persons under private law according to § 5(1) ROG it is to be decided on the introduction of a regional planning procedure after consultation with the relevant authority or person.

(6) The obligation of conducting regional planning procedures does not apply for the Federal States Berlin, Bremen and Hamburg. In case these Federal States create legal regulations on regional planning procedures, either solely or together with other Federal States, paragraphs 1-5 apply.

§ 15 contains several aspects of EIA but solely refers to projects, measures or plans, which are spatially relevant. Instead of naming requirements for an environmental impact assessment comparable to § 5 EIA Directive 2014, no specific requirements are anchored in the ROG. The scope of information is rather up to the competent authorities and to be decided within the Regional Planning Acts (cf. § 15(1-2) ROG). Compared to § 9 ROG this article instead includes both detailed participation procedures (authorities, public, transboundary) and gives concrete time schedules for conduction the regional planning procedure (cf. § 15(3-4) ROG).

Environmental Assessment according Federal Building Act

As stated in § 17 UVPG, environmental assessment for land-use plans is conducted according to the Federal Building Act (BauGB) and so is the monitoring (cf. § 17(1-2) UVPG). The following articles of BauGB are relevant for environmental assessment:

- § 1 (6) No. 7 BauGB on protective goods
- § 1a BauGB on further regulations on environmental protection
- § 2 (4) BauGB on environmental assessment and environmental report
- § 2a BauGB on reasoning for the land-use plan draft and environmental report

- § 3 BauGB, especially § 3(2) on public participation
- § 4(1) BauGB on participation of authorities
- § 4a(5) on Transboundary information and consultation
- § 4c on Monitoring

According to § 1 (6) No. 7 BauGB, the interests of environmental protection, including nature protection and landscape preservation, are to be considered whenever developing a land-use plan. The following concerns are especially to be regarded:

a) effects on animals, plants, soil, water, air, climate and their connection as well as landscape an biological diversity;
b) the aims of preservation and protection of Natura 2000 areas according to the BNatschG;
c) environment-related effects on humans and human health as well as on population;
d) environment-related effects on cultural heritage and other material goods
e) the prevention of emissions and an appropriate dealing with waste and waste water;
f) the utilization of renewable energies as well as a saving dealing with energy;
g) the illustration of landscape plans as well as other plans, especially according to water, waste and emission control laws
h) the preservation of optimal air quality in areas in which […] emission control thresholds shall not be exceeded
i) the interactions between the interests of environmental protection according to a, c and d.

The supplementary regulations on environmental protection according to § 1a are as follows:

(1) When establishing land-use plans, the following regulations on environmental protection are to be applied.
(2) land shall be used sparsely and with due consideration; in order to reduce additional land consumption, rehabilitation of land, condensation and other measures of inner development are to be used and sealing to be restricted to an indispensable measure. […]
(3) The prevention and compensation of potential significant effects on the landscape as well as the productivity and viability of the ecosystem in its components according to § 1(6) Nr. 7a are to be considered in the weighting. […]
(4) In case an area might possibly be significantly affected in its components according to § 1(6) Nr. 7b, the regulations of the BNatsSchG on the legitimacy and conduction of such interventions is to be applied.
(5) The requirements of climate protection are to be considered with measures counteracting climate change as well as measures serving climate change adaptation.

Environmental protection and assessment measures are also included in § 2 BauGB on the establishment of land-use plans. According to paragraph 4, the concerns of environmental protection according to § 1(6) No. 7 and § 1a are to be considered by conducting an environmental assessment and an environmental report. Detailed regulations are to be found in Annex I of BauGB. The scope of the environmental assessment shall be chosen according to the contemporary state of knowledge and generally accepted inspection methods being appropriate proportionally to the content and level of detail of the land-use plan. In § 2a it is furthermore specified that an environmental report according to Annex I BauGB shall identify and assess the interest of environmental protection as a separate part of the reasoning. (Cf. §§2-2a BauGB)

Further relevant articles are § 3 on public participation, § 4 on participation of authorities and public agencies and § 4a on transboundary participation. In all three cases of participation, not only the draft land-use plans but also a (preliminary) report on the environmental situation needs to be provided. Similar to the SEA Directive and the German UVPG the public, other authorities and third country public and authorities are given the opportunity to comment on the draft plan and the (preliminary) environmental report. Furthermore, for transboundary information and consultation, the UVPG shall be considered. (Cf. § 3(2), § 4(1), § 4a(5) BauGB)

Regarding the monitoring of significant environmental effects, § 4c states: *The municipalities monitor the significant environmental effects, which occur due to the implementation of land-use plans, in order to investigate unexpected adverse effects in an early stage and to be able to adopt relief measures. For this purpose, the environmental report and the measures for monitoring shall be used according to Annex I No. 3b BauGB […].*

So far, this chapter presented how the EU Directives are implemented in German law (via the UVPG) and how closely environmental assessment and spatial planning are interwoven, both in environmental and planning law and procedures. The following subchapters address the specific national situations in Slovenia (see chapter 3.2) and Croatia (see chapter 3.3).

The overall research question (*is spatial planning capable of reducing vulnerability through environmental assessment?)* will subsequently be investigated in the chapter 4.

3.2. Spatial Planning and Environmental Assessment in Slovenia

3.2.1. The Slovenian Spatial Planning System

Spatial planning in Slovenia has a long tradition with legal basis in year 1967. Spatial planning is implemented on national and local level with integral approach to all levels.

In Slovenia, the state has the authority to:
- monitor the legality of spatial planning activities at lower levels,
- conduct and implement land policy,
- maintain the spatial data system,
- develop and encourage professional work in spatial planning and to
- participate in matters of spatial planning and management at the international level.

The Ministry of the Environment and Spatial Planning of the Republic of Slovenia has the authorities (among others) to:
- oversight the preparation of Municipal Spatial Plans and determines references and guidelines for planning local spatial arrangements;
- coordinate the preparation of National Spatial Plans (NSP) for spatial arrangements of national significance;
- issue building permits for structures of national importance.

Framework for Preparation of Spatial Plans

On the **national level** the state prepares laws, policies and other instruments in the field of spatial planning. They define the spatial planning system and provide strategic spatial development objectives and guidelines. In addition to the spatial development laws and strategic documents, the state also has the authority to perform measures concerning spatial development activities and construction, which are of national significance. Spatial planning documents in Slovenia are:
- Spatial Development Strategy of Slovenia and Spatial Order of Slovenia (2004);
- The Act Regarding the Siting of Spatial Arrangements of National Significance in Physical Space (ZUPUDPP), October 2010;
- Main difference from ZPNačrt: inclusion of EIA in NSP preparation;
- Spatial Arrangements of National Significance;
- National Spatial Plan (NSP).

The National Spatial Plan (NSP) is a spatial planning document with which the spatial arrangements of national significance are planned. The NSP is the basis for the preparation of designs for the obtaining of a building permit (in accordance with Building Construction and Civil Engineering Act – ZGO-1). EU Strategic Environmental Assessment (SEA) and Environmental Impact Assessment (EIA) procedures (if necessary) are carried out together with the NSP (Regular Preparation Procedure). SEA and EIA procedures, if not specified otherwise by ZUPUDPP, are carried out in accordance with Environmental Protection Act (ZVO-1) and Nature Conservation Act (ZON). Spatial arrangements of national significance are road, railway, air transport, maritime and river transport infrastructure, border crossings and transport terminals, energy industry infrastructure for electricity, natural gas and oil supply, nuclear facilities and mining, public and state authorities' communication network, environment protection meteorology and water infrastructure, defense of the state and protection against natural and other disasters, spatial arrangements in the area of marine water land, spatial arrangements in the protected areas for nature conservation and of cultural monuments.

On the **local level**, local communities have the original right to spatial management and planning of their territories, with exception of spatial development activities which are under direct jurisdiction of the state. A local community is obliged to perform activities in the field of spatial planning and management, as well as planning pursuant to the adopted laws, standards, and criteria. Their principal task in connection with spatial management and planning is concern for rational, mixed, and sustainable land use, as well as economical use of land plots in accordance with the principles of high quality living, working, recreation, and a healthy environment. In decision-making procedures, they are responsible for the direct participation of all the involved and interested parties. They also care for and maintain the identity of the community by considering and protecting the natural and built characteristic features.
Spatial planning documents on the local level are:

- Spatial Planning Act (ZPNačrt), April 2007;
- Spatial Arrangements of Local Importance;
- Municipal Spatial Plans (MSP),
- Municipal Detailed Spatial Plans (MDSP).

A municipal spatial plan (MSP) is a spatial planning document which determines the objectives and references of spatial development of a municipality, plans spatial arrangements of local importance and determines the conditions for the placement of structures into physical space; it contains the strategic and operational part. A MSP is a basis for the preparation of a project for the acquisition of a building permit under regulations on construction (ZGO-1). Only SEA procedure (if necessary) is carried out together with the MSP. If EIA procedure is needed, it is carried out after adoption of the MSP.

3.2.2. Laws and Regulations on Environmental Assessment in Slovenia

As written on the website of the Ministry of the Environment and Spatial Planning, to realize the principles of sustainable development, integrity, prevention and cooperation, the Environmental Protection Act defines procedures under which the impacts of plans and activities affecting the environment in Slovenia and neighboring countries or other EU Member States and parties to the Protocol on Strategic Environmental Assessment (SEA) to the Convention on Environmental Impact Assessment (EIA) in a Transboundary Context are examined.[5]

The Environmental Protection Act lies down that the following assessments should be carried out for plans and activities affecting the environment that can have a significant impact on the environment:

[5] http://www.mop.gov.si/en/areas_of_work/environmental_impact_assessments/

- comprehensive environmental impact assessments, which is based on SEA,
- environmental impact assessments, which is based on EIA and
- environmental impact assessments in a transboundary context for plans with transboundary impact.

Comprehensive environmental impact assessments

A comprehensive environmental impact assessment was on the territory of the European Union introduced in 2001 by Strategic Environmental Impact Assessment Directive 2001/42/EC and was transferred into Slovenian legislation with the Environmental Protection Act 2004.

Determination of whether plans could have a significant impact on the environment is governed, in particular, by the provisions of the Decree on categories of projects for which an environmental impact assessment is mandatory (Uradni list RS (Official Gazette of the Republic of Slovenia), Nos. 78/06 and 72/07, 32/09), defining the types of activities affecting the environment for which environmental protection assessment is mandatory and the types of activities affecting the environment for which environmental protection assessment is mandatory above the specific threshold.

Protected areas for which the effects of the plans are to be assessed are protected areas according to regulations related to nature conservation, including protection in national, regional and landscape parks, strict nature reserves, nature reserves and natural monuments along with all acts designating natural sites of special interest still in force. Moreover, protected areas also include Natura 2000 sites, including special protection areas and special areas of conservation stipulated in the Decree on special protection areas (Natura 2000 sites) (Uradni list RS, Nos. 49/04, 110/04, 59/07 and 43/08).

The objective of a comprehensive environmental impact assessment is to prevent or at least to considerably reduce activities that may have important harmful effects or consequences on the environment and protected areas, thus realizing the principles of sustainable development, integrity and prevention.

The procedure for a comprehensive environmental impact assessment is defined in the Environmental Protection Act and is carried out for plans provided that:
- they define or envisage an activity affecting the environment for which an environmental impact assessment needs to be carried out;
- assessment of the acceptability of impacts on the protected areas according to the regulations governing nature conservation is required;
- the responsible ministry estimates that their implementation could have an important effect on the environment.

In the procedure for comprehensive environmental impact assessment, the effects of the plan are evaluated on the basis of the environmental report. The procedure is conducted by the ministry responsible for the environment. It also includes cooperation between all national authorities within their ministries and organizations, as well as public information and participation. The participation of the public is governed by the Environmental Protection Act, which lays down a 30-day public presentation of the environmental report.

National authorities and local communities must, prior to the preparation of the plan and in the specified manner, inform the ministry responsible for the environment thereof. Non-compliance with legal obligations may result in invalidity of plans.

Environmental impact assessment

Environmental impact assessment is carried out for activities that may have a considerable impact on the environment. Based on the environmental impact assessment carried out, the competent authority issues environmental protection consent. The procedure for environmental protection assessment and the issue of environmental protection consent is laid down in the Environmental Protection Act and is conducted by the Environmental Agency of the Republic of Slovenia.

The Environmental Protection Act transposes the provisions of Directive 2011/92/EU into the Slovenian legislation, especially in Articles 50, 51 and 51a. The Environmental Protection Act specifies that prior to the implementation of interventions which can have a significant impact on the environment next procedures must be carried out:

- Environmental impact assessments or
- Preliminary procedures for determining whether an intervention in the environment has a significant environmental impact or not. If the impact is significant then it is necessary to carry out an environmental impact assessment and obtain an environmental consent.

Types of intervention in the environment for which an assessment of the impact on the environment or the preliminary procedure laid down is required, is regulated by the Decree on activities which are subject to an environmental impact assessment (Uradni list RS, št. 51/14 in 57/15).
The Decree replaces Decree already established, for which the European Commission in infringement procedure against the Republic of Slovenia No. 2012/2162 concluded that it is not fully compliant with all the provisions of Directive 2011/92/EU and Annexes I, II and III of this Directive and legal practice, because it omits the preliminary procedure and the thresholds are too high. The newest Decree eliminates the finding of infringement of the European Commission and enables a complete transfer of the provisions of Directive 2011/92/EU into Slovenian territory. At the same time the decree is important to reduce the environmental load and integration of the environment in various development areas, such as agriculture, mining, manufacturing, energy, environmental infrastructure, transport infrastructure, urban planning and construction, tourism, sport and recreation. By adopting the decree from 4th July 2014, the government edited the alleged violation of the European Commission and prevented the formation of new violations. Furthermore, it enabled easier absorption of EU funds in the new financial perspective for possible project applicants, who will have to perform an environmental impact assessment or preliminary procedure, as this is a prerequisite for the absorption of European funds (Ex-ante conditionality).

The procedures of environmental impact assessment and preliminary procedures are implemented by the Environmental Agency of the Republic of Slovenia.[6]

[6] Adapted from: http://www.mop.gov.si/si/delovna_podrocja/presoje_vplivov_na_okolje/presoja_vplivov_na_okolje/

Environmental impact assessment in a transboundary context

The procedure for assessing transboundary impact on the environment are carried out for plans, programs and projects that could have a significant impact on the environment in neighboring countries or other EU Member States and contracting parties to the Protocol on Strategic Environmental Assessment (SEA) to the Convention on Environmental Impact Assessment (EIA) in a Transboundary Context.

Transboundary assessments are carried out for:

- plans in the context of a comprehensive environmental impact assessment (according to SEA);
- programs in the context of a comprehensive environmental impact assessment (according to SEA);
- projects in the context of an environmental impact assessment (according to EIA);
- equipment and installations within the process of obtaining environmental permits.

The process of transboundary assessment is carried out for plans or projects in other countries, if they could have significant cross-border effects within the territory of the Republic of Slovenia:

- Slovenian public can get involved if neighbor country informs RS about transboundary effects or if RS requests the process of environmental impact assessment or strategic assessment process, which takes place in another country. The material is put up for discussion for at least 30 days, in which the Slovenian public can comment and express opinion.
- The opinion on the plan or project is finalized and prepared by the Ministry of the environment and forwarded to the competent authority of another country.[7]

Environmental Assessment in Spatial Planning Law

With Spatial Planning Act, in the law of Republic Slovenia, the requirements of Directive 2001/42/EC, relating the obligation to ensure the quality of environmental reports, are transferred.
Stated act, in Article 3 specifies that the objective of spatial planning is to enable a coherent spatial development by addressing and coordinating the various needs and interests of the development of public benefit in the fields of environmental protection, nature conservation and cultural heritage, protection of natural resources, defense and protection against natural and other disasters. Further it is defined that interventions in space and spatial arrangements should be designed so that, among other things, it offers protection against natural and other disasters.

Spatial planning takes place at the state and municipal level, whereby responsibility of the state and municipalities and procedures for adopting, are defined in the second chapter (articles 11-69).

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[7] Adapted from: http://www.mop.gov.si/si/delovna_podrocja/presoje_vplivov_na_okolje/cezmejna_presoja_vplivov_na_okolje/

The state has jurisdiction over:
1. determining the objectives of the spatial development of the country,
2. the definition of starting points, guidelines and rules for spatial development planning at all levels,
3. planning of spatial arrangements of national significance,
4. participation in drafting the municipal and inter-municipal spatial planning documents and
5. to review the legality of spatial planning at the municipal level.

The municipality has jurisdiction over:
1. determining the objectives and guidelines for spatial development of the municipality,
2. determine the land use and the conditions for the placement of spatial development;
3. planning of spatial arrangements of local importance.

Institutions performing spatial planning in the preparation of inter-municipal and municipal spatial acts participate so that on the basis of their development policies, strategies and programs, in accordance with sectoral laws, those drafting the spatial documents at their request:
- submit their development needs relating to space;
- provide expert basis for developmental needs for spatial planning documents from their scope of work;
- provide all available information relating to the space, as well as possible guidance, recommendations and explanations of their work areas.

Institutions performing spatial planning, participate in the preparation of spatial planning documents also by issuing guidelines and opinions to the inter-communal and municipal spatial acts.

The spatial arrangements are planned with the spatial planning documents. The spatial planning documents determine policies for interventions in the environment, the range of possible interventions in space and the conditions and criteria for their implementation.
Spatial planning documents are national/state, municipal and inter-municipal spatial planning acts.
State spatial planning documents are State strategic plan and State spatial plan.
Municipal spatial planning documents are municipal spatial plan and detailed municipal spatial plan. Inter-municipal spatial planning document is regional spatial plan.

For spatial planning documents under Spatial Planning Act, except for the national strategic plan, is required to carry out a procedure of comprehensive environmental impact assessment in accordance with the provisions of stated Act and the provisions of the law governing the protection of the environment, whereby the revision of the environmental report is not needed.

In the process of drafting national strategic spatial plan, a draft shall be prepared and the ministry responsible for the environment shall also ensure preparation of a report on the impact of the implementation of this plan.
The report on the impact shall describe and evaluate the impacts of the national strategic spatial plan on economic and social development of the country and achieve

environmental objectives, in extent that it relates to the environmental aspect, contains a description and evaluation of the effects of the implementation of the national strategic spatial plan to achieve environmental objectives, in accordance with the Law on Environmental Protection.
To the draft the ministries and municipalities may submit proposals in and comments. After consideration of proposals in and comments a final proposal is prepared. The national strategic spatial plan is adopted by the National Assembly of the Republic of Slovenia on the proposal of the government by decree.

The process for the preparation of the municipal spatial plan starts with the publication of the Mayor's decision in the official gazette and the World Wide Web, and with it being sent to the Ministry and neighboring municipalities. The municipality prepares a draft of the municipal spatial plan and sends it to the Ministry, together with the status display of space. The municipality invites the holders of spatial planning to submit a first opinion to the planned spatial arrangements. The competent spatial planning stakeholders, in accordance with regulations governing the protection of the environment, participate in the process of a comprehensive environmental impact assessment. In the first opinion they give their evaluation on the likelihood of significant impacts of municipal spatial plan on the environment as regards their competence.
The ministry responsible for environmental protection, in accordance with the law governing the protection of the environment, on the basis of the municipality's application and attached opinions, in writing communicate to municipality whether for municipal spatial plan should be carried out a comprehensive environmental impact assessment.
When for the municipal spatial plan should be carried out a comprehensive environmental impact assessment, the municipality ensures environmental report.
In the process of drafting municipal spatial plan municipality must enable public participation.
Having regard to the views on the comments and suggestions of the public, a municipal spatial plan proposal is prepared. If for the municipal spatial plan a comprehensive environmental impact assessment must be carry out, a municipality attach to that proposal an environmental report.

Detailed requirements of the Directives are regulated under the provisions of the following Decrees:

- Decree on criteria for determining the likely significance of environmental effects of certain plans, programmes or other acts and its modifications in the environmental assessment procedure (Uradni list RS, št. 9/09)
- Decree on environmental encroachments that require environmental impact assessments (Uradni list RS, št. 51/14, 57/15)
- Decree laying down the content of environmental report and on detailed procedure for the assessment of the effects on certain plans and programmes on the environment and (Uradni list RS, št. 73/05)

In spatial planning decisions in practice, it is necessary to follow the requirements set out in Decree on protective forests and forests with a special purpose (Uradni list RS, št. 88/05, 56/07, 29/09, 91/10, 1/13 in 39/15).

When preparing project documentation, for the calculation of statics of objects, the European Standards: SIST EN 1991-1-4 is used; therein is a special section devoted the impact of wind on structures.

By the planning of roads, buildings etc. which are built in areas where strong winds are present, conceptual design (idejna zasnova) and conceptual project (idejni project) against the wind are made.

Municipality Ajdovščina, in the issued location information indicates also the wind speed for the plot on which the information relates.

It can be concluded that in Slovenia, comprehensive environmental impact assessment is required for any municipal spatial plan, according to the Spatial Planning Act. In several decrees it is ensured that both EIA and SEA are implemented and conducted according to the EU Directives.
Unlike in Germany, in Slovenia the influence of environmental protection on spatial planning seems to be greater than vice versa. This circumstance shall be further interpreted in chapter 4.

The following subchapter addresses the specific national situations in and Croatia (see chapter 3.3).

The overall research question (*is spatial planning capable of reducing vulnerability through environmental assessment?)* will subsequently be investigated in the chapter 4.

3.3. Spatial Planning and Environmental Assessment in Croatia

3.3.1. The Croatian Spatial Planning System

The Croatian spatial planning system stems from the same branch as the Slovenian spatial planning system, as the countries were joined in the state of Yugoslavia when spatial planning regulations were first developed. The Croatian spatial planning system is therefore very similar to Slovenia's with some differences due to territorial and political specifications.

The Croatian spatial planning system consists of subjects, documents, regulations and laws with functions of tracking and predicting the spatial state concerning land usage and resources, defining conditions and type of development, proposing and executing spatial development plans. Three levels of spatial planning are employed in Croatia – national, regional (on county level) and local (city/town/municipality level). On the national level, the governing body is the Ministry of Environmental Protection and Spatial Planning and on the regional and local level, governing bodies are the County spatial planning offices and municipal spatial planning office, which is governed within the local government administration.

Framework for Preparation of Spatial Plans

The legal framework for spatial planning consists of laws and regulations concerning the spatial planning system. Laws concerning spatial planning are:

- Physical Planning Act (Zakon o prostornom uređenju) (OG 153/13)
  which is the principal law governing spatial planning. Its first two articles define the scope of the law:
  Article 1
  This Act regulates the physical planning system: aims, principles and subjects of physical planning, spatial monitoring and physical planning area, planning requirements, adoption of the Spatial Development Strategy of the Republic of Croatia, spatial plans including the process of development and adoption thereof, implementation of spatial plans, building land development, property postulates of building land development and supervision.
  Article 2
  Physical planning provides the conditions for use (governance), protection and management of the space of the Republic of Croatia (hereinafter: the State), as a particularly valuable and limited national asset, and also creates the prerequisites for social and economic development, environment and nature protection, building excellence and rational use of natural and cultural goods.
- Building Act (Zakon o gradnji) (OG 153/13)

Articles 1 and 2 of the Physical Planning act give regulations on how to facilitate plans and actions regarding spatial planning. The most important regulations are:

- Regulation concerning content of project (Pravilnik o obveznom sadržaju idejnog projekta) (OG 55/14, 41/15, 67/16)
- Mandatory content and scope of building documentation regulation (Pravilnik o obveznom sadržaju I opremanju projekata građevina) (OG 64/14, 41/15, 105/15, 61/16)

- Regulation on contents of report on spatial planning state and mandatory indicators (Pravilnik o sadržaju I obveznim prostornim pokazateljima izvješća o stanju u prostoru) (OG 48/14, 19/15)
- Regulation concerning standard of spatial planning plans (Pravilnik o sadržaju, mjerilima kartografskih prikaza, obveznim prostornim pokazateljima I standardu elaborata prostornih planova) (OG 106/98, 39/04, 45/04-addendum, 163/04, 148/10-ceased validity, 9/11)
- Regulations on municipality with option of reduced spatial planning (Pravilnik o općinama koje mogu donijeti prostorni plan uređenja općine smanjenog sadržaja I sadržaju, mjerilima kartografskih prikaza I obveznim prilozima toga plana) (OG 135/10)
- Regulation concerning national spatial planning plan (Pravilnik o državnom planu prostornog razvoja) (OG 122/15)
- Regulation concerning issuing approval for doing jobs in spatial planning (Pravilnik o izdavanju suglasnosti za obavljanje stručnih poslova prostornog uređenja) (OG 136/15)

The above mentioned laws and regulations are the bases for developing and conducting spatial plans. In Croatia, spatial plans are differentiated into three levels concerning scope and detailing of plans. Top most level is national plans, upon which lesser plans are developed. The content and scale of plans are defined in regulations (OG 55/14, 41/15, 67/16, 122/15, 106/98, 39/04, 45/04, 163/04, 148/10).

- Strategy of Spatial Development of Republic of Croatia (Strategija prostornog razvoja Republike Hrvatske). It is a plan on 1:250 000 and 1:500 000 scale. It is top most spatial development document and all lesser documents must abide it. The purpose of this plan is to set guidelines for long term spatial development and coordination of spatial development measures.
- National Spatial Plan (Program prostornog uređenja Republike Hrvatske). The scale of this plan is 1:250 000 up to 1:500 000. The National Spatial Plan defines measures and activities for conducting the spatial strategy and harmonizes ground rules, criteria and rules of spatial planning on national, regional and local level on time scale of eight years.
- Spatial plans of special defined area (PROSTORNI PLANOVI PODRUČJA POSEBNIH OBILJEŽJA). These plans concern nationwide relevant areas, such as national parks, significant natural parks, tourist zones, military compounds etc. These special areas confine to the spatial strategy and the National Spatial Plan but acknowledge special natural, landscape and heritage values of location. Along with spatial plans, they contain programs of environmental protection, definition of usage and requirements for area.

Lesser spatial planning documents are divided into regional and local documents. Regional plans are developed by the county authority and local plans are developed by the city or municipality administration. There is an option for reduced content of local spatial plan. The municipalities where that option is viable are defined in special regulation (“Regulations concerning municipalities where reduced plans are viable” (ad lib translation) OG 135/10). The regulations also define propositions for plan makers and method for developing plans (OG 129/16, OG 136/15)

Regional spatial planning documents are:

1. County spatial development plan (Prostorni plan uređenja županije) in scale of 1:100 000.
2. Spatial development plan of city Zagreb (Prostorni plan uređenja grada Zagreba) in scale of 1:100 000.
3. Spatial development plans of specially defined regions (Prostorni planovi područja posebnih obilježja) in scale of 1:100 000. These plans are made for areas inside counties with features like national wide plans but with lesser significance. These areas are defined in regional spatial development plans.

Local spatial planning documents are:

1. City, town of municipality spatial development plans (Prostorni plan uređenja velikog grada, grada ili općine) in scale of 1:25 000.
2. Urbanistic plans (Urbanistički plan uređenja) in scale of 1:2 000 or 1:1 000.
3. Detailed spatial development plan (Detaljni plan uređenja) in scale of 1:1 000 or 1:500.

The division between regional and local plans coincides with administrative borders of the region or municipality. To keep track of land usage and resources, a four-year report concerning the state of spatial planning (Izvještaj o stanju u prostoru) is written and adopted by the body defined for spatial planning. The reports contain analyses of the current and predicted states of spatial planning, based on indicators and previously adopted documents in accordance with regulation on contents of report on spatial planning state and mandatory indicators (Pravilnik o sadržaju I obveznim prostornim pokazateljima izviješća o stanju u prostoru) (OG 48/14, 19/15). The reports also evaluate the harmonization of documents with the current status and suggest changes in documents or define new measures of land usage and environmental protection.

3.3.2. Laws and Regulations on Environmental Assessment in Croatia

In Croatia, the implementation of environmental impact assessment is prescribed pursuant to the Environmental Protection Act (OG 80/13, 153/13. 78/15) (EPA) and Regulation on environmental impact assessment (OG 61/14) (REIA). Through the adoption of these regulations the procedure has been systematically regulated and harmonized with the corresponding EU Directives: Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment, amended by Council Directive 97/11/EC of 3 March 1997 and by Directive 2003/35/EC of the European Parliament and of the Council of 26 May 2003. Furthermore, the adopted regulations are based on the provisions of the international treaty which was ratified by the Republic of Croatia through the adoption of the Act on the Ratification of the Convention on Environmental Impact Assessment in a Transboundary Context (Official Gazette IT No. 6/96).

The environmental impact assessment, its evaluation and acceptability are assessed by the Advisory Expert Committee for the Environmental Impact Assessment Procedure (further: Committee) on the basis of the Environment Impact Study (EIS). Members of the committee can only be persons listed in the List of persons eligible to be appointed members and deputy members of committees in procedures of strategic assessment, environmental impact assessment of projects and establishment of integrated environmental requirements (OG No. 126/09, 65/12). Committee members are appointed among scientific and expert professionals, representatives of bodies and/or persons determined pursuant to a special regulation, representatives of local and regional self-government units, and representatives of the Ministry. The committee is appointed by the Ministry for projects determined in the List of projects from Annexes I and II of the Regulation on environmental impact assessment (Official Gazette No. 64/08, 67/09), and by the administrative body in the county or the City of Zagreb for projects from Annex III of the REIA. The committee performs its work in sessions and upon having established that the EIS is complete and well-founded in expert terms, it proposes to the competent authority that the public hearing on the study should be carried out. After the conducted public hearing, the committee delivers its opinion on project acceptability and submits it to the competent body for issuance of a decision which is the mandatory content of future permits for project implementation.

Environmental Impact Assessment (EIA)

The legal framework

Legal framework for EIA procedure consists of these laws:

- Environmental Protection Act (OG 80/13, 153/13, 78/15)
- Regulation on Environmental Impact Assessment (OG 61/14)
- Regulation on Information and Participation of the Public and Public
- Concerned in Environmental Matters (OG 64/08)
- Act on Ratification of the Convention on EIA in a Transboundary
- context (Espoo Convention) (OG-IT 6/96)
- General Administrative Procedure Act (OG 47/09)

Two levels of competent bodies are realizing the above listed legal framework. On the national level, the competent body is the Ministry of Environment and Nature Protection. On the regional level, the county or the city of Zagreb is defining the competent body. Along with these institutions, other involved institutions are the concerned environmental authorities (ministries, state administration and expert organizations and public sector) and regional and local authorities.

EIA Procedure

In REIA, Annex I states that EIA is mandatory for projects. For those projects, the nature impact assessment is carried out within same procedure in coordination with Nature Protection Directorate. Annex II defines the screening procedure in which it is up to the Ministry of Environmental and Nature Protection to decide if EIA is needed or not. Annex III defines the procedure on the regional level. Annex IV defines the mandatory contents of the Environmental Report (Environmental impact study) which is an integral part of the application.

EIA procedure in Croatia is executing in steps described in following table. Subsequently, each step is described in detail.

Tab. 5: EIA procedure in Croatia

Action	Party	Notes
Screening	Ministry of Environmental and Nature Protection	the procedure to determine whether or not an EIA is required
Scoping	Ministry of Environmental and Nature Protection	the procedure where a developer can request advice on the impacts to be assessed in the EIA
Preparation of environmental report	Authorized institution	The “Report” (including a non Technical summary)
Request and environmental report	Developer / MENP	
Review of the study	EIA committee	
Information and consultation	Public	
Finalization of the study	Authorized institution	
Decision	Ministry of environmental and nature protection	Takes account to fenv. Report and consultations End of EIA process

Screening

Screening procedure is performed as case-by-case analysis in line with set criteria and/or criteria prescribed in Annex V of REIA. For screening to be conducted a request must be submitted in which is included:

- Information on the developer
- Description of the location
- Description of the characteristics of the project, including considered alternatives
- Description of the likely significant effects of the project on the environment
- Proposal of environmental protection measures

Another key aspect of screening procedure is to inform the public about request. During the information process, reviewing the opinions of other responsible bodies and opinions and concerns of public is also performed.
On the end of screening procedure, a decision is provided to carry out or not to carry out EIA. Decision is based on reasons which also must be presented. Public must be informed about decision, also.

Scoping

Scoping procedure is not mandatory. The request for scoping must consist of same data as request for screening. Request is submitted to bodies or persons designated by special regulation for obtaining their opinion. Public is informed, in same way as in screening procedure. As result, instructions on the content of the Environmental Report are given. The instructions do not affect the right to request supplement of the Report content in the course of the EIA procedure. The public must be informed about instructions.
Environmental Report is made by companies authorized for professional environmental protection activities. The regulation is defining which organizations can make environmental reports. The report is based on updated, authentic and available information. The Environmental Report is the result of:

- ➢ Scoping
- Mandatory content – as prescribed in Annex IV of REIA

- In case if project has significant impact on ecological network (i.e. Natura 2000) the Environmental Report must include a chapter elaborating effects projected to the ecological network.

Advisory Expert Committee (AEC) is appointed for each individual project. Competent body is determining composition and number of members of AEC, depending on type of projects. The members are listed in Official Gazette. The members are scientific and expert employees, representatives of bodies and/or persons designated by special regulations, representatives of local and regional government units and representatives of Ministry.

Informing the public and public participation

Competent bodies have to inform the public of:

- EIA procedure
  - the request
  - the decision on submitting Environmental Report for public debate
  - the decision on environmental acceptability of the project
- screening
  - the request
  - the decision
- Scoping
  - the request,
  - the instruction on content of Environmental Report

Methods of information dissipation is web page of competent bodies, public notices in the press, official journals and relevant notice boards.
Direct public participation in EIA procedure is during the public debate. These debates include public inspection and public hearing. The debate must be opened for at least 30 days. The public and public concerned participate in the public debate in a way as right of access to public inspection, ask questions during the public hearing, having the right to enter proposals and objections into the book of comments, submitting proposals and objections into the minutes during the public hearing, submitting written proposals and objections to the competent body. The opinions, objections and suggestions of the public and public concerned must be reviewed prior to issuing decision.

Decision

The Decision on Environmental Acceptability will be adopted only after competent body reviews the AEC's opinion on the acceptability of the project, opinions, objections and proposal of the public and public concerned submitted during the public debate and results of any transboundary consultations. The decision can be challenged in the Administrative Court.

Strategic Environmental Assessment (SEA)

SEA procedure in Croatia is regulated in the following regulations:

- Environmental protection Act (OG 110/07)
- Regulation on strategic environmental assessment of plans and programmes (OG 64/08)

- Ordinance on the committee for strategic assessment (OG 70/08)
- Regulation on information and participation of the public and public concerned in environmental matters (OG 64/08)
- Ordinance on the committee for strategic assessment (OG 70/08)
- List of persons eligible to be appointed members and deputy members of committees in procedures of strategic assessment, environmental impact assessment of projects and establishment of integrated environmental requirements (OG 126/09, 65/12)

Through the aforementioned regulations the procedure has been aligned with the provisions of the Directive 2001/42/EC on Environmental Assessment of Plans and Programs and the Protocol on Strategic Environmental Assessment to the Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention).

Art. 56 of the Environmental Protection Act determines that strategic environmental assessment has to be carried out for plans and programs adopted at the national and local (regional) level in the field of agriculture, forestry, fisheries, energy, industry, mining, transport, telecommunications, tourism, waste management and water management and for spatial plans of counties and the Physical plan of the City of Zagreb (excluding its amendments). However, in case of amendments to plans and programs subject to strategic assessment a procedure has to be carried out in which a decision is made about the necessity of implementing the strategic assessment. The evaluation of the need for strategic assessment of amendments to plans or programs at the national level is carried out by the bodies competent for the implementation of strategic assessment, in cooperation with the Ministry when the evaluation is not under the competence of the Ministry. The evaluation of the need for strategic assessment of amendments to plans or programs at the county level is carried out by the body competent for the implementation of strategic assessment.

SEA Procedure

Strategic assessment at the national level is carried out by the Ministry or the ministry competent for the sector for which the plan or program is being adopted. At the regional level the procedure is carried out by the competent administrative body in the county or the City of Zagreb, in cooperation with the competent administrative department in the county or the City of Zagreb, depending on the area for which the plan or program is being adopted.

Although, the transposition of the EU SEA Directive was done properly, the situation with the implementation of the procedure can currently be stated as insufficient. Apparently, although the SEA procedure is envisaged in Croatian legislation since (2007) not one procedure is finished yet. According to the information from the Ministry of Environment Protection and Nature, there are 12 ongoing procedures, six full SEA procedures and six evaluations of the need for strategic assessment. Additionally, only one procedure is at the very end of the whole process, meaning that only the final decision is still missing. The Ministry indicates that there are few problems with this procedure: lack of administrative capacity for this process, lack of cooperation between different administrative bodies, lack of knowledge of competent authorities and lack of interest from the public (including NGOs) for SEA procedure.

Strategic assessment is carried out during the development of the draft proposal of the plan or program, prior to the establishment of the final proposal and its submission into the adoption procedure. Strategic impact study is prepared in the procedure of strategic assessment. Strategic assessment is carried out on the basis of the results set out in the strategic impact study. The strategic impact study must contain the chapters and contents as prescribed in Annex I of Regulation on strategic environmental assessment of plans and programs (O.G. No. 64/08). When the opinion of the body competent for nature protection establishes that the plan and program may have significant effects on the ecological network, the content of the strategic impact study must also include a chapter identifying the effects of the plan or program on the ecological network, pursuant to special regulations governing nature protection. In the procedure of determining the content of the strategic impact study, the competent body must obtain the opinion of the bodies and/or persons designated by special regulations on the content and scope of information that has to be covered by the strategic impact study, relating to the area under the competence of that body and/or persons.

The strategic impact study defines, describes and assesses expected significant effects on the environment which may be caused by the implementation of a plan or program, and its reasonable alternatives related to environmental protection that take into account the objectives and scope of the plan or program in question. The body competent for the implementation of strategic assessment must submit the strategic impact study and the draft proposal of plan and program for an opinion by the bodies and/or persons designated by special regulations.

Prior to defining the draft proposal of the plan or program to be submitted for public debate, including public inspection and public display, the draft plan and program must be reviewed and the results of the strategic assessment study evaluated by the Advisory Expert Committee (hereinafter: the Strategic Assessment Committee; SAC) which issues an opinion thereupon. The SAC of each plan or program is appointed by the head of the body competent for carrying out strategic environmental assessment. The composition and number of members of the SAC is determined depending on the scope and other features of the plan or program for which a strategic assessment is carried out.
The members of the committee are appointed from the list of persons selected by the Minister from among scientific and expert employees, representatives of regional and local self-government, representatives of the state's four administration bodies, representatives of legal persons with public authorities and representatives of the Ministry. It is determined that, prior to submission into the adoption procedure, when defining the final proposal of the plan or program, it is mandatory to take into account the results of strategic assessment, opinions of bodies and/or persons designated by special regulations and to review the objections, proposals and opinions of the public as well as the results of any transboundary consultations if mandatory under the Environmental protection Act (O.G. No. 110/07), which have been made with regard to the draft proposal plan or program, and the opinion of the Ministry.

The strategic assessment procedure is concluded by the report of the body competent for the implementation of strategic assessment. It must contain information on the manner in which environmental protection issues have been integrated in the plan or program, the results of that procedure and the environmental protection measures and method of monitoring the implementation of measures which are included in the content of the plan or program as well as the method of monitoring the significant environmental impacts of the adopted plan or program.

Public information and participation

The obligation to inform the public and to ensure public participation in procedures of strategic environmental assessment of plans and programs is determined by Article 137 (1) of the Environmental Protection Act. Pursuant to paragraph 2 of the same Article, it is defined that the period of time determined for informing the public shall not be shorter than 30 days. The manner of informing the public and the public concerned in the aforementioned procedures is determined in detail by the Regulation on Information and Participation of the Public and Public Concerned in Environmental Matters (Official Gazette 64/08).
Pursuant to this regulation, the public shall be informed on the aforementioned procedures in the following manner: As a rule, the competent body provides and publishes the information on its web pages. The competent body, given the complexity and nature of the subject matter on which it is obliged to provide information in accordance with the Act and Regulation, except by means of its web page, may also provide such information through other means of informing that are more appropriate in a specific case given the local community or individual citizen, specifically: public notices in the press, public notices in the official journal of a local or regional self-government unit, public notices on the notice board at a particular location, notices in other means of public information, i.e. electronic media, etc. When the information procedures regulated pursuant to the Act and this Regulation are used to inform the public concerned, the competent body must publish the information by displaying it on the notice board at a particular location, as well as in the local or regional press.

In the procedure of strategic environmental assessment of plans and programs the public must be informed of:

1. the decision on initiating the strategic assessment and developing the strategic impact study,
2. the decision on determining the content of the strategic impact study,
3. the decision on submitting the strategic impact study and the draft proposal of the plan or program for public debate,
4. the procedure relating to potential transboundary effects of a plan or program and the procedure of participation in the strategic assessment in another country,
5. the report of the competent body concerning the performed strategic assessment and the adopted plan or program.

In the evaluation of the need for strategic assessment, the public shall be informed of the decision issued in that procedure. As a rule, the information on the above acts such as: decisions, assessments and reports are made available by publishing those acts on the web page. If the nature of the act – because it contains technical and cartographic representations – does not permit its publication in its entirety, the summary of the act without technical and cartographic representations shall be published. The summary shall contain the relevant statement and explanation of the act, if contained in the act. Notice on conducting of a public hearing must be published on the official website of the Authority and coordinator of the public debate in the newspapers for at least eight days before the public hearing. Following the publication of notice on the public debate, the subject of the public debate is put on public insight for a minimum of 30 days. During the public insight the Authority organizes public presentation.

In accordance with the provisions of the Environmental Protect Act, in the early phase of the decision-making procedure for environmental issues relating to the relevant activity of the developer or the operator, the public and public concerned must be appropriately, timely and efficiently informed of their right to participate in the procedure of strategic environmental impact assessment. In the procedure of strategic assessment of plans and programs, the public can participate in:

1. the development of the strategic impact study – determining the content; by written opinions and proposals to the competent body within the period set in accordance with the Regulation,
2. the public debate on the strategic impact study and the draft proposal of the plan or program; in accordance with the provisions of the Act and Regulation that regulate the manner of conducting the public debate, except in the case of the strategic environmental assessment of a physical plan, when public participation is regulated in accordance with the provisions of the law governing physical planning.

In a public debate, the public and other participants in the public debate such as bodies and/or persons designated by special regulations, local and regional self-government units and other bodies (hereinafter: public debate participants) can submit opinions, proposals and objections in relation to the subject of public debate within the period and in the manner prescribed by Regulation. The subject of public debate may be the strategic impact study with the draft proposal of the plan or program. The public debate, including public inspection and public display in the procedure of strategic assessment shall be coordinated and performed by the competent body.
The public shall participate in the public debate in a way as to:

- have the right of access to public inspection of the subject of public debate,
- ask questions during the public display on the proposed solutions, which are answered by the persons referred to in Article 19 of the Regulation on strategic environmental assessment of plans and programs (O.G. No. 64/08), orally or in writing according to the request of the public debate participants,
- have the right to enter proposals and objections into the book of comments which shall be placed next to the subject case on which the public debate is performed,
- submit proposals and objections into the minutes during the public display,
- submit written proposals and objections to the competent body within the period set in the notification on the public debate.

The competent body shall prepare a report on the performed public debate. In the case that, based on the accepted opinions, proposals and objections submitted in the public debate, the subject of public debate is changed in such extent that the new solutions are not in conformity with the significant determinants of the subject of public debate on the basis of which it was developed, a repeated public debate shall be performed. If the repeated public debate refers to the changes proposed in the first public debate, the period of public inspection may be shorter than the prescribed period in the Regulation on strategic environmental assessment of plans and programs (O.G. No. 64/08), but not shorter than eight days. The notification on the repeated public debate shall be published in the manner prescribed by the provision of Article 16 of the Regulation.
New proposals and objections relating to the amended part of the subject of public debate may be submitted only in reference to the changes resulting from the accepted proposals submitted in the first public debate. Repeated public debate may be performed no more than two times, after which the decision on new preparation of the subject of public debate shall be issued.

4. Discussion: Is Spatial Planning Capable of Reducing Vulnerability through Environmental Assessment?

As presented in the previous chapters, spatial planning and environmental assessment procedures are closely interwoven in both planning and environmental law. However, the key question to be answered is:

- *Is spatial planning capable of reducing vulnerability through environmental assessment?*

In order to answer this question, first general potentials and restraints are discussed, before the specific situations in the three Wind Risk partner countries are compared.

As already stated in the introduction of this report, spatial planning decides about future land uses, which is why the discipline essentially influences the vulnerability of areas. More specifically, spatial planning is especially capable of influencing the vulnerability components exposure and adaptive capacity, as illustrated with the following examples.

Exposure	e.g. by prohibiting building permissions in flood prone areas
Adaptive Capacity	e.g. by increasing urban green spaces and decreasing sealing in order to enable quick infiltration of precipitation in case of extreme events

The most important instrument for implementing spatial planning measures with the aim of reducing the exposure and increasing the adaptive capacity of an area, are plans and programs. As land-use plans have a high-spatial resolution[8] they are a suitable instruments for addressing location-based vulnerabilities.

Environmental assessment is a systematic procedure that bases on EU Directives and is therefore implemented in national law in all EU Member States. The aim of environmental assessment is to identify, describe and assess potentially significant adverse effects on the environment, which may result from the establishment of a project, plan or program. In other words, environmental assessment shall ensure that spatial plans and individual projects within a certain spatial area do not have adverse effects on the environment. These adverse effects on the environment are to be assessed according to specific procedures, addressing various protective goods. These protective goods, to some extent, reflect the possible vulnerabilities of the environment.

To conclude, spatial planning and environmental assessment are closely interwoven. Whenever a spatial plan or program is set up, an assessment of the potentially significant adverse effects on the environment (and specific vulnerability parameters) needs to be conducted. As projects can generally also be considered spatially relevant, the same close connection between spatial planning and environmental assessment applies to them.
Therefore it can be stated, that there is a theoretical capability of spatial planning to reduce vulnerabilities. In the following, the EIA and SEA Directives are to be investigated article by article on their suitability of reducing vulnerabilities.

[8] Binding local land-use plans are even parcel-specific (meaning they illustrate specific properties).

4.1. European Perspective on Reducing Vulnerability through Environmental Assessment

The following table contains the potentials and restraints for reducing vulnerability by applying the EIA and the SEA Directives. This table is not intended to be exhaustive but is rather to be understood as a basis for further discussion.

Tab. 6: Potentials and restraints for reducing vulnerability by EIA and SEA

<table>
<tr><th>Subjects and EU Directive</th><th>Potentials for Reducing Vulnerability</th><th>Restraints for Reducing Vulnerability</th></tr>
<tr><td>EIA 2011
Art. 5
Scope: Info on Project</td><td>The information on the project to be provided embraces measures to avoid or remedy significant environmental effects. These could be used for adaptation purposes, e.g. increasing the structural resilience of buildings or increasing green structures.</td><td>The information to be provided only has minimum standard and are of rather descriptive character. A more specific target would increase an early debate on vulnerability reduction and increase of adaptation measures.
➢ see recommendations below</td></tr>
<tr><td>EIA 2011
Art. 6
Participation</td><td>Participation procedures ensure an active involvement of authorities, public agencies and the public. The aim is to reflect on a project from different (disciplinary) perspectives and to embrace all concerns. Participation processes therefore are a potential for the reduction of vulnerability, as possible effects are assessed from various perspectives, e.g. spatial planning, health care, water management, landscape planning, etc.</td><td></td></tr>
<tr><td>EIA 2011
Art. 7
Transboundary Participation</td><td>see Art. 6 EIA 2011</td><td></td></tr>
<tr><td>EIA 2011
Art. 8
Consideration</td><td colspan="2">In the step of consideration all information and statements gathered are weight among themselves and against each other. The consideration is necessary in order to secure the ability of taking a (planning) decision. The consideration can be understood as both an opportunity for vulnerability reduction as well as a restraint because it is in the power of the authority to weigh certain aspects more important than others.
➢ see recommendation</td></tr>
<tr><td>EIA 2011
Art. 9
Decision</td><td>In the decision, measures on avoiding or remedying effects on the environment can be determined. If done so, vulnerability aspects can potentially be considered, which is to be understood as a potential.</td><td>But if no measures on avoiding or remedying effects on the environment are necessary (or determined), either the vulnerability is low or other aspects were weighed of higher priority.</td></tr>
</table>

EIA 2014 Art. 5 **Scope: EIA Report**	With the introduction of an EIA report, a broadening of scope takes place, e.g.: • reasonable alternatives are to provided; • climate change is to be considered; • risks from severe accidents and/or disasters are to be considered in environmental assessment procedures. These changes can be understood as a potential for vulnerability reduction, as especially with the inclusion of climate change and accidents/disasters the vulnerability of an area is to be made subject of environmental assessment. ➢ see recommendations	The reasonable alternatives are to be developed by the developer and might therefore be led by economic interest. ➢ see recommendations A definition of what ‘severe accidents and/or disaster’ are and how these shall be included is missing. ➢ see recommendations
EIA 2014 Art. 6 **Participation**	see EIA Directive 2011 Art. 6	see EIA Directive 2011 Art. 6
EIA 2014 Art. 7 **Transboundary Participation**	see EIA Directive 2011 Art. 7	see EIA Directive 2011 Art. 7
EIA 2014 Art. 8 **Consideration**	see EIA Directive 2011 Art. 8	see EIA Directive 2011 Art. 8
EIA 2014 Art. 8a **Scope of Consideration + Monitoring Parameters**	The introduction of monitoring procedures in the amended EIA gives the opportunity to regularly assess the potential negative effects and to arrange adaptation measures if needed.	
EIA 2014 Art. 9 **Decision**	see EIA Directive 2011 Art. 9	
EIA 2014 Art. 9a **Conflict of Interest**		
SEA 2001 Art. 5 **Scope: Environmental Report**	The environmental report is of great scope and ensures an involvement of other authorities in the scoping phase, which can be seen as a possibility for vulnerability reduction as from the beginning the broadest involvement of disciplines is secured. ➢ see recommendations	
SEA 2001 Art. 6 **Participation**	see EIA Directive 2011 Art. 6	see EIA Directive 2011 Art. 6
SEA 2001 Art. 7 **Transboundary Participation**	see EIA Directive 2011 Art. 7	see EIA Directive 2011 Art. 7

SEA 2001 Art. 8 **Consideration**	see EIA Directive 2011 Art. 8	see EIA Directive 2011 Art. 8
SEA 2001 Art. 9 **Decision**	The decision step in the SEA embraces a publication of monitoring measures to be implemented. This gives the opportunity to regularly assess the potential negative effects and to arrange adaptation measures, reducing the vulnerability, if needed.	
SEA 2001 Art. 10 **Monitoring**	It can be seen as a possibility for reducing vulnerabilities that monitoring is a separate article in the SEA Directive.	A restraint is though, that there is no authority designated to conduct the monitoring. ➢ see recommendations

Source: own depiction.

General Recommendations for EIA and SEA Directives

EIA Directive 2011
If the catalogue of information required from the developer (according to Art. 5 EIA 2011) were more specific, an early debate on vulnerability reduction could be established. It can therefore be recommended to raise the requirements of information required (→ as done by the amendment of the Directive).

Regarding the step of consideration (Art. 8 EIA 2011), the competent authority weighs all information gathered among themselves and against each other. It therefore is in the power of the authority to focus on certain vulnerability aspects or to decide that other aspects are even more relevant. If the general EU policy would focus more on the vulnerability of structures and societies, vulnerability-related statements could be stronger acknowledged.

EIA Directive 2014
The broadening of the scope of information required and their presentation in form of an environmental impact assessment report may present the greatest opportunity for including and reducing vulnerabilities, as the Directive directly addresses these. As described in chapter 2.2 it is not sufficient anymore to describe the possible significant effects of projects on climatic factors, but an assessment of the vulnerability of planned structures and objects towards climate change becomes necessary. (Cf. Statement 13 2014/52/EU) Furthermore, according to statement 15, precautionary actions regarding accidents and/or disasters in the habit of risks analyses are to be enforced. The Directive even provides the exact procedure for doing so:

i. The vulnerability of projects towards major accidents and/or natural disasters needs to be assessed by investigating exposure and resilience of the projects.
ii. The risk of occurrence for these accidents and/or disasters needs to be estimated.
iii. Implications for the likelihood of significant adverse effects on the environment need to be described. (Cf. Statement 15 2014/52/EU)

To conclude, the EIA according to the amended Directive 2014/52/EU needs to be conducted with respect to exposure, vulnerability and coping capacity.

Besides these above-mentioned possibilities of including and reducing vulnerability, two restraints can be identified accompanying the amendment of Art. 5. First, the reasonable alternatives are to be developed by the developer and might therefore be led by economic interest. It can be recommended to handle this issue as in the SEA Directive, where the competent authority provides alternatives and outlines reasons for selecting the alternatives dealt with, and a description of how the assessment was undertaken including any difficulties (such as technical deficiencies or lack of know-how) (cf. Art. 5 2001/42/EC). Second, so far a definition of what 'severe accidents and/or disaster' are and how these shall be included is missing. In practice this may lead to neglecting severe accidents and/or disasters. It is therefore recommended for both EU and the national levels to develop a catalogue with accidents and disasters to be included. If a catalogue like this would be implemented a special focus could also be set on storms.

SEA Directive

The involvement of other concerned authorities in the development of the environmental report secures a broad perspective on possible effects from the first step of the procedure. It is recommended to apply the same early consultation processes into the EIA, which, even in the amended Directive, only apply consultation procedures in case of a lack of expertise (cf. Art. 5 2014/52/EU).

Furthermore, it is recommended that a competent authority be designated to conduct the monitoring. The SEA Directive should generally state the necessity to designate a competent authority so that in national laws, specifications are possible.

4.2. Perspectives on Environmental Assessment and Spatial Planning from Germany, Slovenia and Croatia

4.2.1. Potentials and Restraints of Environmental Assessment as a Systematic Spatial Planning Approach for Vulnerability Reduction

In all three Wind Risk Prevention Project partner countries, namely Germany, Slovenia and Croatia, environmental assessment needs to be conducted whenever a spatial plan, a spatial program or a spatially relevant project is implemented or changed. As required by the EU, the environmental assessment procedures are derived and implemented according to the EU Directives EIA and SEA in all three countries.

The previous chapters showed that there are differences in the approaches of the three countries regarding environmental assessment and spatial planning. First of all, the spatial planning systems differ in the three countries. Although the spatial planning systems of Slovenia and Croatia originate from the former state of Yugoslavia, in Slovenia spatial planning is conducted on only two instead of three administrative levels. In Slovenia, spatial planning responsibilities are divided between the national and the local level. In Croatia and Germany, there is an additional regional level in between the national and local level. Structure-wise therefore the organization of spatial planning systems of Germany and Croatia are more similar than of Croatia and Slovenia.

Chapter 3 of this Wind Risk Prevention Project report showed, that so far spatial planning and environmental assessment are especially strongly interwoven in Germany. In Germany, environmental assessment is implemented as a superordinate procedure of spatial planning, anchored in spatial planning laws (ROG and BauGB).

In Slovenia and Croatia, the interlinkage between spatial planning and environmental assessment mainly bases on the SEA procedure, which needs to be conducted before the implementation of a plan or program. Furthermore it is interesting to notice that in both Slovenia and Croatia, the authority responsible for spatial planning on the national level is the Ministry of the Environment and Spatial Planning of the Republic of Slovenia, i.e. the Republic of Croatia, hinting at an administrative connection of the topics on the national level.

4.2.2. Recommendations from Germany, Slovenia and Croatia

First of all, a general recommendation that can be drawn from this report is that both EIA and SEA should be further supported in their implementation and execution within all three Wind Risk Prevention Project partner countries. Furthermore, the relevance of EIA and SEA as a systematic approach for addressing environmental issues needs to be further amplified and transposed into administrative actions.

As especially chapter 3 of this report illustrated, environmental assessment is of high priority and closely interwoven with spatial planning in Germany. The following recommendations are therefore derived from the 'German approach' and may be adapted by other EU Member States:

- **Joined implementation of EIA and SEA procedures.**
  A special characteristic about Germany's implementation of EIA and SEA is that they are jointly implemented in one law; the UVPG. The reason for the joint implementation of EIA and SEA is that in Germany, plans and programs are already made subject to environmental assessment before the implementation of the SEA Directive. This special characteristic reflects the importance of environmental assessment for spatial planning (see chapter 3.2.1).
  A joined implementation of EIA and SEA has the following advantages:
  - A combination of EIA and SEA secures the opportunity to assess potential environmental effects by finding the most suitable location for potentially hazardous projects within the development procedures of a spatial plan (within SEA procedures) even before any discussion on the realization of concrete individual projects (within EIA procedures).
  - A combination of EIA and SEA saves resources (time and staff) as they can be conducted in one procedure instead of two consecutive ones.

- **Screening Procedures for SEA and EIA:**
  According to § 3 of German UVPG, screening is mandatory not only for SEA but also for EIA. Therefore, § 3 UVPG determines that environmental assessment has to decide on whether EIA is mandatory according to Annex I or if projects require individual preliminary examination (either in general or due to their specific location).

- **Monitoring Procedures for SEA:**
  The German regulations on SEA explicitly assign monitoring requirements to the competent authority (cf. § 14m UVP).

- **Encourage a close connection between environmental assessment and spatial planning law in order to help environmental assessment procedures become a systematic approach for spatial planning in addressing vulnerabilities.**
  In Germany, environmental assessment and spatial planning are closely interwoven through spatial planning law. The following two examples may be copied by other Member States:
  - In §§ 16 and 17 UVPG is stated that environmental assessment procedures for spatial plans (spatial structure plans and land-use plans) shall be subject the assessment procedures as described in ROG and BauGB. Although the ROG is less specific regarding regulations than the BauGB, this circumstance can be understood as a potential for vulnerability reduction, because more detailed and more (spatially) specific regulations can be implemented. The close connection between spatial planning (law) and environmental assessment procedures ensures an early and comprehensive consideration of potential environmental effects of projects as these are especially to be considered in any spatial plan or program.[9]

[9] Of course it also needs to be considered, that this close connection results in a need for amending not only the UVPG, but also on ROG and BauGB if the EU SEA and EIA Directives are amended. The national amending procedures might therefore be even more extensive than on the European level, as potentially several laws need to be amended.

- In the German BauGB all articles with general prescriptions (§§1-4c) contain relevant information on how to include environmental assessment into spatial planning procedures. These regulations are very detailed and either refer to the UVPG or exceed it in the requirements. With these general prescriptions it can be ensured that environmental assessment is fitted within spatial planning procedures and the respective time schedules. Especially suitable for considering and reducing vulnerabilities is § 1(6) No. 7 BauGB, which determines that measures on climate protection and climate change adaptation are to be included in the environmental assessment report. This paragraph is even suitable for including vulnerabilities towards storm, e.g. is it imaginable to include a measure that city trees should not be planted close to the driveways of fire brigades, hospitals or other emergency units in order to prevent that in case of a summer storm, these trees fall, block the driveways and prevent the units from operating.

5. Conclusions

This report focused on recommendations from a spatial planning perspective on how to reduce vulnerabilities. As stated in the introduction, the aims was to investigate on whether spatial planning is capable of systematically addressing vulnerabilities, although these are location-based and differ according to the location. The overall research question was:

- *Is Spatial Planning Capable of Reducing Vulnerability through Environmental Assessment?*

The approach chosen in this report was to investigate environmental assessment as a systematic procedure, closely linked with spatial planning. It was shown that the EU Directives on Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) offer various possibilities of addressing vulnerabilities. Furthermore, the national implementations of the EU Directives were presented. It was shown that in all three countries, spatial planning and environmental assessment are somehow interwoven.

Nonetheless, this report showed that so far spatial planning in average of the three countries has only partly influence on environmental assessment and this influence is mainly restricted to SEA procedures. Therefore it can be concluded, that spatial planning is currently not fully capable of systematically reducing vulnerabilities, e.g. towards storms. Nevertheless, sophisticated approaches on a systematic implementation of environmental assessment into spatial planning procedures already exist within the EU (see e.g. chapter 3.1) and could be extended to other Member States. It needs to be stated though that the 'German approach' strongly depends on the three-level planning system consisting of national level, regional level and local level. For countries like Slovenia, where there are only two levels of spatial planning, new approaches might need to be developed.

As an outlook it can be recommended that the national authorities in the EU deal with the amendments of the EIA directive in an early stage, preferably before the implementation of Directive 2014/52/EU in national law until May 2017. Especially the questions on how to embrace climate change and severe accidents and/or disasters into the scope of environmental reports will be challenging. This is even more complicated due to the fact that there is no definition or catalogue on accidents/disasters on the European level. Concluding, instructions or recommendations would be desirable.

Concluding it can be stated, that spatial planning as a comprehensive discipline can be well capable of addressing vulnerabilities and that environmental assessment is a suitable procedure for systematically approaching differing location-based vulnerabilities. A major advantage of environmental assessment is that both on the level of projects as well as on the level of plans and programs, measures can be implemented and vulnerabilities reduced. Nonetheless, it has to be kept in mind that the prerequisite for addressing vulnerabilities via spatial planning is knowledge on these vulnerabilities. This insight further stresses the importance of the Wind Risk Prevention Project.

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Zakon o gradnji NN 153/13

Zakon o prostornom uređenju NN 153/13

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WIND RISK

Task D – Action plan

Action D.2: Recommendations concerning the physical investments that will be required to protect and upgrade the infrastructure, transport, buildings and forests

For the Wind Risk prevention project

University of Ljubljana
Technical University of Dortmund
University of Split
Municipality of Ajdovščina

Chapter D.2 – Recommendations concerning the physical investments that will be required to protect and upgrade the infrastructure, transport, buildings and forests

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1. Introduction

Although **Wind Risk project** territorial coverage is focused on three European countries with climate conditions that are not considered severe, all countries suffer from occasional unexpected meteorological conditions that can cause damages**.** Wind is movement of atmospheric gas and meteorologists measure the wind intensity (speed) and direction**.** World Meteorological organization proscribes standards for wind instruments and methods of observations. However, observations in standardized conditions do not describe local effect of wind**.** **Wind risk** is defined as probability that wind intensity measurement at a site exceeds a specified threshold within a time period of interest.

Wind Risk project aims to produce recommendations that will lower unwanted effects of high wind in partners' areas. In previous reports, project partners concluded that, in the spirit of expected climate changes, more high wind events are expected in all areas. Partners analyzed current legislation and practices for dealing with wind risk. Also assessment of vulnerability has been done in partner's area. Cost analysis has been done on several high wind events proving the both social and economic damages are high and there is need to prevent them.

The task of this report is to:

- Develop specific recommendations concerning the physical investments that will be required to protect or upgrade the infrastructure, transit, buildings and forests
- Assessed vulnerability will be provided with answers for reducing the wind risk
- Wind fences an obstacles for the protection of transit, the replacement of telephone lines that are at risk due to the wrong design or just old age, repairing and upgrading civil buildings planting trees
- Expected outcome: Maps with pinpoint locations that need physical investments!

High wind is natural phenomenon that happens occasionally. All partner areas have experienced high wind phenomenon occurrence and consequences that are sometimes hazardous. The occurrence of wind cannot be avoided, but in the conclusions of previous tasks and activities of this project it is stressed out that it is important to learn from past events and increase preparedness and apply preventive measures.

Since the measure of wind risk is comprised of probability of wind occurrence and occurrence of damage in the specific area reduction of wind risk should be done by lowering either occurrence of wind either occurrence of damage. Reducing wind risk is not possible by lowering the occurrence of high wind events. The right direction is lowering vulnerability and increasing preparedness of the area.

In this report we performed spatial analysis of target areas for project partners and highlighted affected areas with high winds. The spatial analysis is done using GIS (Geographical information system) tools. We cross-compared locations of critical infrastructure, buildings, transportation routes and forests with those areas and produced recommendations for lowering the risk of damage.

The following report is structured as follows: In the following chapter we present methodology for identifying high risk zones in areas of project partner. General recommendations for investments that will mitigate the risk in vulnerable areas are presented after that. After that specific vulnerability zones of each partner area is assessed with recommendation. Final chapter gives conclusion of all recommendations.

2. High risk zones

High risk zones are areas of space where wind high wind speed can locally increase and produce damages. In this chapter we will present methodology for determination of high risk zones. High risk zones determination is a method of classification where areas is classified as a high risk zone on the basis of several inputs. In this report we will classify high risk areas on the basis of these inputs:

- Wind load (basic wind speed)
- Terrain cover
- Topography of the terrain

These input data can be obtained as freely available data for all partner areas and can be transformed to the format to be used with GIS software. Geographic information system (or GIS) is a system designed to capture, store, manipulate, analyze, manage, and present spatial or geographical data. When performing operations on spatial data we are using GRASS GIS software tool. GRASS GIS, commonly referred to as GRASS (Geographic Resources Analysis Support System), is a free and open source Geographic Information System (GIS) software suite used for geospatial data management and analysis, image processing, graphics and maps production, spatial modeling, and visualization. GRASS GIS is currently used in academic and commercial settings around the world, as well as by many governmental agencies and environmental consulting companies. It is a founding member of the Open Source Geospatial Foundation (OSGeo).

All spatial data analysis result used in this document can be found online at http://geoportal.gradst.unist.hr/maps/19/view.

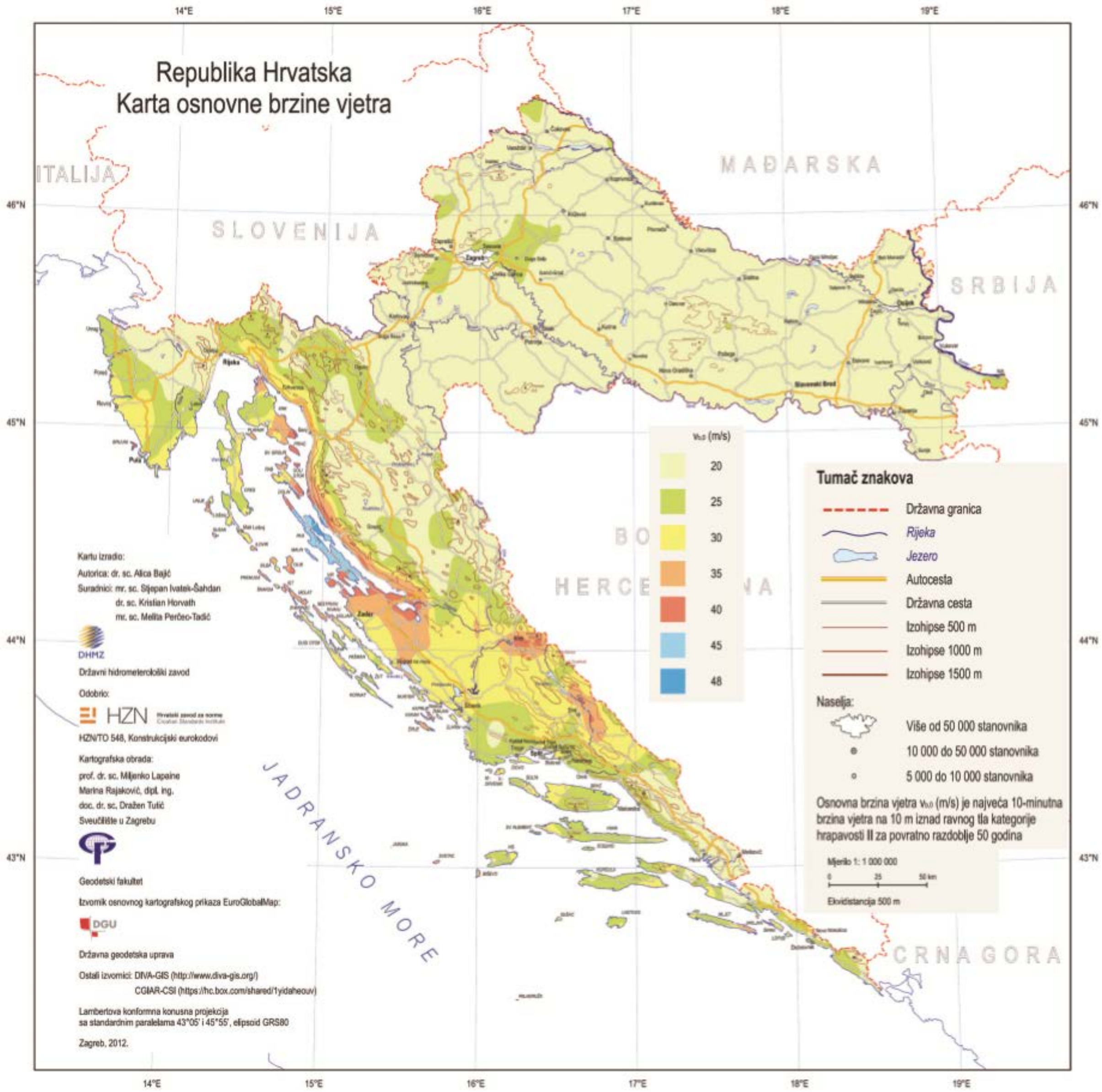
2.1. Wind load

First input for determining high risk zones is basic wind load map of the area. The occurrence of the wind speed higher than the average speed is precondition for wind hazard, so the areas where higher wind speeds occurs are more prone to have wind risk event.

Wind load map is a part of National Annex of building norm EN 1991-1-4 2012 for each partner country. The maps shows maximum expected wind velocity with return period of 50 years, averaged on 10-minute scale on 10 m height above the land.
The map defines several levels of risk wind load zones, and more risky areas are classified to the higher level zone.

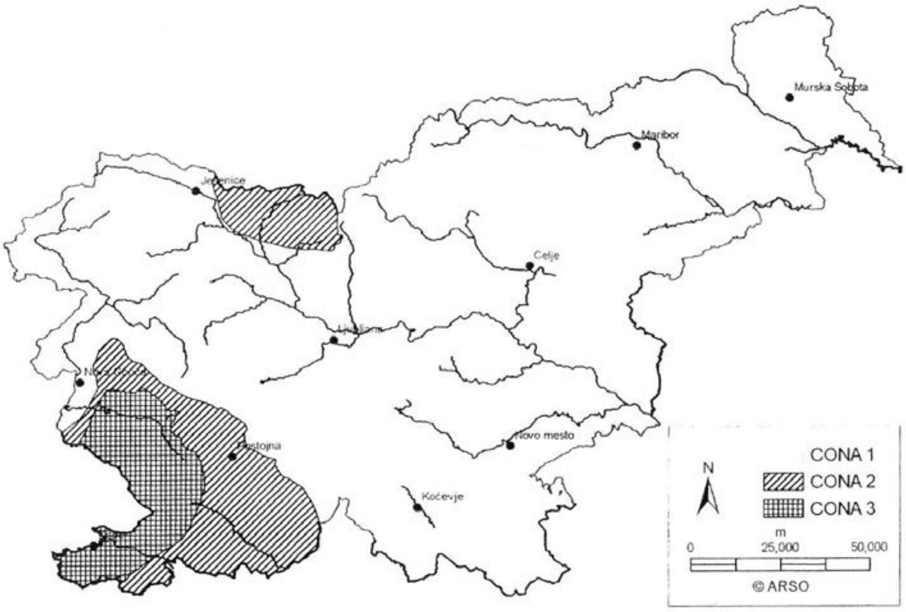
Format of the map that can be obtained from the documents is image and it is not easy (or not free) to find georeferenced image. Since areas of basic wind speed zones are rather large, we drawn the images using GIS software for each partner country.

Figure 1: Basic wind speed (from HRN EN 1991-1-4 NA) for Croatia



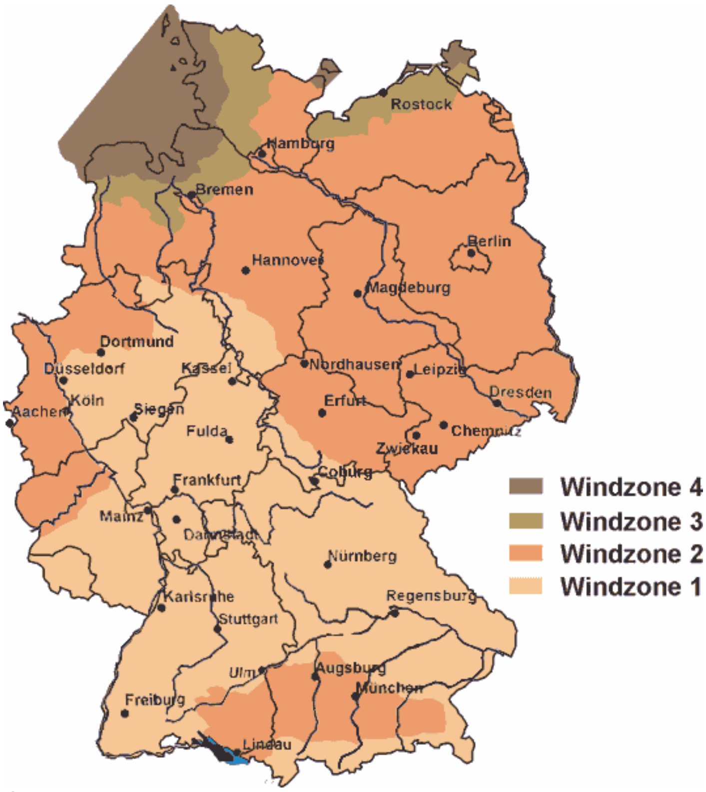
Source: HRN EN 1991-1-4 NA

Figure 2: Basic wind speed map for Slovenia



Source: SIST EN 1991-1-4:2005, National Annex, 2008

Figure 3: Basic wind speed map for Germany



Source: Eurocode 1

2.2. Terrain cover

Structure of terrain and terrain cover has significant influence on evolution of the wind in the local area. For example, grass area without obstacles will allow wind flow to reach higher speeds then those where roughness of the terrain causes wind to slow down.

Classes of terrain that will be used as input data for risk determination are:

1. High density urban area
2. Small packing urban area
3. Forests , high vegetation
4. Grass, low vegetation
5. Water

The classes are based on classes used in building norms 1991-1-4 for determination of terrain roughness factor, but are slightly revised. For determining values of this part of input we will use georeferenced data about terrain that is freely available for all project partner countries - Corine Land Cover. The Corine Land Cover (Coordination of Information on the Environment Land Cover, CLC) is European programme establishing a computerised inventory on land cover of the 27 EC member states and other European countries, at an original scale of 1: 100 000, using 44 classes of the 3-level Corine nomenclature. It is produced by the European Environment Agency (EEA) and its member countries and is based on the results of IMAGE2000, a satellite imaging programme undertaken jointly by the Joint Research Centre of the European Commission and the EEA.

In order to obtain data about terrain that can be used for determination of high wind risk zones we introduced translation table for translation of CLC codes to terrain category.

Figure 4: CLC Corine Land Cover nomenclature

Level 1	Level 2	Level 3
1. Artificial surfaces	1.1. Urban fabric	1.1.1. Continuous urban fabric 1.1.2. Discontinuous urban fabric
	1.2. Industrial, commercial and transport units	1.2.1. Industrial or commercial units 1.2.2. Road and rail networks and associated land 1.2.3. Port areas 1.2.4. Airports
	1.3. Mine, dump and construction sites	1.3.1. Mineral extraction sites 1.3.2. Dump sites 1.3.3. Construction sites
	1.4. Artificial non-agricultural vegetated areas	1.4.1. Green urban areas 1.4.2. Sport and leisure facilities
2. Agricultural areas	2.1.Arable land	2.1.1. Non-irrigated arable land 2.1.2. Permanently irrigated land 2.1.3. Rice fields
	2.2. Permanent crops	2.2.1. Vineyards 2.2.2. Fruit trees and berry plantations 2.2.3. Olive groves
	2.3. Pastures	2.3.1. Pastures
	2.4. Heterogeneous agricultural areas	2.4.1. Annual crops associated with permanent crops 2.4.2. Complex cultivation 2.4.3. Land principally occupied by agriculture, with significant areas of natural vegetation 2.4.4. Agro-forestry areas
3. Forests and semi-natural areas	3.1. Forests	3.1.1. Broad-leaved forest 3.1.2. Coniferous forest 3.1.3. Mixed forest
	3.2. Shrub and/or herbaceous vegetation association	3.2.1. Natural grassland 3.2.2. Moors and heathland 3.2.3. Sclerophyllous vegetation 3.2.4. Transitional woodland shrub
	3.3. Open spaces with little or no vegetation	3.3.1. Beaches, dunes, and sand plains 3.3.2. Bare rock 3.3.3. Sparsely vegetated areas 3.3.4. Burnt areas 3.3.5. Glaciers and perpetual snow
4. Wetlands	4.1. inland wetlands	4.1.1. Inland marshes 4.1.2.Peatbogs
	4.2. Coastal wetlands	4.2.1. Salt marshes 4.2.2. Salines 4.2.3. Intertidal flats

Source: CLC Corine Land Cover nomenclature

Table 1: Translation table from CLC codes to terrain roughness

Class number	CLC codes included	Class description
1	**1.1.1 Continous urban fabric**	**High density urban area**
2	1.1.2. Discontinuous urban fabric 1.2. Industrial, commercial and transport units 1.3. Mine, dump and construction sites	**Small packing urban area**
3	1.4.1. Green urban areas 2.2.2. Fruit trees and berry plantations 2.2.3. Olive groves 3.1. Forests 3.2. Shrub and/or herbaceous vegetation association	**Forests , high vegetation**
4	1.4.2. Sport and leisure facilities 2.1.1. Non-irrigated arable land 2.1.3. Rice fields 2.2.1. Vineyards 2.3.1. Pastures 2.4. Heterogeneous *agricultural areas* 3.3. Open spaces with little or no vegetation	**Grass, low vegetation**
5	4. Wetlands 2.1.2. Permanently irrigated land	**water**

Source: CLC Corine Land Cover nomenclature

The translation is implemented as function in GRASS GIS software.

2.3. Topography

Bora wind is observed to be most hazardous in areas where slope of specific orientation in the direction of the Bora wind is present in topography. This kind of slopes can be identified by perforing analysis of the elevation data of the area.

For analyses of topography of the area we can use freely available DEM (digital elevation model) data. DEM model is used to identify areas where wind speed can locally increase due to the effect that is named terrain orography. This effect is also included as a part of building norms, when caclucated the expected wind speed for specific location. The orography effect is traditionally observed only locally for specific building on particular location. In this work we perform spatial analysis of the DEM data of the terrain and calculate areas with significant orography factor for expected wind directions.

Areas with both upslope and down slope with the orientation of high wind direction are more endangered to local acceleration of wind speed and are more exposed to risk.
DEM data for all partner countries are analysed and all areas with slope higher than 5% in the direction of wind (Bora and Sirocco for Croatia and Slovenia and North West winter wind for Germany) are highlighted.

These highlighted areas are areas where wind gains velocity relative to basic wind speed. That is why subjects in these areas are exposed to higher wind energy then other areas and need additional investments on protection from high wind.

3. Subject of analysis

High risk zones determined and identified using previously described methodology are used to pinpoint specific subjects located in those areas. The specific subjects are categorized to: infrastructure, transportation lines, buildings and forests.

3.1. Infrastructure data

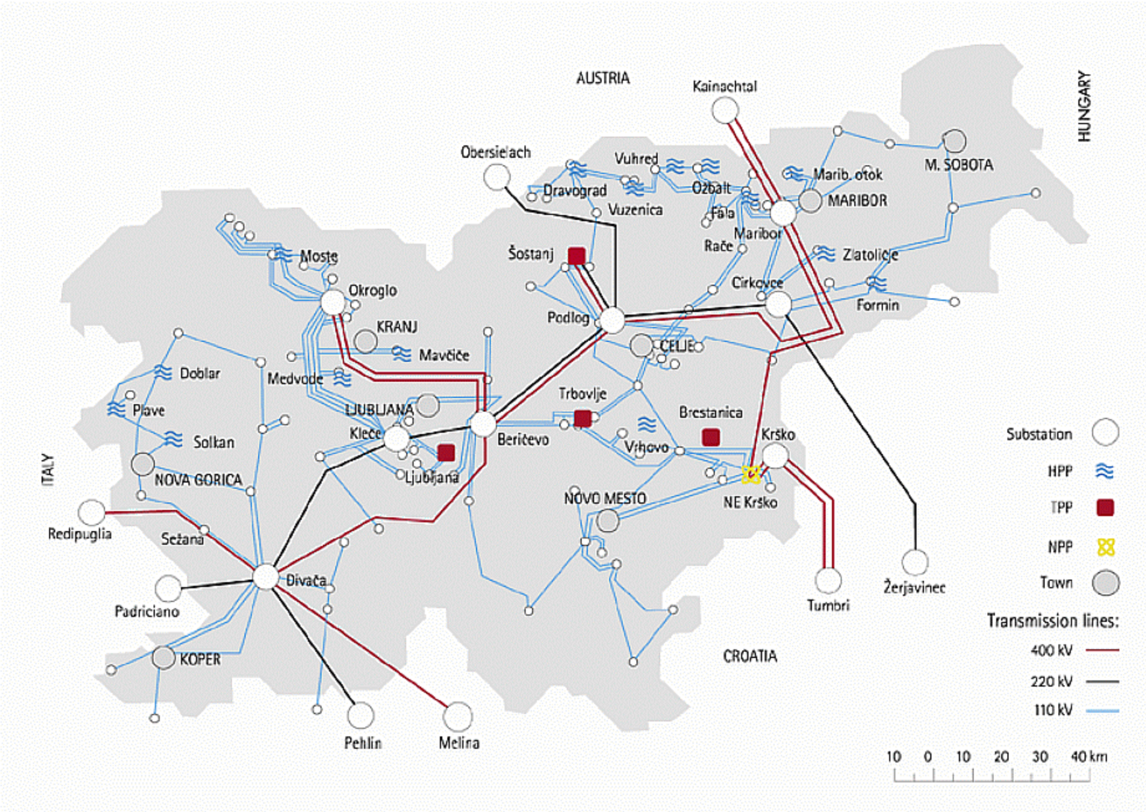
Critical infrastructure is often vulnerable from high, especialy when situated in high risk zones. All constructions above ground level are vulnerable from high wind. Power transmission lines installed above level of ground can find to be situated in high wind zones. Power pillars, telecom antenna pillars are also sometimes damaged by high wind.

Data about power infrastructure for partner countries can be found on http://www.geni.org/.

Figure 5: Power lines in Croatia

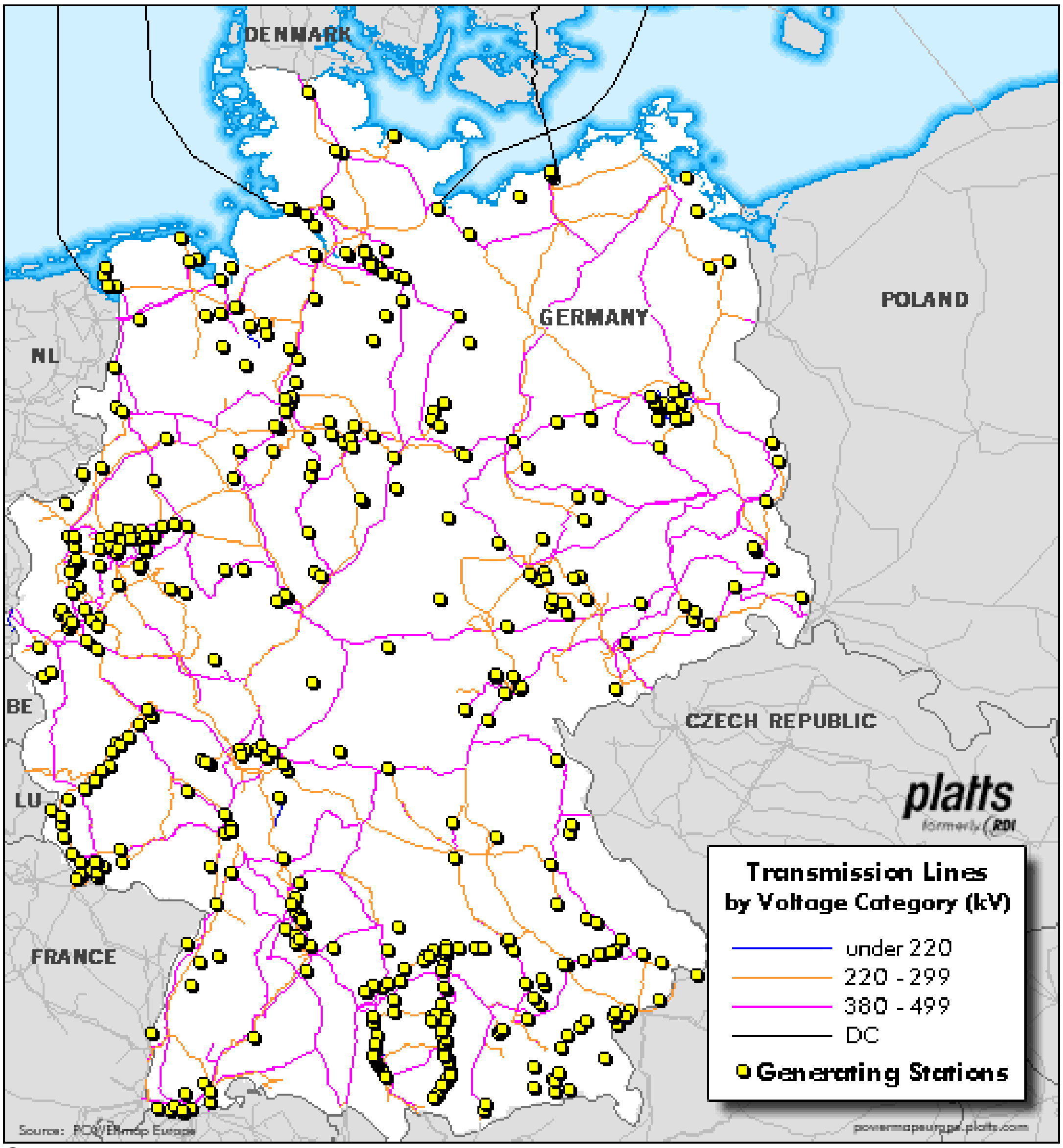
Source:http://www.geni.org/globalenergy/library/national_energy_grid/croatia/croatiannationalelectricitygrid.shtml

Figure 6: Slovenia, power lines.



Source: http://www.geni.org/globalenergy/library/national_energy_grid/slovenia/sloveniannationalelectricitygrid.shtml

Figure 7: Germany, power lines



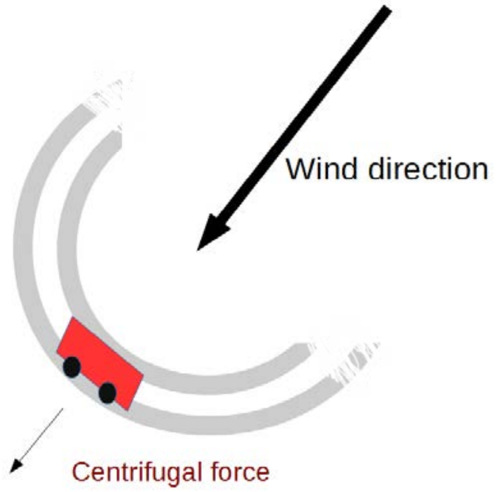
Source: http://www.geni.org/globalenergy/library/national_energy_grid/germany/germannationallectricitygrid.shtml

3.2. Transportation

Location of roads in the map is presented in road map of the area. OpenStreetMap is a project that aims to provide free road map for everyone based on contributions of the society. These maps are not official road maps but are precise enough for use in navigation software and for the purpose of map visualizations.

All roads in area of high wind are affected but especially vulnerable parts are road curves with center of curvature upwards regarding the winds. Vehicles driving along these parts are subjected to centrifugal forces on which wind loads are superimposed which can lead to vehicle turnover. Similar effects are expected on railroad cars, but are diminished due to large mass of train composition, slow speeds (in Croatia) and length of train that is much longer than wind induced vortex.

Figure 8: Road with center of curvature upwards regarding the winds



Source: Archive Split

3.3. Buildings

Locations of buildings in a map are obtained in order to locate the buildings located in high risk zones without appropriate wind protection. Buildings location can also be obtained from OpenStreetMap maps. Urban areas in CLC map are those were most of the area is covered by buildings. It is hard to speculate which building is more important to protect, since damage on all buildings can cause injuries, costs and degradation of life quality.

Old buildings that represent cultural heritage are among most endangered from the wind mostly because of degradation of material with age. But also, newly built buildings, in case when constructors did not take safety rules into account are endangered. Public buildings like kindergartens, schools, government buildings are also important to protect from wind because of fluctuation of people in the nearby.

3.4. Forests

Majority of the unpopulated area of each partner country is covered with low or high vegetation. Some of the areas are covered with dense forests, either privately owned or state owned. Dense forests are considered natural heritage and are protected regularly. High wind in forests that are not maintained properly can cause damages on trees which influences on forest ecosystem. Location of forests on the map is estimated from Corinne land cover maps by extracting only forest categories.

4. General recommendation for mitigation of risk

There are many different approaches to wind risk management that can be applied depending on the subject of protection. But before applying the mitigation means, we must understand effect and nature of the wind locally at the place of the endangered subject.

Currently official measurements are done only sparsely, by meteorological services. Building dense network of wind measuring stations can provide better understanding on effects of local wind phenomena. Also the dens measurement station network can be used for alarming public of upcoming strong winds

Wind is very sensitive to topological configurations. Well known “canyon effect” can funnel winds and have local extreme wind speed values higher than surrounding. Also, terrain has strong effect on wind direction. By developing dense grid of measurements station and pairing it with adequate numerical model a various tasks can be performed:

- defining local hotspots of strong winds
- early warning systems for stopping traffic before high wind
- developing spatial urbanistic plans that include strong winds data
- developing alternative routes

Figure 9: Franjo Tuđman bridge (a.k.a. Dubrovnik bridge)

Source: Archive Split

4.1.1. Critical infrastructure

Infrastructure (power and IT) can benefit from windbreakers in areas where high winds are frequent. Also, special types of cable shielding can be used. Cable shielding with protruding helicoidally strands acts as fixed barrier for vortex shedding which is lowering Karman forces and stabilizing its position. Such cables are more resisting to fatigue. Additionally, vibration suppression elements can be added. All these additions are rising costs of cable lines significantly so economical approach is required.

4.1.2. Critical Transportation

Wind barriers are effective in protection of roads but they have to be efficiently planned and regularly maintained. Efficient planning is function input data – wind loads, which leads to importance of measurement grid of wind stations.

Bridges require individual attention. Regarding traffic, same proposition apply as in roads. For constructional safety under strong winds, they are dependent on main construction material, construction type and bridge design. Most vulnerable types are cable stayed bridges. Nearest such bridge is Dubrovnik bridge which have lot of problems regarding winds.

The stay cables vibrate under wind forces as result of Karman forces. As specific wind speed, cables resonate and their amplitude increases. That leads to impact between cables, degrading surface of cables and rising possibility of bridge failure (Čaušević, Bulić, 2015). The effect of wind was partially mitigated by installing wind oscillation suppressors. Cause of this problem is inadequate wind surveying and modeling in bridge design phase.

Efficient and sustainable way of protecting roads is by developing specific urban green areas, with vegetation high enough to provide shelter from wind and resilient enough to withstand wind and wind carried debris.

4.1.3. Critical buildings

In urban areas, buildings are under impact of high wind loads. Effect on buildings are due to direct wind loading or under concentrated wind loading after funneling of wind currents in city canyons. The wind loading can be reduced by planting green urban areas that dissipates wind energy. To make them efficient, prior to design a careful monitoring must be performed and its result, as well as geometry of area must be input to CFD (computational fluid dynamics) model or physical model to be tested in wind tunnel.

In building phase of the constructions, special design and organization attention requires building scaffolding, light walls and parts of the construction transported on higher levels of construction. Building in areas where strong winds are occurring should be under strict building site monitoring. Also, in design phase the timing of building steps should not leave parts of the construction without outer shell while building interior walls. Education of civil engineers and local administrative officers should be enhanced in that area.

Building quality is also reflected in building wind safety. Proper materials and installation techniques are required to ensure all parts of construction to be attached to main construction under all regimes of wind loading. A brochure for civil engineering contractors is a good communication tool to rise attention of builders what can badly installed parts do. Damage arisen from badly installed parts of construction is twice: main building is damaged by ripping of part and other buildings or people can be hurt by ripped flying debris.

Over the time materials degrade and constant monitoring and maintenance is required. The highways have good internal systems of regular check-up of all parts of roads and series of scheduled and extraordinary repairs of them. It is all included in Quality Assurance manual of HAC – Croatian authorities for highways. Few of other constructions in Croatia have them and even fewer follow rules from them.

Extremely high buildings, which are not yet build in Croatia, can benefit from ATMD (active tuned mass dumpers). It is a electrically manipulated mass on top of high building that can counter seismic and wind vibrations to enhances security of construction.

4.1.4. Critical forests

Specific types of forest are resilient to wind actions, but special percussions are needed to protect them from fires in combination with winds.

Other important maintenance issue is forest thinning. With forest thinning, the forest benefits both to fire safety and wind safety.

5. Identification of high risk areas for partner countries

5.1. Croatia

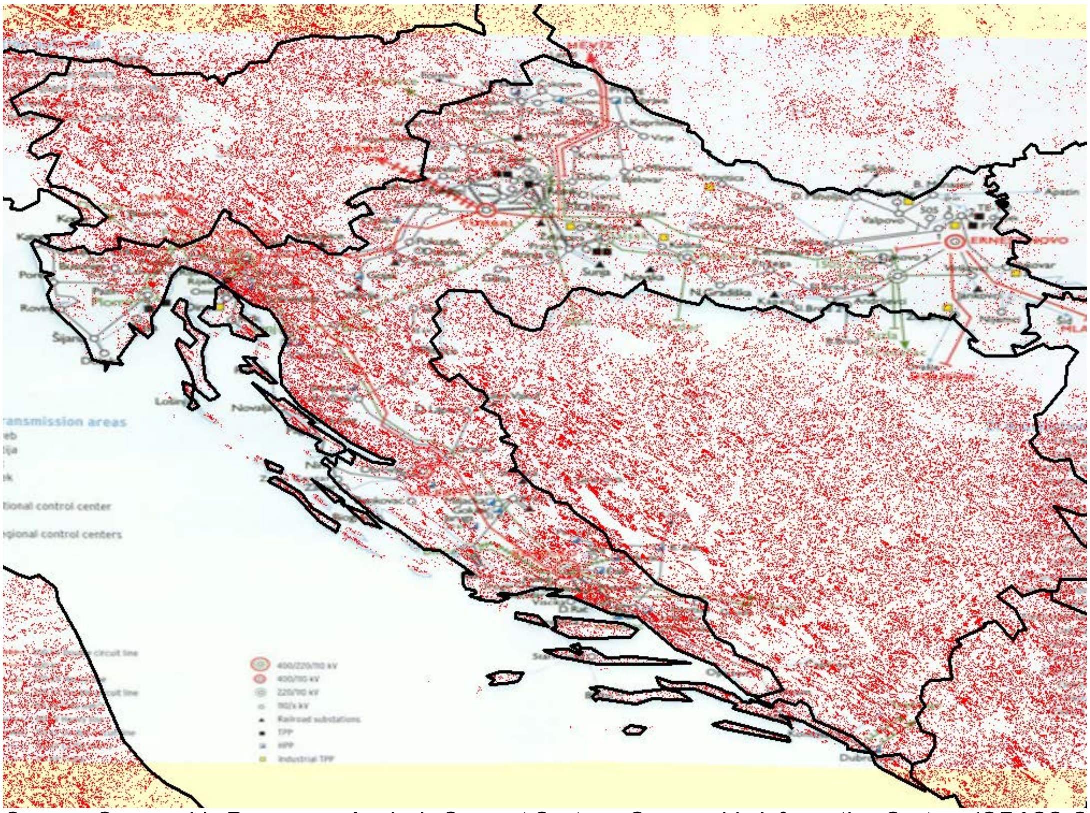
In Croatia we have two main wind directions that cause damage on infrastructure, buildings, transportation and forests – Bora North wind and Sirocco.

In the following text we will overlay the locations of critical subjects and analyse the locations with regard to exposedness to these winds.

5.1.1. Critical infrastructure

Among critical infrastructure we will take into account locations of power lines. In the image below we can see the map of Croatian power lines with superposed locations with topography slope orientation in the direction of Bora and Sirocco. We can see that coastal part of Croatia is more exposed to these two winds and that is where majority of damages happen. Dalmatia region is also selected as target area of the Wind Risk project so we will focus only on this part of the country.

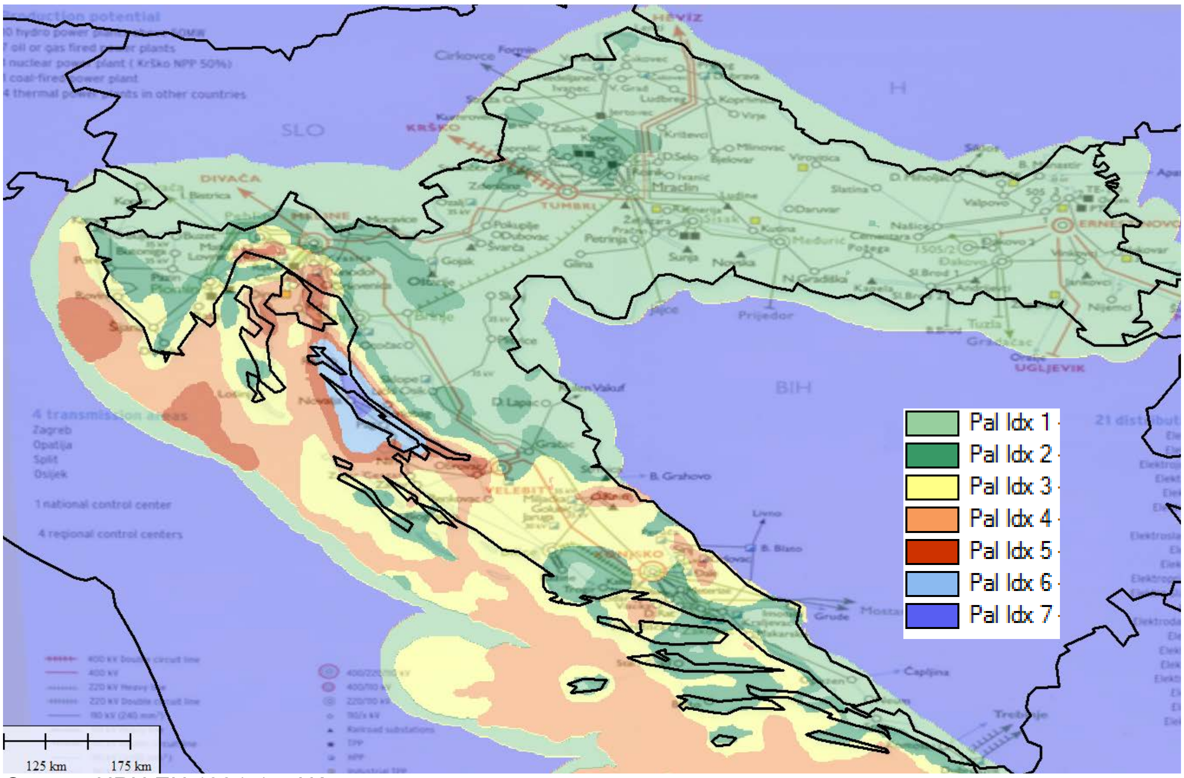
Figure 10: Power lines and Bora and Jugo vulnerability



Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

The same can be observed from wind load map shown in Figure 11.

Figure 11: Power lines and wind load map



Source: HRN EN 1991-1-4 NA

If we zoom in to Split and Damatia County, we can see thet there are no class 6 or 7 zone present, but there is area around Peruca Lake classified as zone 4 and 5. This area is important as the main electrical plant is located on Peruca Lake and power is distributed from here.

Another exposed area is between cities Split and Omis, where pover lines are located. Basic wind speed for this area is class 2, but in case of Bora wind, below Mosor mountain wind can gain speed and additional protection of lines is recommended. On the other hand, as shown in figure 16 Sirocco wind does not have critical influence on electrical power lines infrastructure in Dalmatia.

Figure 12: Bora wind and infrastructure in area of City of Split

Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

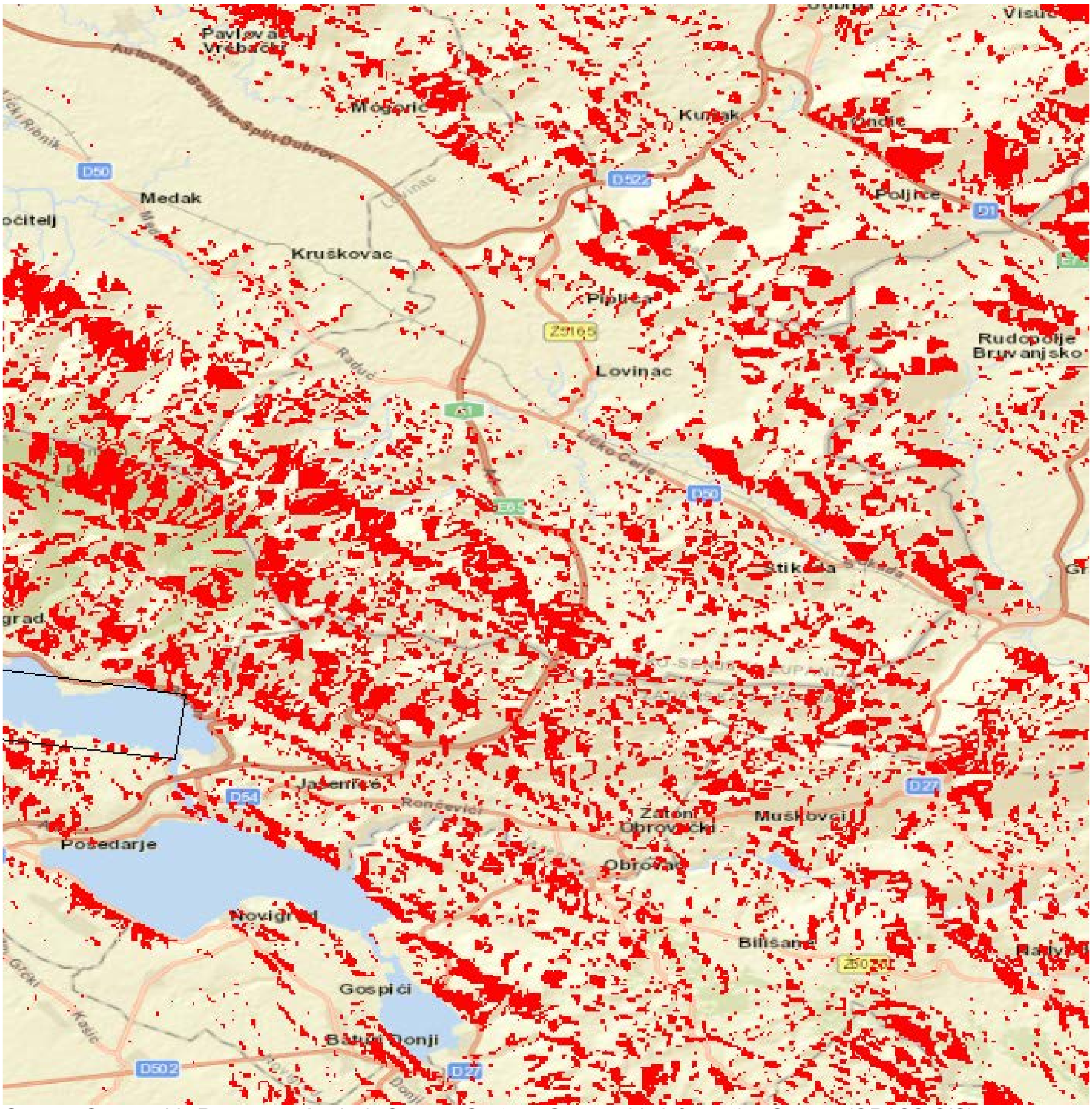
Figure 13: Sirocco and power lines in Dalmatia

Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

5.1.2. Critical Transportation

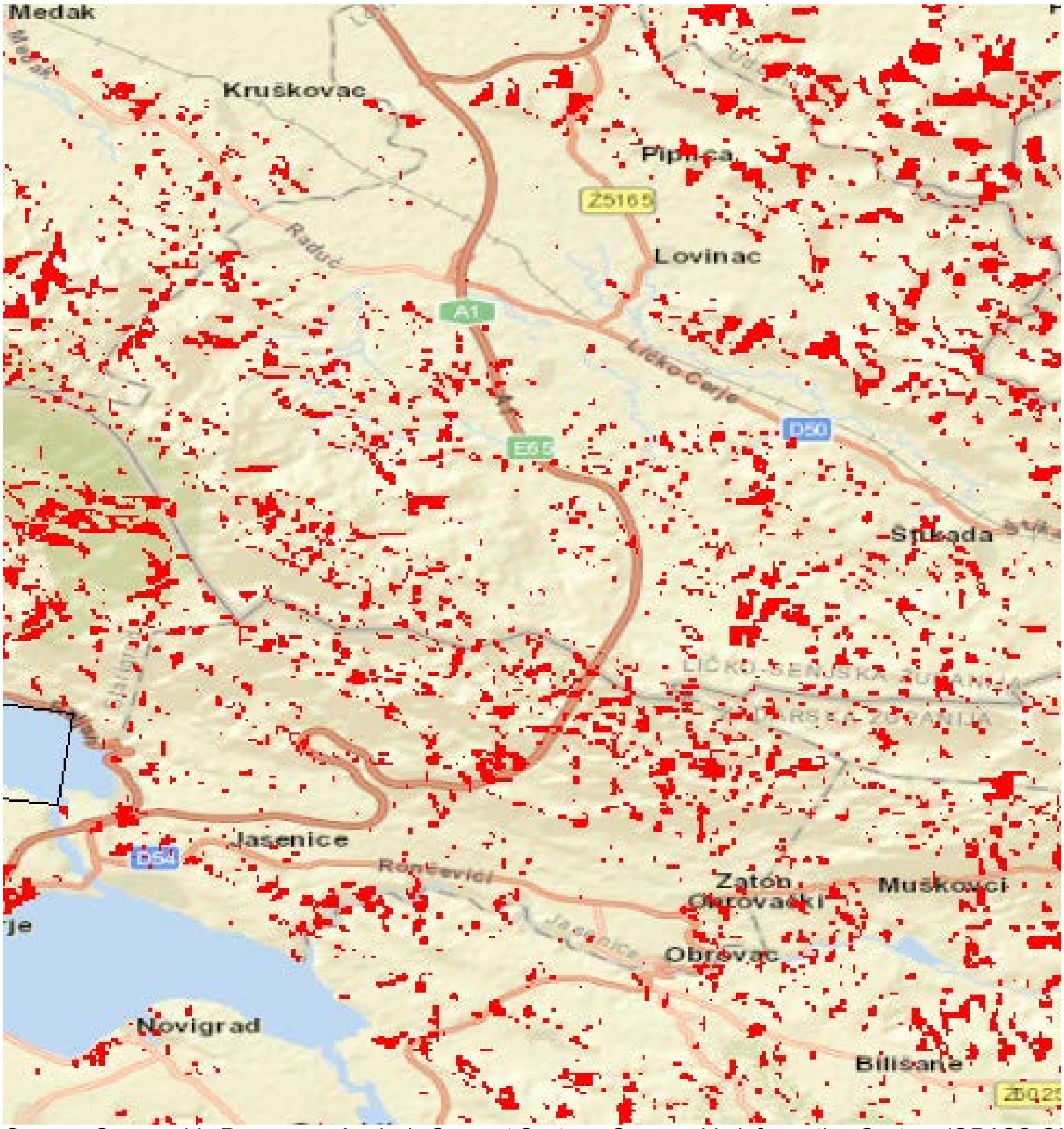
It is noted that part of the highway Sv.Rok-Posedarje is often closed because of the strong wind. In the image we can see that the part of road is often exposed to high bora wind

Figure 14: Bora on Sv.Rok-Posedarje part of the highway



Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

Figure 15: Sirocco direction influence on the same part of the highway



Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

Figure 16. Maslenica Bridge and effect of Bora

Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

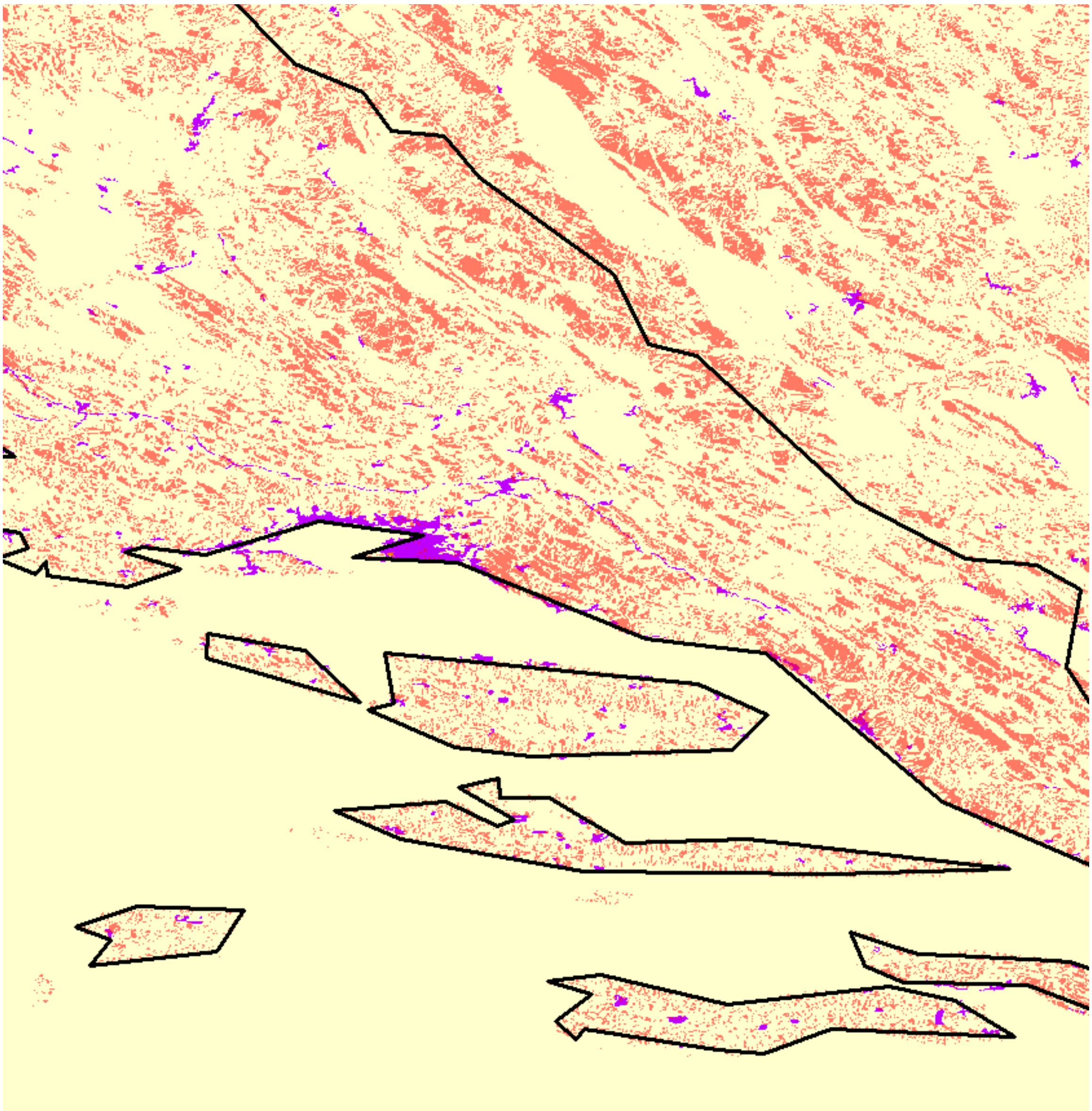
5.1.3. Critical buildings

Urban areas are areas where buildings are located. The purple areas shown in Figure 12 are matching major cities in Dalmatia. In this report we will further analyze the area of city Split as it is the biggest city in the area.

Damages on old buildings due to material degradation happen and not only represent safety problem, but also loss of cultural heritage. Both major wind directions can cause roofs or facade damage on old houses as well as on newly built houses if proper building measures were not applied.

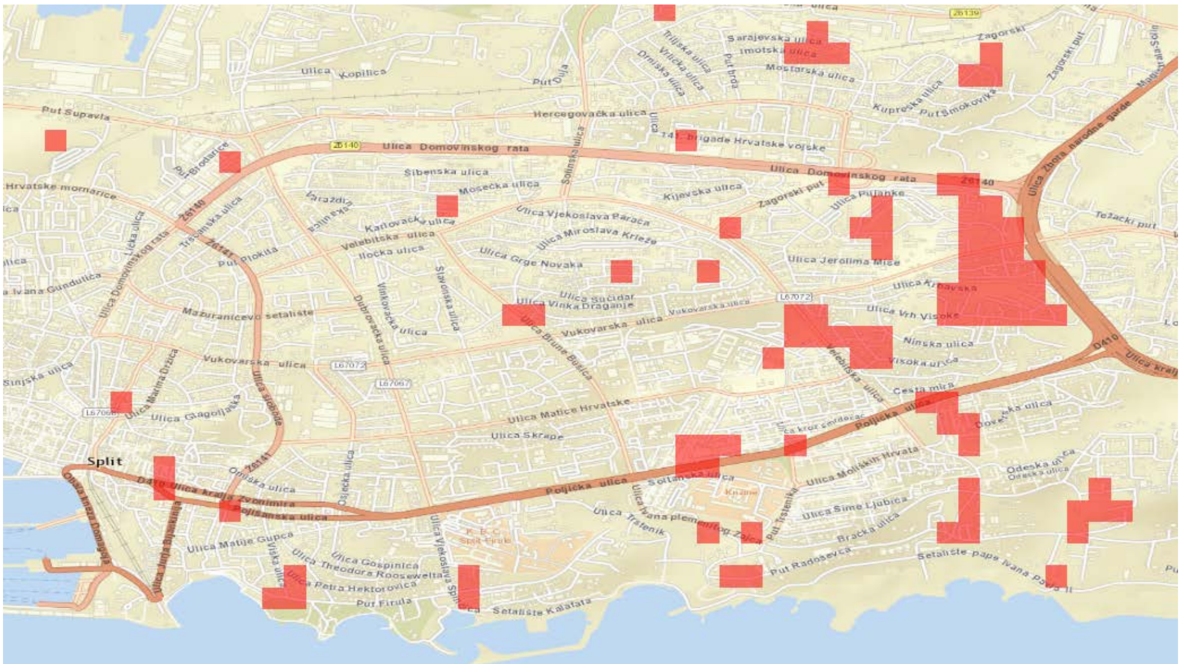
It is not uncommon for local news to report warnings on locations where buildings are damaged because of the wind or are dangerous due to possibility of damage. One such warning on local web site can be seen on Figure 14.

Figure 17: Urban areas in central Dalmatia and topography exposed to Bora



Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

Figure 18: Split critical zones from Bora



Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

Figure 19: News from local news web site

Foto: Zvonimir Barišin / CROPIX

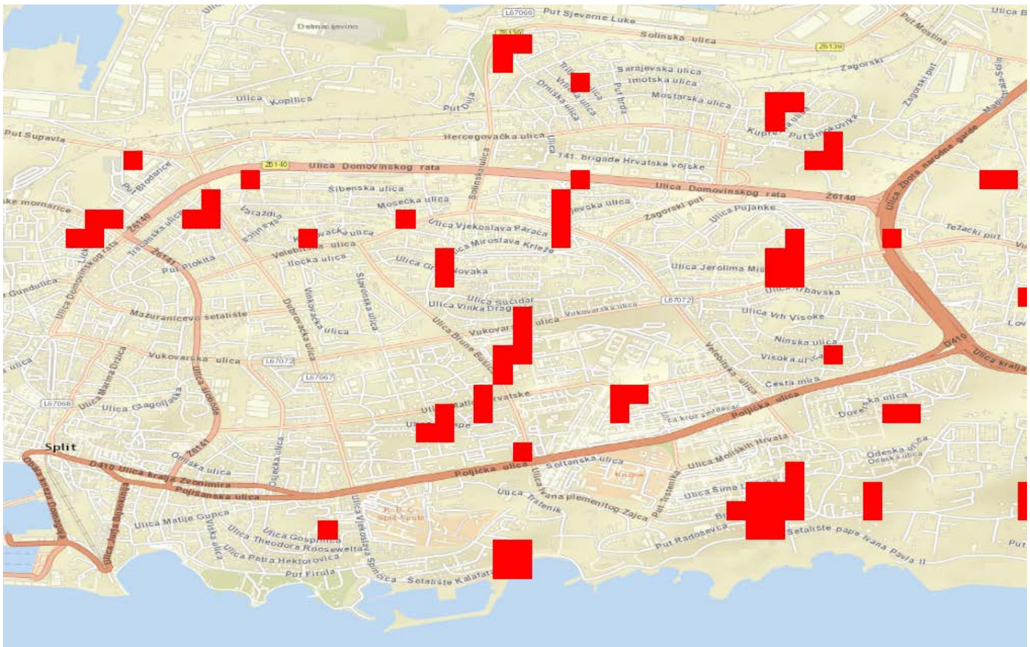
Prijeti raspadanje pregradnih zidova zgrade: Zatvorena ulica u Splitu!

Zatvoren je sjeverni kolnički trak ulice Domovinskog rata, od Solinske do Dubrovačke

16.01.2016. u 19:50h
MARIO MATANA

Source: Mario Matana. Local news.

Figure 20: Split critical zones form sirocco



Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

Sirocco wind blows from direction that exposes lesser area directly to wind direction, but this wind sometimes can produce damages. In Figure 21 we can see building which facade was damaged.

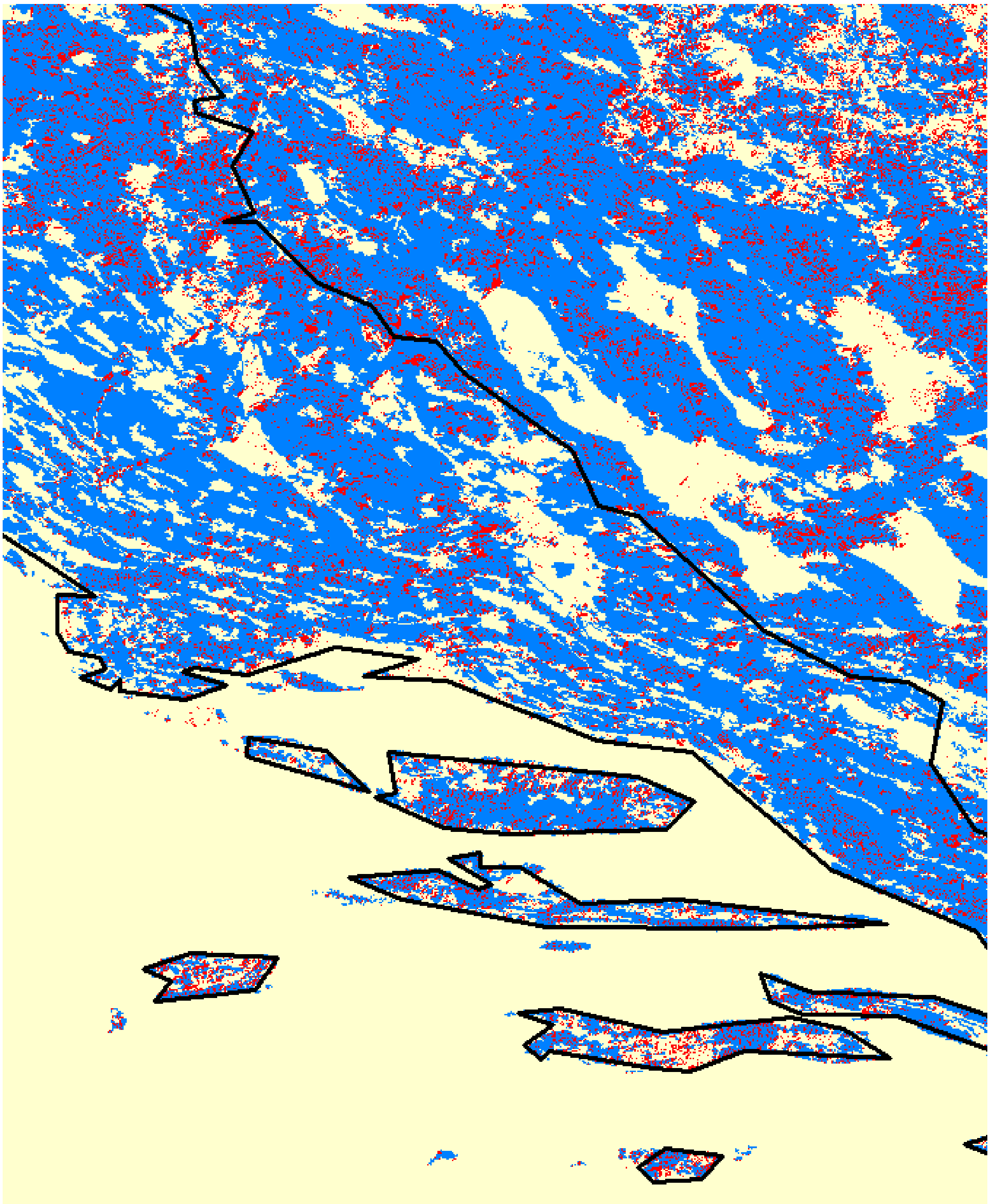
Figure 21: Damaged facade from strong Sirocco

Source: Photo Miranda Cikotic

5.1.4. Critical forests

With respect of forest vulnerability to high wind events no physical investments are recommended, only regular maintenance. Thinning forests and maintaining forest roads are regular measures used both for wind and fire protection. Also, traditional species of trees are more resilient to wind damage and are more often chosen when reforesting.

Figure 22: Forests exposed to Bora



Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

5.2. Slovenia

In Slovenia, the high winds are not very frequent when compared to the prevailing high winds over Western Europe since it is located in the lee-side of the Alps. On the one hand, the hills and mountains create a barrier to the wind, and on the other hand, they deflect the air flows, which have to adjust to the surface. For the local conditions, the distribution of water surfaces as well as a daily heating and cooling of the atmosphere are also very important.

The winds in Slovenia with their range of activity of around 100 km are the results of general winds and the effect of Alpine and Dinaric mountain barrier as well. Over the Slovenia surface three ‘regional’ winds are: bora, jugo and foehn. All of them are described in Task C.2 in detail.

In our case studies for Slovenia (Ajdovščina and Ljubljana area) is difference between storms, bora and sirocco wind. The bora wind has a distinct storm path which is usually according to the main wind direction; north-east to south-east. The sirocco has just the opposite main wind direction. Storms, on the other hand, cannot be associated with one major wind direction. Storm events have no predictable storm paths, no main wind direction and can cause large-scale damages.

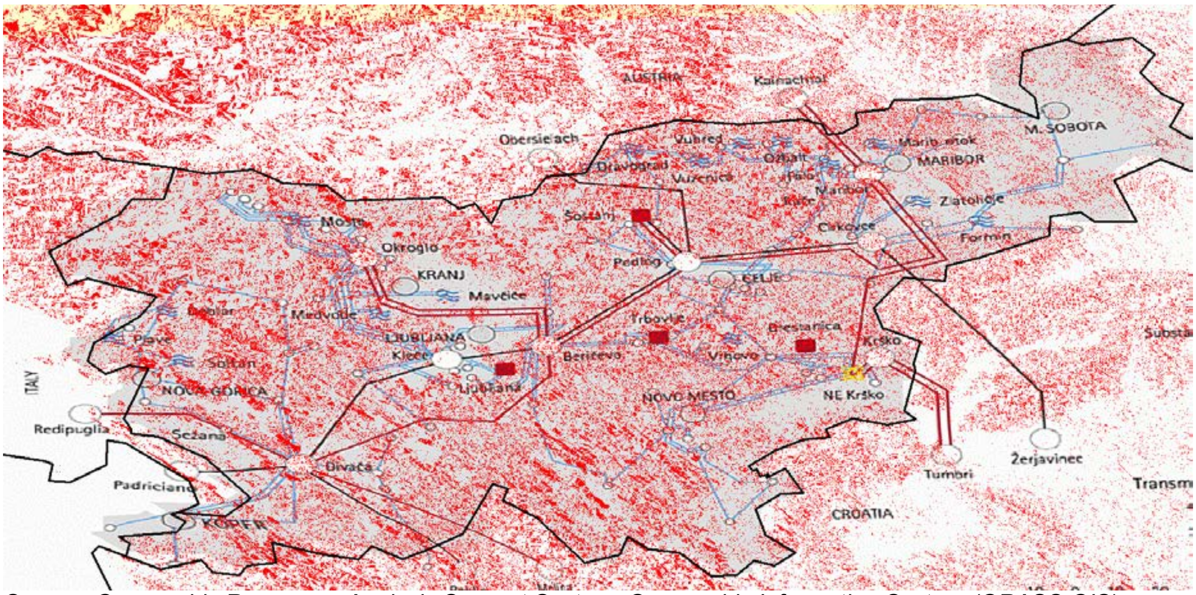
The focus of this chapter is on physical investments or measures that can help enhancing the vulnerability parameters such as infrastructure, transport, forest and buildings and decreasing potential losses from bora wind and storms. The institutional preparedness/warning management is the topic of Report D.3. Further, some recommendations concerning additional building code, rules and regulations are presented in Report D.4, while guidelines for local economical endorsements for construction of buildings are described in Report D.7.

5.2.1. Critical infrastructure

The energy supply infrastructure and communication infrastructure are the main vulnerability parameter of infrastructure. The most important components in the electric power system for electricity transmission are electrical overhead lines as well as telephone landlines and radio masts.

Regarding bora wind, the location of power supply lines and transformer stations are of special importance. The following figure shows high voltage transmission lines in Slovenia in relation to two main wind direction. In the first figure it can be seen that the exposure to bora wind is especially high in western and south-western Slovenia (Primorska region, Vipava valley) as well as in south-eastern Slovenia (Ribnica, Kočevje) which is due to topography and main wind direction.

Figure 23: Bora on power lines

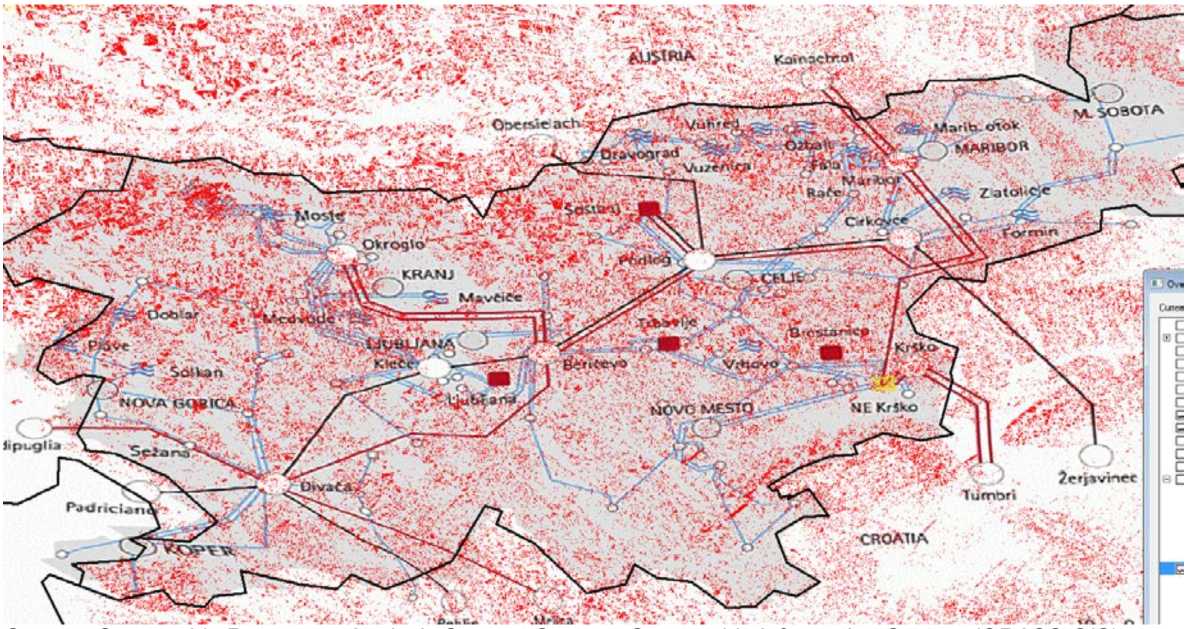


Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

On the other hand, the following map of the sirocco wind shows that especially at the coasts wind loads are very high. The sirocco wind appears as a strong wind from the southwest to southeast before a cold front passing Mediterranean cyclone. It appears exclusively in the coastal area and moves inland no further than the ridge of Karst.

The difference is probably due to local wind characteristics which differ strongly between the coastal areas and the inland.

Figure 24: Sirocco on power lines



Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

The newly constructed 400 kV Beričevo-Krško transmission line provide continuous supply to the central Slovenia, so it has to be noted that without this transmission line Ljubljana and its surroundings may have sustained large-scale blackout when it was hit by sleet and wind in the beginning of February 2014. This event more than just confirmed the fact, that the newly constructed transmission line is a great importance for a reliable and quality power in Slovenia; in addition to the already important role from the standpoint of increased possibilities of cross-border exchanges with foreign countries.

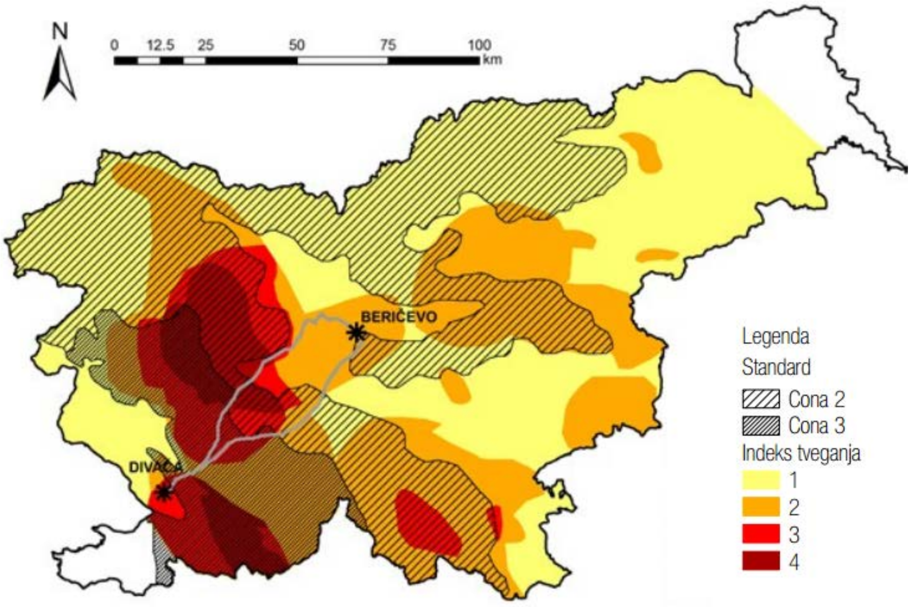
A risk assessment method for energy infrastructure due to extreme weather events was developed and tested on a case study of damage to electric transmission and distribution grid due to glaze ice. The results of the risk assessment – risk maps – can be used in the spatial planning process for the allocation of planned infrastructure in areas where damage due to extreme weather events is expected to be smaller. For the existing infrastructure in high risk areas, additional technical measures for enhancement of resilience can be proposed (Matko et al., 2015).

The method presented by Matko et al. (2015) was divided in four steps:

1. Step: Determination of the intensity and spatial extension of extreme weather event based on data of occurrence of similar events in the past.
2. Step: Analysis of the vulnerability of energy infrastructures or areas where the infrastructure is, to a certain type of extreme weather event.
3. Step: Determination of probability/frequency of occurrence of extreme weather events in an area where there is already infrastructure and energy will be placed in the future.
4. Step: Merging the above steps for the determination of physical and other (economic, medical) consequences and determining the index of risk for a given area and energy infrastructure.

Next figure shows map of comparison between risks to power grid and standard SIST EN 50341-3-21 for building high voltage power lines. Besides, there are also presented the proposed alternatives of the planned 400 kV power line Beričevo-Divača.

Figure 25: Map of risks to power grid due to glaze ice covered with standard SIST EN 50341-3-21 for building high voltage power lines and proposed alternatives of the planned 400 kV power line Beričevo-Divača.



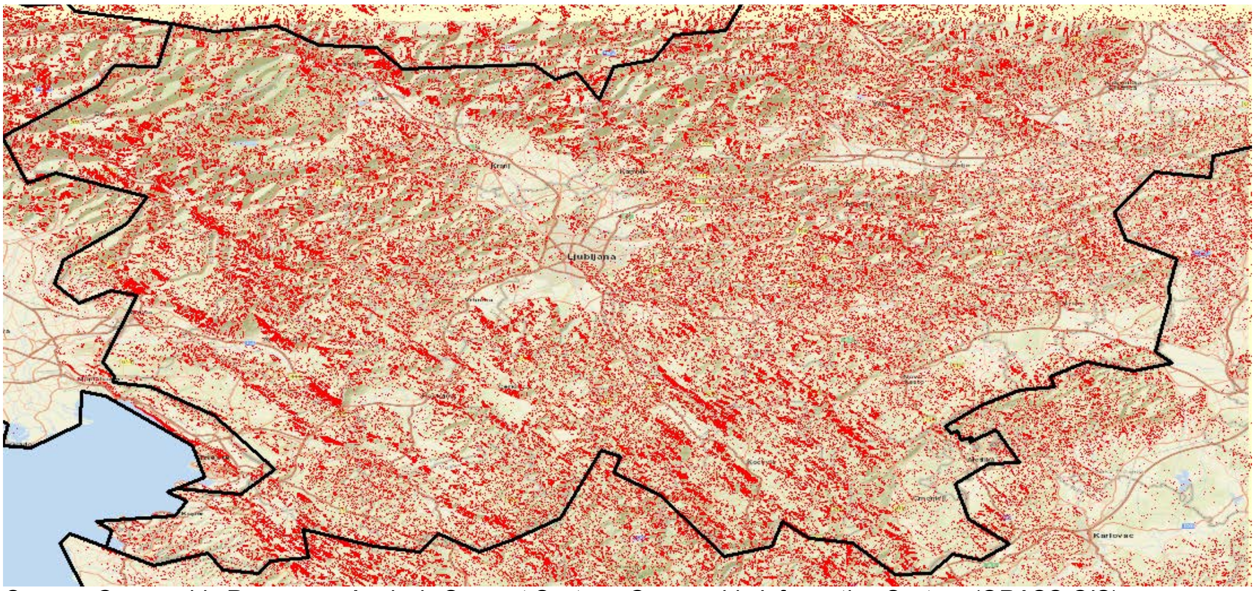
Source: Standard SIST EN 50341-3-21 covered by risk index zones

We may conclude that there exist two approaches to reduce and prevent damages to infrastructure due to extreme weather events. The first comprise technical improvements to the mechanical components in the way that are more resistant to physical stress; and at the second it goes for setting the infrastructure to places where vulnerability is lower regarding to climatic events. According to Auld et al. (2006) the risk assessment for energy infrastructure is an important part of ensuring resistance in the context of adapting the energy sector on climate change and should be involved in the planning of new infrastructure.

5.2.2. Critical Transportation

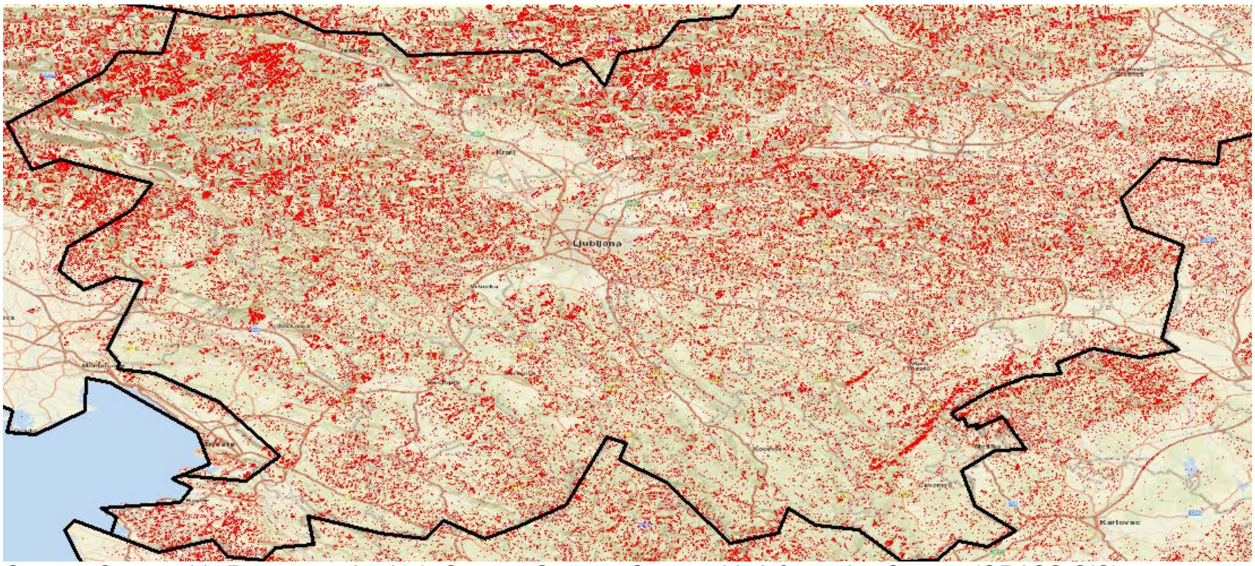
The roads network and railway network are the main vulnerability parameter of transport. The most important part of this is the transport of population and cargo transport. The following two maps depict the main highways and gives indications of zones with high exposure towards wind. Due to strong wind and high wind gusts, the roads in the Vipava valley are often closed. In other region, the transport network is affected by combination of strong wind and snowfalls and/or sleet.

Figure 26: Overlay of Bora zones and road map of Slovenia



Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

Figure 27: Sirocco high risk zones and road map of Slovenia



Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

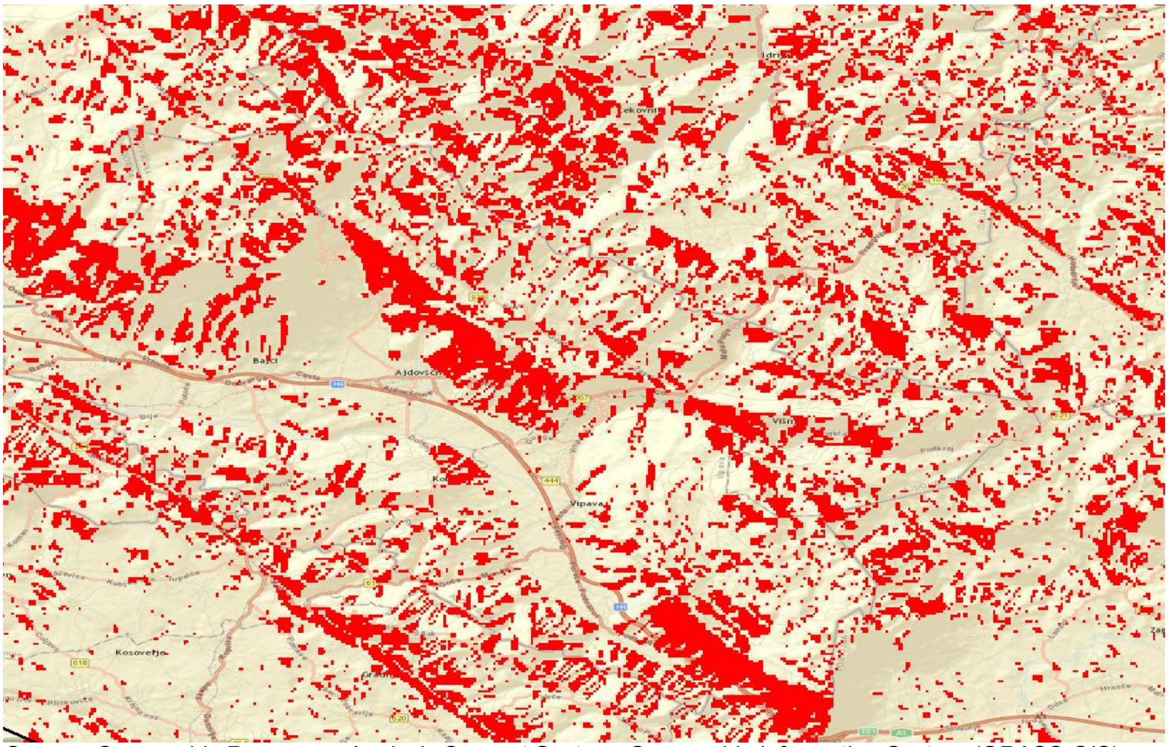
Transport management is a delicate matter and therefore should be studied by using test fields and additional measurements at the exposed parts of highways and local roads of great importance; in an order to design and establish wind protection by using wind barriers to reduce high wind effect on transport and therefore reduce the losses of local and also international industry.

5.2.3. Critical buildings

According to our case studies, we will present the impact of high wind, bora and sirocco, to buildings in Ajdovščina in Ljubljana. As can be seen in the following figures, the most effect of high bora wind to buildings is in Ajdovščina. The Ajdovščina is less affected by sirocco wind.

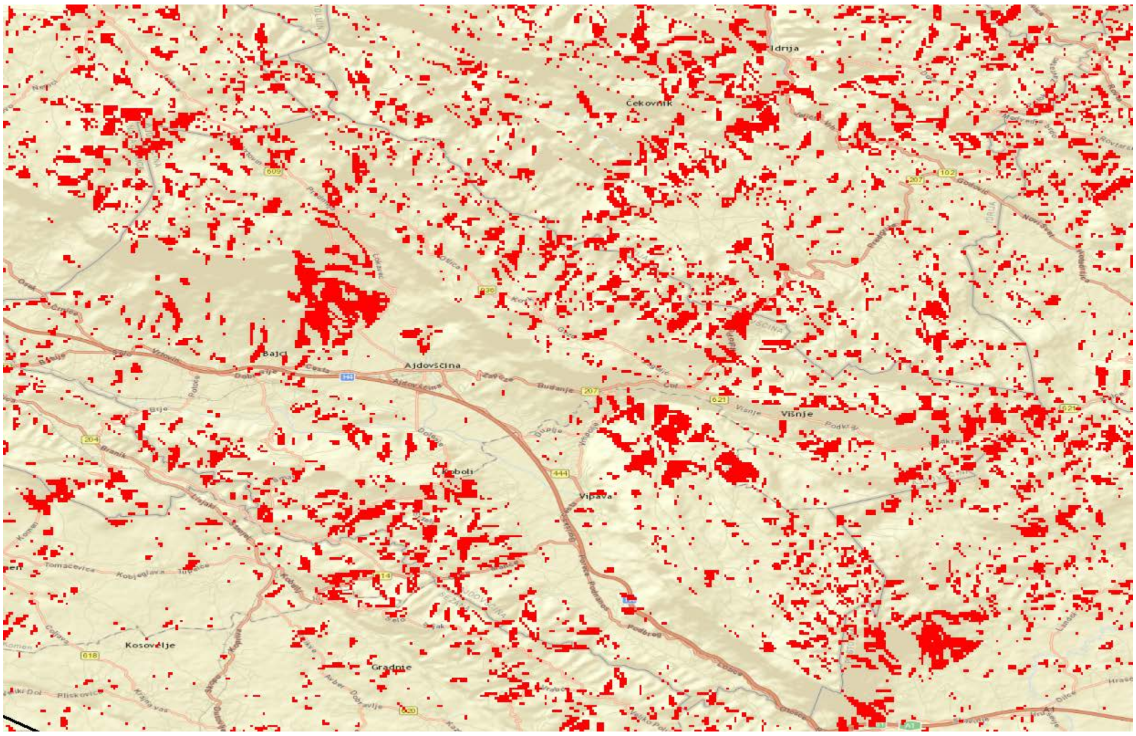
5.2.3.1. Ajdovscina

Figure 28: High risk zones of Bora wind in Ajdovščina area



Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

Figure 29: High risk zones of Sirocco wind in Ajdovščina area

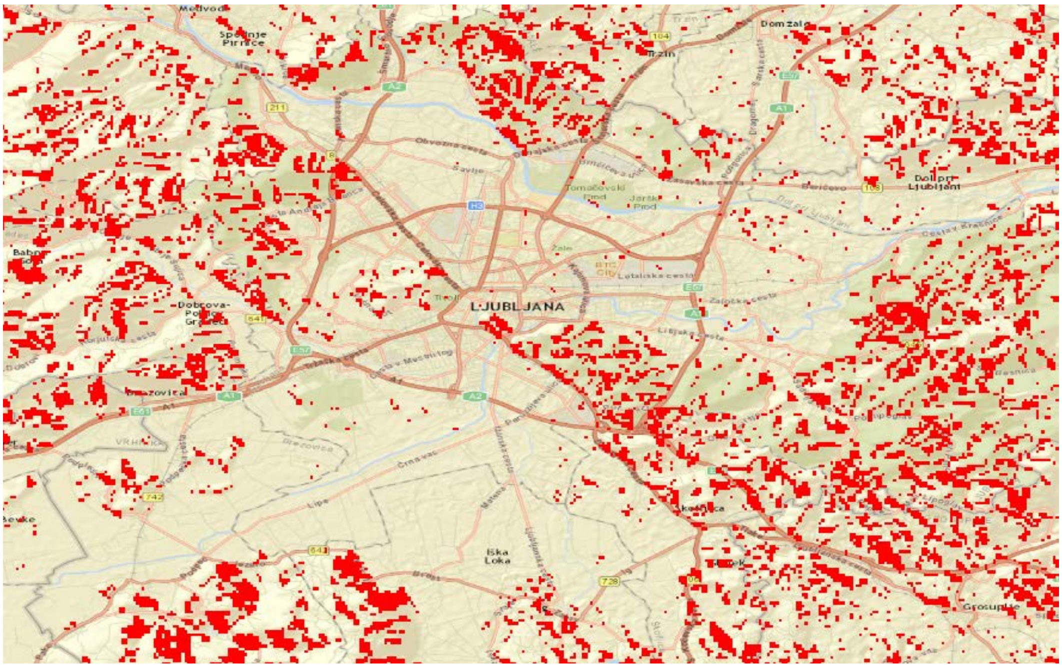


Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

5.2.3.2. Ljubljana

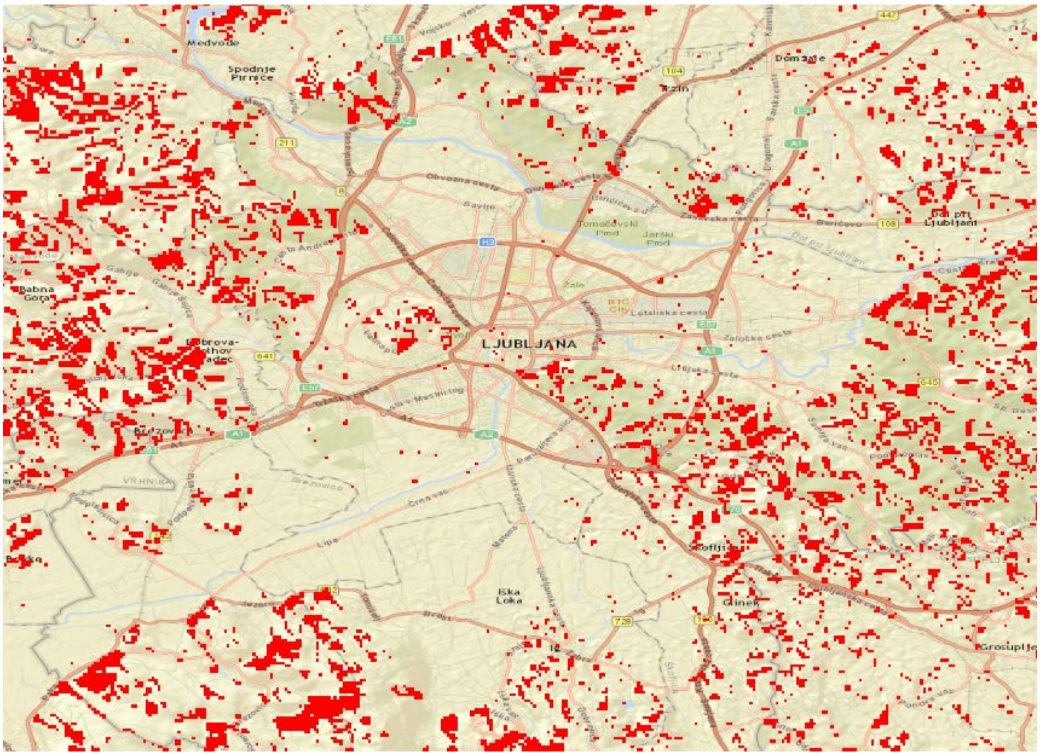
In urban areas, such is Ljubljana; buildings are also affected by high gusty wind, but not because of the bora or sirocco, but because of the storms where the main direct is unknown. Wind speed may be reduced by planting green urban areas which dissipates wind energy.

Figure 30: High risk zones of Bora wind in Ljubljana City



Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

Figure 31: High risk zones of Sirocco wind in Ljubljana area



Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

5.2.4. Critical forests

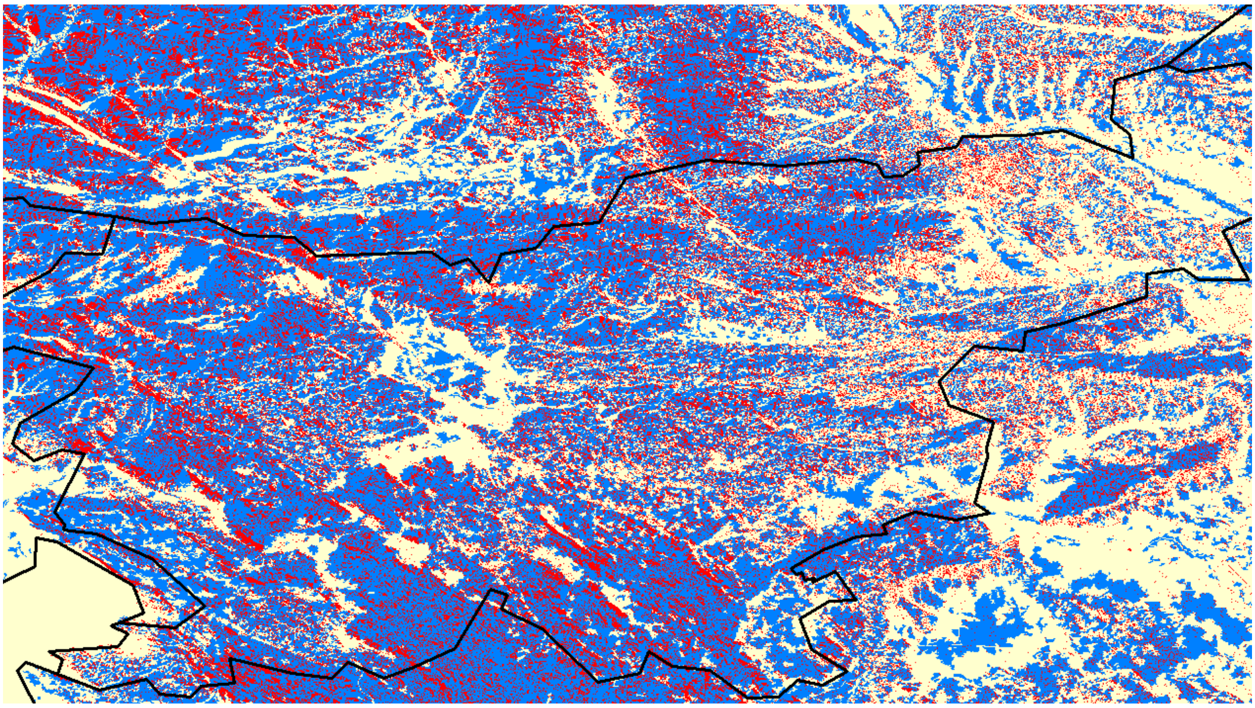
Slovenia belongs to the most forested countries in Europe and, as it is seen in following figures, the bora wind has more influence on forest than sirocco wind. Ajdovščina area is more affected by high wind in one main direction when compared to Ljubljana area where the storms are more often.

The direction of most frequent winds should be included by forestry management as:

- cutting down trees
- thinning of trees (the intensity of thinning)
- adaptation to the forest edge (avoiding sharp edges)
- reconstruction of stands (the reforestation start on the leeward side)
- priority should be given to trees that has stabilize stands (healthy, well-rooted, ...)

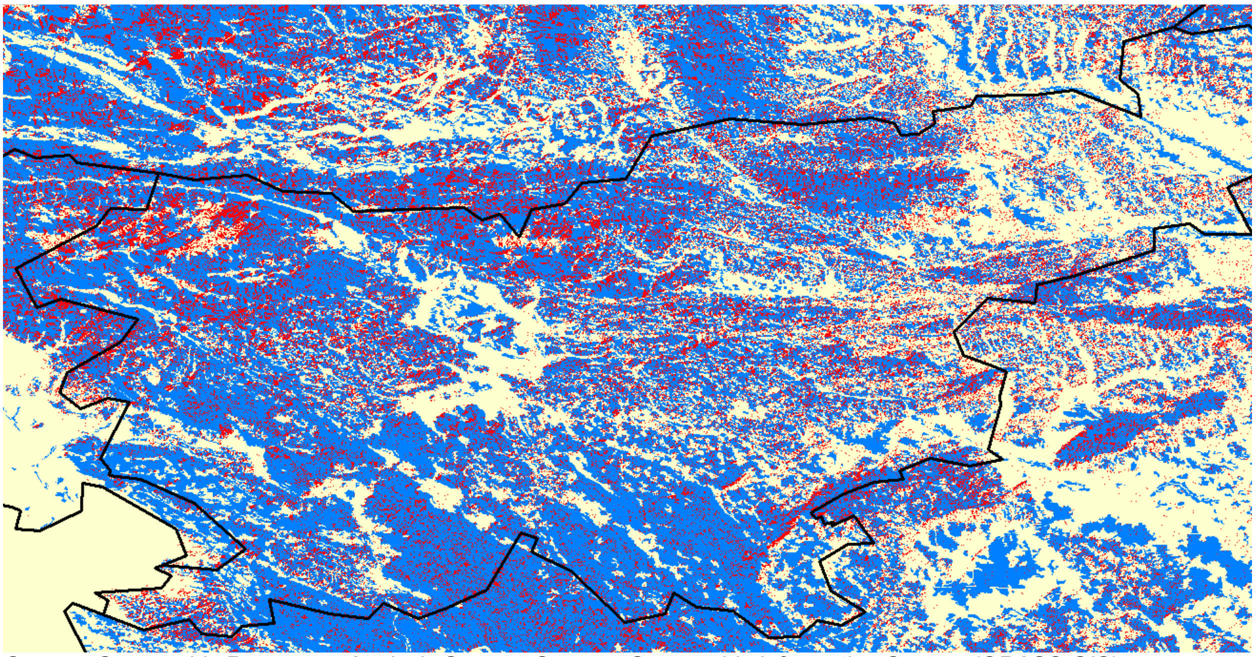
In Ljubljana, urban forest is affected by high gusty wind during storms with unknown main wind direction. Wind speed may be reduced by vegetation zones which dissipates wind energy.

Figure 32: Overlay of high risk zones from Bora wind and forests map



Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

Figure 33: Overlay of high risk zones from Sirocco wind and forests map



Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

5.3. Germany

In Germany, there is a major difference between winter storms and summer storms. Winter storms, as e.g. *Kyrill* (in 2009), have a distinct storm path which is usually according to the main wind direction; south-west to north-east. Summer storms on the other hand cannot be associated with one major wind direction. As thunderstorms, summerly storm events have no predictable storm paths, no main wind direction and the most damaging characteristic about them are downbursts[1].

The approach taken for the German case is therefore within each of the following subchapters to first present results for winter storms, following the methodology of the Croatian and Slovenian partners. Secondly, an additional thoughts and recommendations will be given for physical investments regarding prevention and preparedness measures for extreme summer storm events like thunderstorm *Ela*.

Beforehand it needs to be stated though, that the focus of this chapter is on physical, meaning tangible investments or measures that can help enhancing the above mentioned vulnerability parameters and decreasing potential losses from storms. Respectively, intangible measures, as e.g. an enhancement of institutional preparedness or warning management, are not addressed in this report but are the focus topic of Wind Risk Prevention Project Report D.3.

5.3.1. Critical infrastructure

The vulnerability parameter "infrastructure" can be divided into "technical" and "social infrastructure". Therein "technical infrastructure" refers to all infrastructure facilities in the fields of water, energy, transport, telecommunication and others. "Social infrastructure" entitles facilities of societal use as e.g. in the fields of education, health as well as cultural heritage and sports[2].

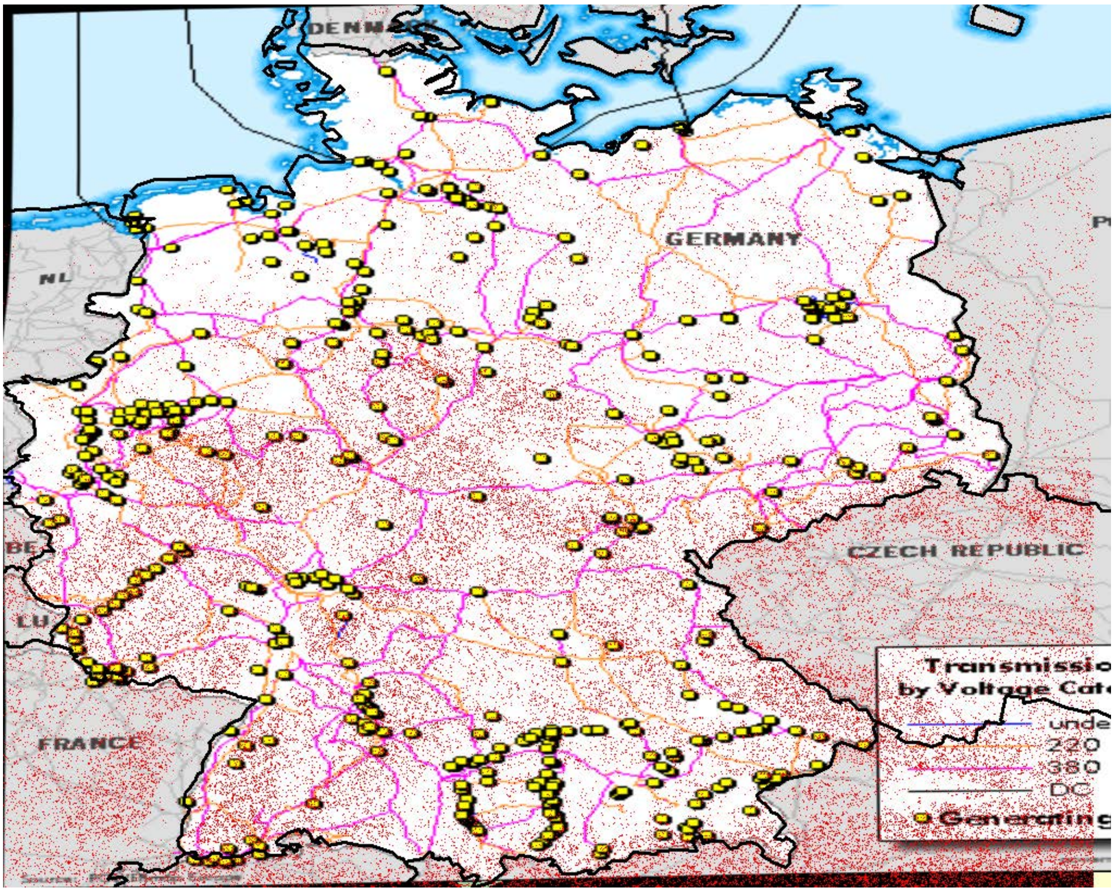
5.3.1.1. Winter storms

Regarding winter storms, the location of power supply lines and transformer stations are of special importance. The following figure shows high voltage transmission lines in Germany in relation to topography and south-west to north-east wind direction.

In the following two figures a contradiction becomes obvious: In the first map it can be seen that the exposure to winter storms is especially high in south-western Germany (*Bundesländer* Baden-Wuerttemberg and Rhineland-Palatinate) as well as in south-eastern Germany (*Bundesland* Bavaria), which is due to topography and main wind direction.

[1] For further information please see Wind Risk Prevention Project Report C.2/C4.
[2] Please note that as "transport" is a separately addressed vulnerability parameter within the Wind Risk Prevention Project, transport-related recommendations will be given in the following subchapter.

Figure 34: Exposure of high voltage transmission lines to winter storms in Germany

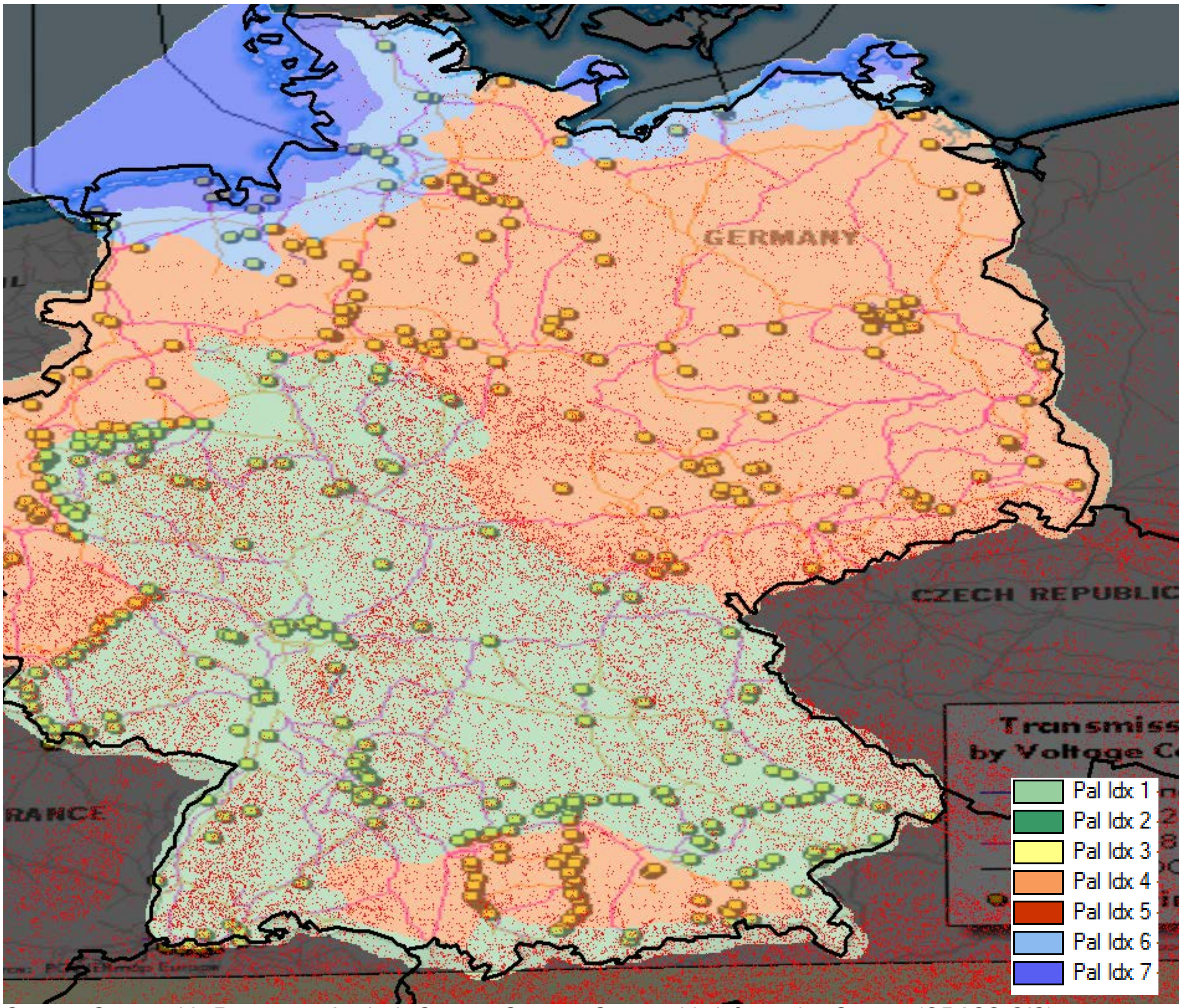


Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

On the other hand, the following map of the wind load zones shows that especially at the coasts wind loads are very high and in the rest of the country between classes 1-4.
The reason for these contradicting maps is that local wind characteristics differ strongly between the coastal areas and the inland.

Nevertheless, as the number of high voltage transmission lines and converter stations in the southern part of Germany is by far higher than in the northern parts, potential higher damages occur in middle and southern Germany.

Figure 35: Wind load map and high voltage transmission lines in Germany



Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

5.3.1.2. Summer storms

According to the city administration, there were no losses to report from summer storm Ela in the fields of energy and water supply, wastewater treatment and telecommunication (cf. Stadt Essen 2014: Annex). Unfortunately, the bigger were the losses in the field of transport infrastructure, embracing public and private transport and especially rail, air and road infrastructure, which are subject to subchapter 1.2.

Although luckily there were no major damages from summer storm Ela in the fields of energy supply and water supply it is worth considering these technical infrastructures as they are especially “critical” when it comes to natural hazards. If for example the energy network would have broken down as in the example of the Münsterländer Schneechaos (the Munsterland blizzard, see Wind Risk Prevention Project Report C.3), the densely populated Ruhr Area would have been without electricity and therefore also without telecommunication opportunities.

As this example shows, it is of major importance to preserve critical technical infrastructures from breaking down. Therefore the following recommendations can be given regarding technical infrastructures and thunderstorm hazard:

- Keep transformer stations and electricity land lines free off trees.
  As stated above, the electricity supply system is an especially “critical” technical infrastructure. Therefore, land lines and, more importantly, transformer stations, should be kept free off nearby trees in order to prevent branches from falling on them.

- Preserve water reservoirs, supply lines and groundwater from contamination.
  Furthermore, as anchored in the SEVESO Directive and the German Major Accidents Ordinance (Störfallverordnung), standards for storage of hazardous goods, e.g. chemicals, need to be complied.

In the City of Essen, especially social infrastructures in the fields of education and sports were damaged by thunderstorm Ela. All of the city’s schools as well as kindergartens needed to be closed for several days. In some education facilities, outdoor grounds like school yards and playgrounds remained closed for more than six weeks. (Cf. Stadt Essen 2014: 5).

Furthermore, nearly 80 % of athletics fields, gymnasiums and other sports facilities were damaged and closed for several weeks; costing more than € 81,500.00. (Cf. Stadt Essen 2014: 14f.) During the same time period (until end of 08/2014) circa 15 % of public events, like open air concerts were cancelled or postponed (cf. Stadt Essen 2014: 6f.).

Recommendations, which can be drawn in the fields of social infrastructure, are:

- Timely evacuation of education facilities.
  Children are, together with older people, an especially vulnerable population group which needs to be taken care of in the case of an extreme storm event. Therefore, timely evacuation of educational facilities like schools and kindergartens should be performed.

- Timely losing of sports facilities and playgrounds.
  Sports facilities are often green outdoor facilities. In the case of a storm event it is important that these facilities are closed before risking people’s health. Furthermore, these facilities need to be closed until the status of road safety is regained.

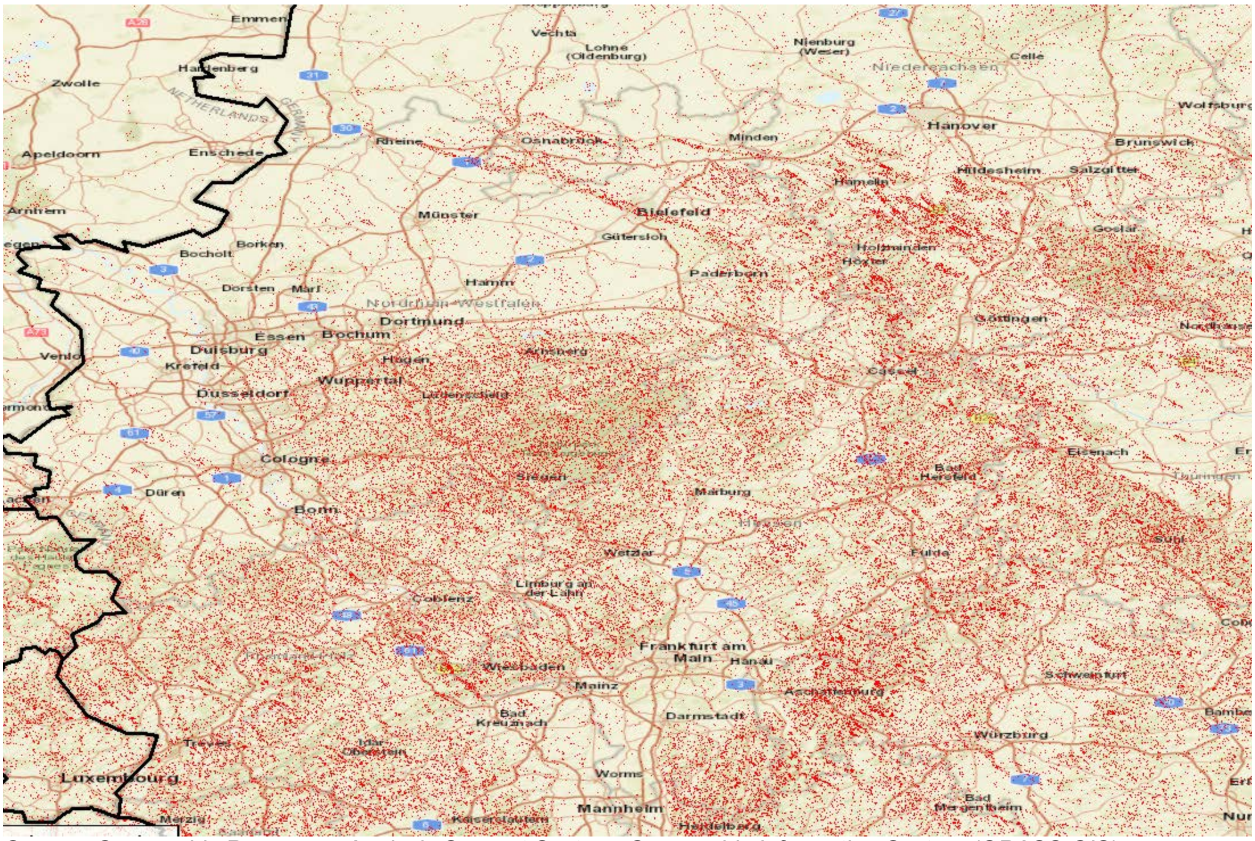
5.3.2. Critical Transportation

Especially in North-Rhine Westphalia, the transport network consisting of roads, rail and airports is very dense which is why special attention is drawn to this field in the Wind Risk Prevention Project.

5.3.2.1. Winter storms

The following map depicts the federal highways (*Autobahn*) and gives indication of zones with high exposure towards wind coming from south-eastern direction. It is interesting to see that due to the topography of the *Bundesland* North-Rhine Westphalia the western and northern areas are far less exposed to winter storms than the southern and eastern parts. Interestingly southern and eastern North-Rhine Westphalia is less densely populated and wide areas consist of forests.

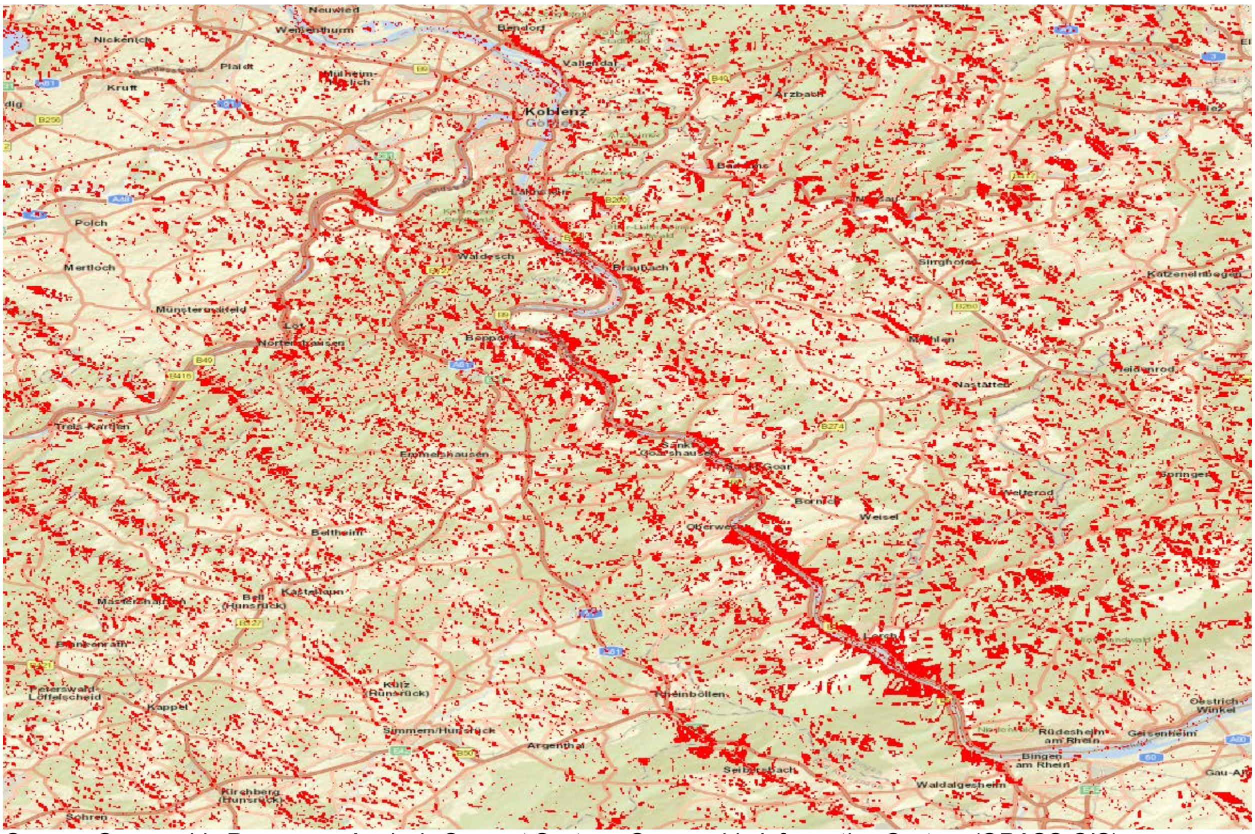
Figure 36: Exposure of transport infrastructure to winter storms



Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

If zoomed in into the lower part of the above depicted map, one area appears to be extremely exposed to winter storms, which can be seen in the following figure.

Figure 37: Exposure of transport infrastructure to winter storms in Koblenz area



Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

It can be seen that along the river Rhine, on both river sides, rail track are installed and slopes of topography are so steep that the exposure towards winter storms is especially high in this area. The following figure gives an impression of how rail tracks and topography are shaped.

Figure 38: Rail tracks in highly exposed winter storm area

Source: Website SWR 2016, Rainer Unkel

5.3.2.2. Summer storms

As stated before, in case of summer storm Ela damages to infrastructure facilities mainly occurred in the field of transport infrastructure. In the City of Essen, nearly all federal and municipal roads were blocked by fallen trees. Additionally, the public transport system broke down as the regional and long-distance rail network was not available due to fallen trees blocking the tracks and tearing down overhead electricity lines. In total, about one third of the rail network of the Deutsche Bahn was damaged by thunderstorm Ela. At airports, flights were delayed and temporarily departure and landing was stopped, which also led to losses. Moreover, for both road and rail traffic, indirect costs arose as employees were unable to get to their offices and there was a shortfall in receipts. The overall costs in the field of transport infrastructure amounted up to € 8.5 million; mainly representing public and mainly uninsured losses (Cf. Bundestag 2014; Deutsche Rückversicherung 2015: 22f.; Stadt Essen 2014: 1).

This damage pattern depicts an urgent need for physical investments to upgrade transport infrastructure and transit system. Recommendations in the field of transport are:

- Prioritization of clearance procedures, in road and rail transport system:
  The City of Essen made positive experiences with ranking all roads according to how important and urgent clearing procedures are. First priority was given to clearing the most important roads, a north-south as well as east-west axis and all driveways to and from emergency response facilities including fire brigade and hospitals.

- Keeping driveways of emergency response units' and health facility buildings free of trees:
  In order to provide for smooth emergency operations, response units like fire brigades and ambulance need to be able get from and to buildings. This basically demands for tree-free driveways, meaning that under no circumstances, trees may fall onto driveways, e.g. by logging activities in a certain radius.

5.3.3. Critical buildings

5.3.3.1. Winter storms

The following map shows the exposure of built structures in the City of Essen towards winter storms. According to the input parameters of the spatial model it becomes visible that especially in the southern parts of the city, which shows greater topographic variety that the northern parts, are more exposed to winter storms. In the city center (see black circle) there are only few areas especially exposed to winter storms. But along lake 'Baldeney' (*Baldeneysee*), there are several exposed areas due to steeper slopes and less spatial roughness. Luckily, there are only few buildings in the especially exposed areas along lake 'Baldeney' as the areas are mainly covered by forests.

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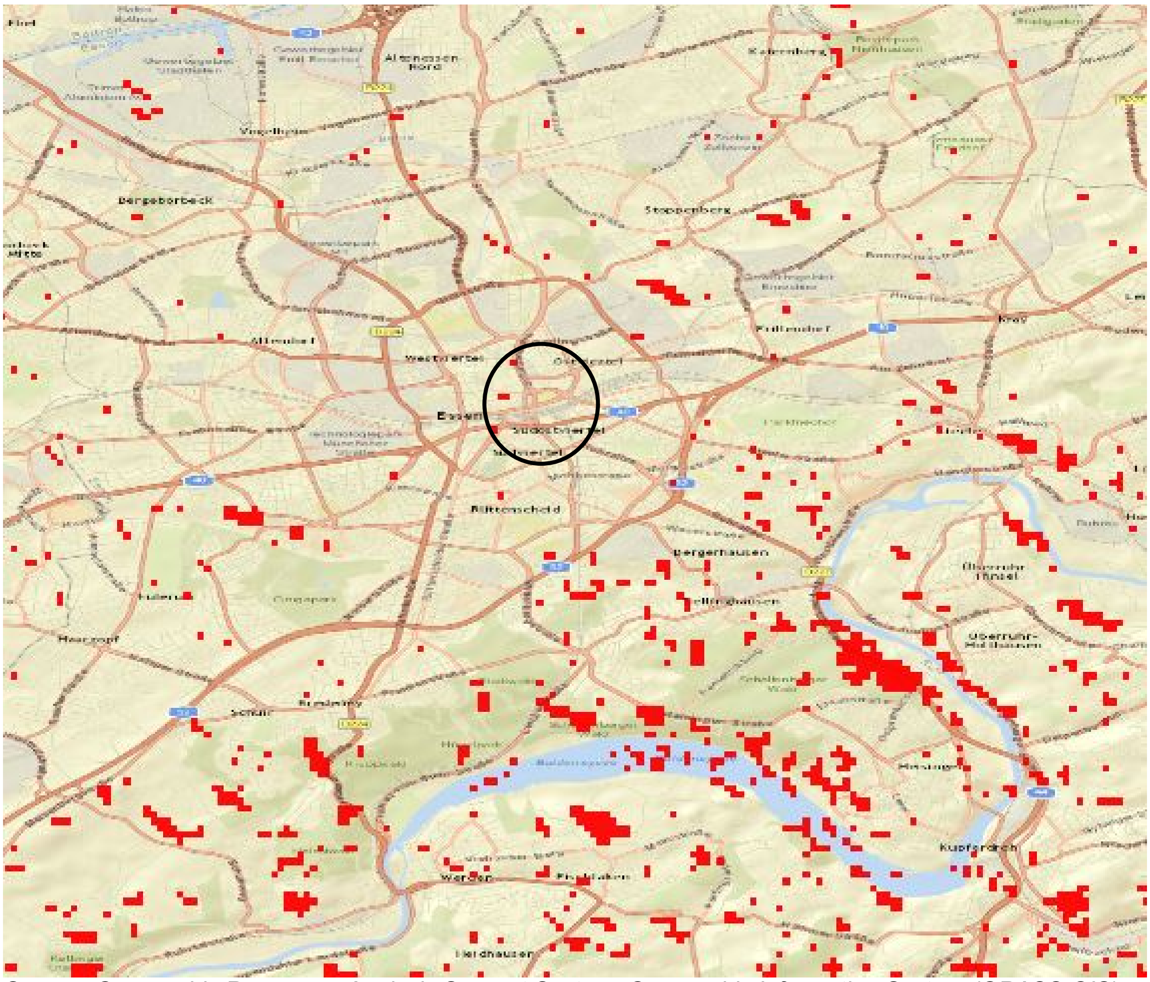
Figure 39: Exposure of built structures in the City of Essen to winter storms



Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

5.3.3.2. Summer storms

Damages to building through summer storm *Ela* mainly occurred as trees were uprooted and falling into and onto buildings. Most affected building parts were roofs, windows and fences. In total, losses due to damages to buildings were only marginally higher than damage costs that arose to outdoor facilities (see social infrastructure); (Cf. Stadt Essen 2014: 14).

In comparison to the Slovenian and Croatian case study, recommendations focus less on texture and quality of e.g. roofs but again more on trees and planting strategies.

- Conduct regular tree inspections also on private property.
  Major damages to buildings arose due to branches or trees falling into and onto buildings. Nevertheless it would be disproportionate to recommend logging existing trees. The recommendation given for physical investment in building is therefore to increase regular tree inspections not only for public but also for private property. Tree inspections as required for public spaces could e.g. help identifying diseased and therefore more prone trees within a city.

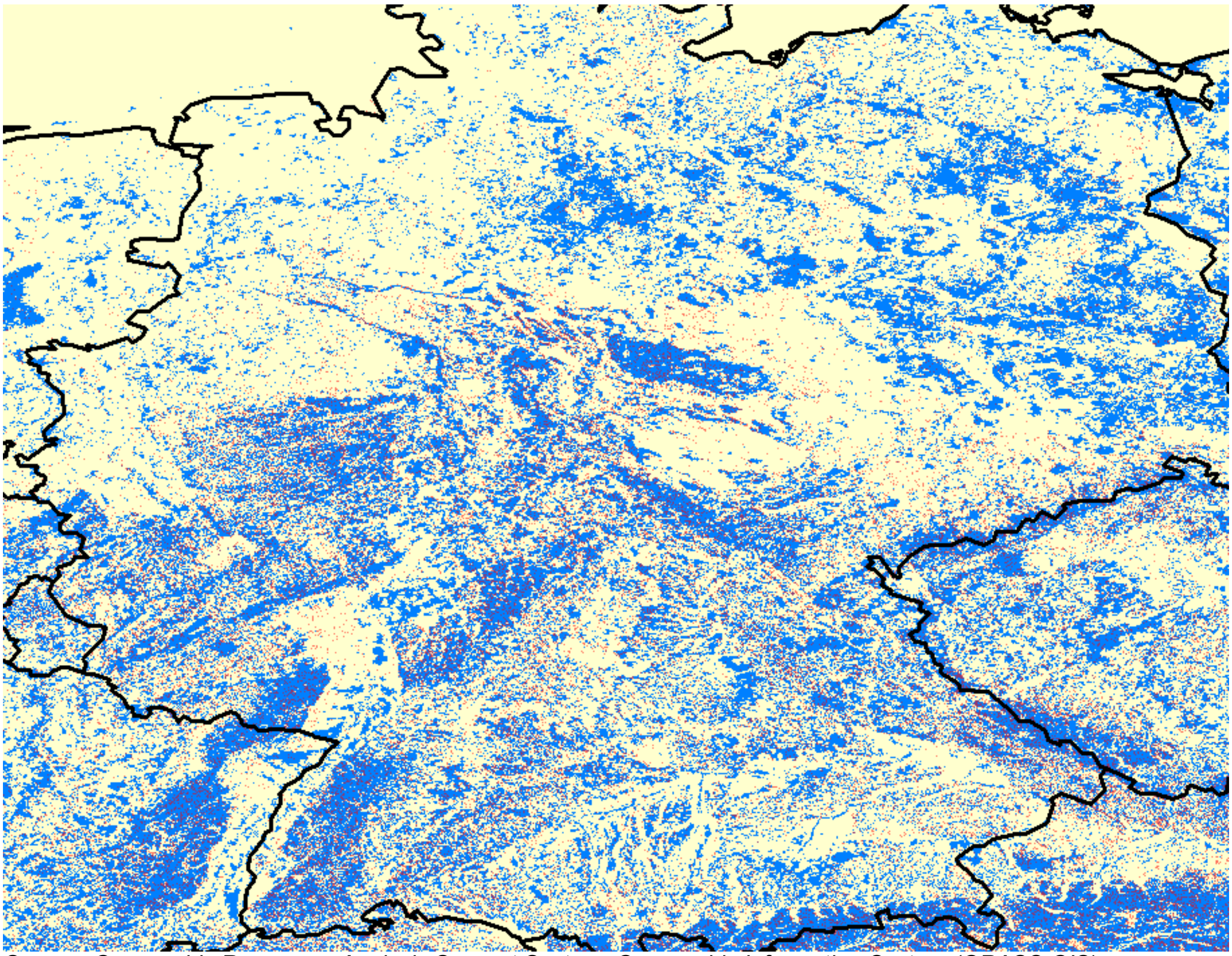
- Planting of wind-resistant tree species.
  For new plantings it can be recommended for both public and private property to choose more wind-resistant (and in total: more climate-resistant) tree species. A valuable guideline on tree species can be taken from Wind Risk Prevention Project Report D.5.

5.3.4. Critical forests

5.3.4.1. Winter storms

The following two figures show represent the exposure of forests in Germany towards winter storms coming from a wind direction south-west to north-east. The first map gives an impression of both the distribution of forests and Germany's topography. While in the southern as well as eastern parts there are still dense forest areas, especially the northern part of North-Rhine Westphalia and up to the North Sea lack dense forests.

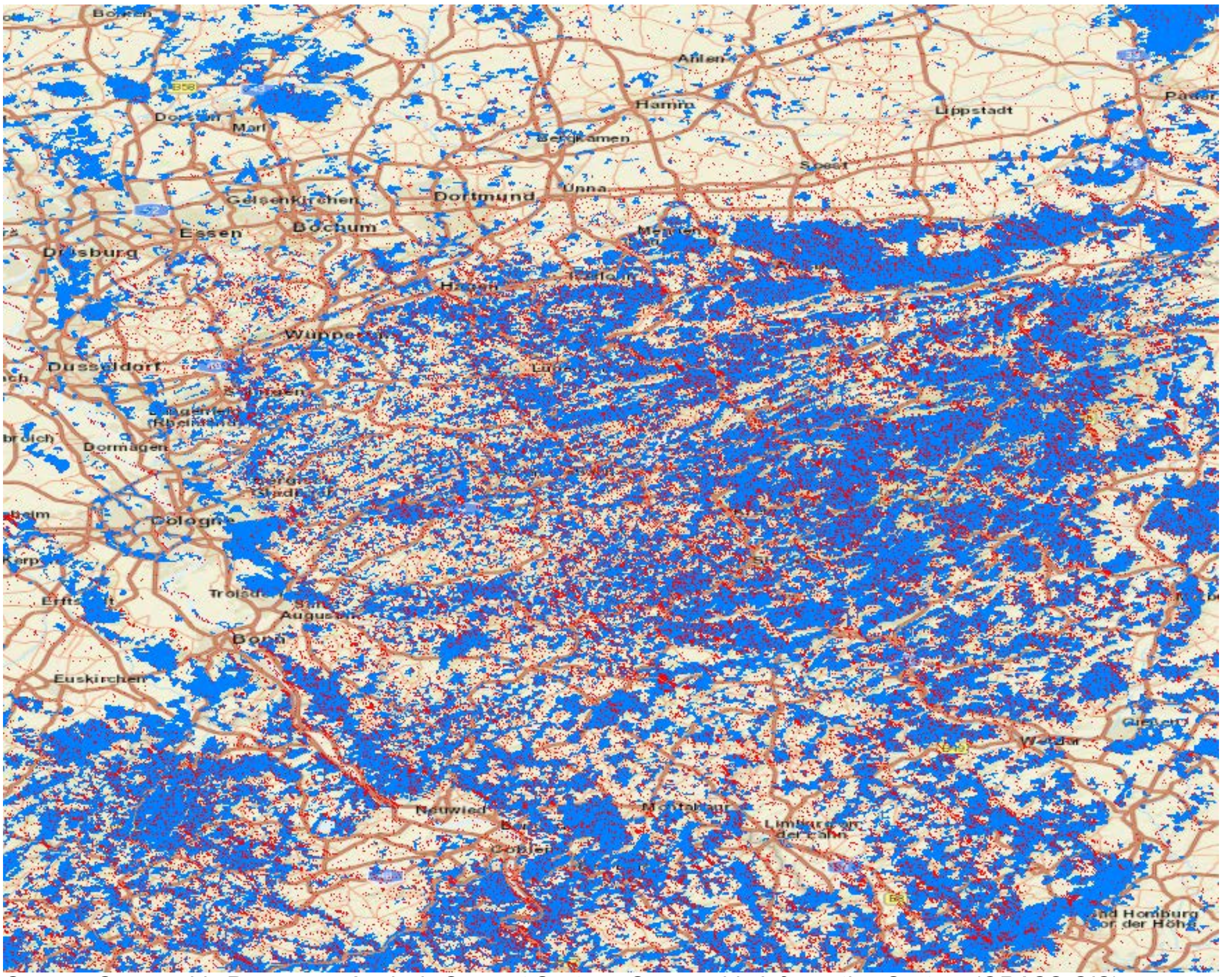
Figure 40: Exposure of forests in Germany towards winter storms



Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

The second map gives indication about where the densely populated inner cities of the Ruhr Area are located (north-east of the section) and where forests can be found.

Figure 41: Exposure of forests in Germany towards winter storms



Source: Geographic Resources Analysis Support System, Geographic Information System (GRASS GIS)

5.3.4.2. Summer storms

As thunderstorm Ela occurred in the middle of the summer, deciduous trees were in full leaf and bared great windage, which is why about 20,000 city and forest trees were damaged; solely in the City of Essen (cf. Stadt Essen 2014: 13). Besides the damage costs that resulted from fallen trees, the recreational and ecological function of trees and forests was restricted for several months.

Recommendations for physical investments in forests are explained in detail in Wind Risk Prevention Project Report D.5. Nonetheless, the most important recommendations shall be presented in the following:

- Increase (funding for) research activities on weather extremes and trees. Knowledge is essential when developing and promoting good practice examples in the field of forest planning and management. So far, the focus of research activities is more on forests than on city trees, which, for some storm phenomena, are not the focus of damages. Damages to forest and city trees were in fact about four times higher with thunderstorm Ela than they were with winter storm Kyrill (cf. Stadt Essen 2014: 13). Therefore, further research activities should be funded and conducted, focusing on weather extremes and the vulnerabilities of city and forest trees.

- Conduct periodical tree inspections and regular pruning measures.
  Tree tops were commonly damaged by thunderstorm Ela. Therefore, after the storm event, each tree was checked for acute damages, p.r.n. pruned and p.r.n checked again in order to ensure road safety. This procedure was the main reason why no major follow-up damages occurred in the City of Essen.

- Conduct periodical tree inspections and regular pruning measures.
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- Encourage sophisticated forest management strategies:
  There is an urgent need for sophisticated forest and tree management strategies, which explicitly address the challenges and additional stress factors for trees due to climate change and more and more densely populated and built city environments. A recommendation is therefore to fund good practice measures and further encourage cities and regions to implement sophisticated strategies.

6. Conclusions

In this report we proposed methodology for identification of high risk zones from wind damages on having in mind acceleration of basic wind speed due to terrain and topology of the local area. Parameters that can cause local acceleration of wind are adopted from methodology for building determination described in building norms. All factors together are combined to total high risk assessment, and are used in identification of high risk zones.

High risk zones maps are overlaid with maps containing spatial information about location of infrastructure, transportation, buildings and forests. Each of the partners has identified critical subjects that need physical investments for protection of high winds.

Recommendations for wind risk mitigation are first and most focused on wind risk prevention. Instalment of better wind measurement network with higher density of measurement stations and higher frequency of measurement is precondition for better wind phenomenon understanding. When aware of local phenomenon we can propose instalment of equipment for protection.

Infrastructure exposed to high wind can be upgraded by instalment of protective shields. Roads that are located in high risk zones, especially with curves that can additionally endanger vehicles, can be protected by placing wind obstacles along the road. Wind barriers are often used on highway parts where wind gusts are noticed.

In urban areas, planting trees can be planned in a way that trees serve as protection for both roads and buildings. Selecting traditional species of trees that are more resilient to high wind is recommended. Trees that are not resistant to high wind can break and produce additional damage to buildings and endanger traffic participants.

Old buildings are protected by regular maintenance and fixing damaged parts of roof, facades and other damaged material. New buildings should be constructed in accordance with building norms.

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WIND RISK

Task D – Action plan

Action D.3: Recommendations concerning the institutional preparedness and emergency plans for civil protection institutions in view of wind risk

For the Wind Risk prevention project

University of Ljubljana
Technical University of Dortmund
University of Split
Municipality of Ajdovščina

Chapter D.3 – Recommendations concerning the institutional preparedness and emergency plans for civil protection institutions in view of wind risk

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1. Introduction

Strong winds present a real danger, especially when combined with hail and other extreme weather conditions. Strong winds cause damage to buildings, infrastructure, transit, forests and especially threaten the safety of people. This is why in areas where this events occur preparedness actions are of utter importance.

The Chapter D.3 focuses on preparing recommendations for Protection and Rescue Plans and Plans for Mobilization and Communication of Protection and Rescue Providers for the Wind Risk study cases: Ajdovščina and Ljubljana (Slovenia), Central Dalmatia (Croatia) and North Rhine Westphalia (Germany). The basis for Protection and Rescue Plans is Risk Assessments which was already described in Action C taking into account five parameters; population, infrastructure, transport, buildings and forests.

In Slovenia, institutional preparedness and emergency plans for local civil protection institutions in view of wind risk are made on national, regional and municipal level. They comprise of Natural and Other Risk Assessments, Protection and Rescue Plans, Plan for Mobilization and Communication of Protection and Rescue Providers and Other documents. These documents include recommendations for organizational measures, demonstrate systematic linkages with the emergency units responsible for civil protection and disaster relief and early warning systems and reveal the importance of technical, financial and logistical factors in protection mechanisms.

In Germany, civil protection takes place at three administrative and geographical levels; the national level (federal state), the regional level (Bundesländer) and the local level (counties and country free cities like the City of Essen).

In Croatia, vulnerability assessment, and protection and rescue plans are delivered on national, regional and local level. National vulnerability assessment and protection and rescue plans serve as a basis for regional documents, while regional assessments and plans are basis for local level vulnerability assessment and protection and rescue plans.

Protection and Rescue Plans in general cover topics: scope and levels of planning, protection, rescue and relief concept, available forces, assets and resources, observation, warning and alarm, activation of leadership, forces and resources, administration and management, protection, rescue and relief, personal and reciprocal protection, damage assessment and mitigation of consequences. All these topics are thoroughly examined in this report with recommendations for better institutional preparedness.

2. Civil Protection and Emergency Response Procedures in Slovenia and the Municipality of Ajdovščina

Protection and Rescue Plans are developed for the cases of natural and other risks that pose the greatest threat to the Municipality of Ajdovščina. These documents ensure an organized and coordinated action in order to prevent accidents or to mitigate their consequences. They also ensure the earliest possible provision of basic living conditions in the case of disaster. As soon as the Protection and Rescue Plan is launched, services and units with available resources can successfully intervene and take appropriate actions. The decision to activate the Plan measures is a matter of the CP Commander or the Mayor.

The Protection and Rescue Plan in the case of strong wind composes of the next concepts and sections:

1. Characteristics of the strong wind
2. Scope and levels of planning
3. Protection, rescue and relief concept
4. Available services, assets and resources
5. Observation, warning and alarming system
6. Activation of leadership, forces and resources
7. Administration and management
8. Protection, rescue and relief
9. Personal and reciprocal protection
10. Damage assessment and mitigation of consequences
11. Explanation of terms and abbreviations
12. Annexes

According to Wind Risk Project Action D.3. Municipality of Ajdovščina updated its Protection and Rescue Plan also for the case of wind risk which is made on the basis of the Law on Protection against natural and other disasters (Ur. L. RS, no. 97/2010), Regulation on the content and development of protection and rescue plans (Ur. L. RS, no. 24/2012), Risk assessment in the Municipality of Ajdovščina, general legislation and implementing regulations.

In the updated version of the document Risk assessment, strong winds are recognized as a threat to Municipality of Ajdovščina. Especially the typical wind Bora which can achieve the speed up to 180 km/h and more. This is why a Protection and Rescue Plan for the case of strong wind is necessary in the municipality.

From the below Figure 1 and Figure 2, drawn up by the Agency of the Republic of Slovenia for environment (ARSO), it is clear that the wind in the area of the Vipava Valley is very active. Thus, the average wind speed as well as the average annual wind power density are in this area very high.

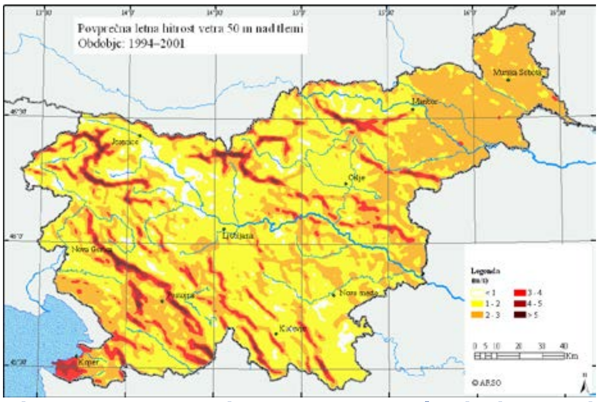

Figure 1: ARSO (average annual wind speed of 50 m above the ground (1994-2001))

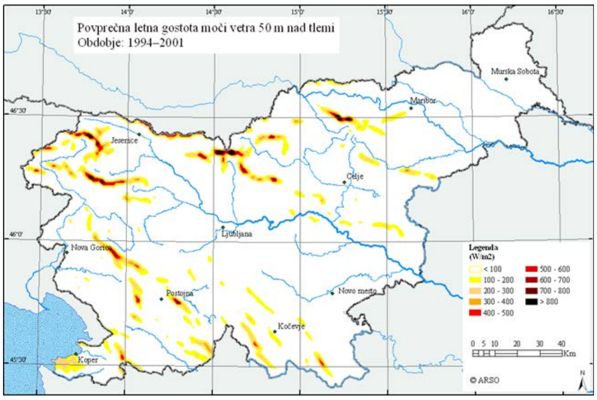

Figure 2: ARSO (annual average wind power density of 50 m above the ground (1994-2001))

Wind conditions are monitored at several levels. Above mentioned agency ARSO is responsible for measuring the current intensity of the wind. Its task is to monitor, analyse and predict natural phenomena and processes in the environment and reducing natural threats to people and property. ARSO therefor in the event of a major hazard triggers red alert (Table 1).

Table 1: Awareness levels provided by Meteoalarm and used by ARSO

COLOR MARK	HAZARD LEVEL	DESCRIPITION OF HAZARD LEVEL
WHITE	No data	Missing, insufficient, outdated or suspicious data.
GREEN	No danger	No particular awareness of the weather is required.
YELLOW	No greater danger	The weather is potentially dangerous. The weather phenomena that have been forecast are not unusual, but be attentive if you intend to practice activities exposed to meteorological risks. Keep informed about the expected meteorological conditions and do not take any avoidable risk.
ORANGE	High level of danger	The weather is dangerous. Unusual meteorological phenomena have been forecast. Damage and casualties are likely to happen. Be very vigilant and keep regularly informed about the detailed expected meteorological conditions. Be aware of the risks that might be unavoidable. Follow any advice given by your authorities.
RED	The highest level of danger	The weather is very dangerous. Exceptionally intense meteorological phenomena have been forecast. Major damage and accidents are likely, in many cases with threat to life and limb, over a wide area. Keep frequently informed about detailed expected meteorological conditions and risks. Follow orders and any advice given by your authorities under all circumstances, be prepared for extraordinary measures.

Source: Meteoalarm, 2016: http://www.meteoalarm.eu/index2.php?lang=sl_SI&country=SI

Within the Wind Risk prevention project another system to measure wind characteristics and get information about different types of wind was set up in Ajdovščina which is WindMaster Pro anemometer from GILL Instruments. It was set up on the roof of the stadium of the local football team next to the sport plane airport. The WindMaster Pro not only measures wind speed but also forces it generates alongside with air temperature. The readings of this anemometer are also used as an alarm system for local civil protection service and will alert them immediately after average wind speed or wind gusts exceed specific limits.

From the point of view of traffic restrictions and measures, Motorway Company of the Republic of Slovenia (DARS) and the Directorate of the Republic of Slovenia for Roads (DRSC) monitor wind conditions. DARS has all through the Vipava Valley, along the main highway H4 Razdrto - Vrtojba, positioned nine measuring devices, which measure the wind speed and according to their measures alert people of road conditions and restrictions.

Scope and levels of planning

The core emergency plan in case of strong wind is municipal. It has been prepared on the basis of national and regional emergency response plans.

The expected consequences in the case of strong wind are:

- Disrupted or blocked traffic due to traffic accidents or objects on roads and railways,
- Damage to infrastructure installations and therefor the possibility of interrupted supply of electricity, plumbing and interrupted telecommunication connections
- Damage to buildings (real estate), also of such a nature that the facility is not applicable for stay (removal of roof collapse of part of the building or the entire building in the event that this is not maintained or has worn out, etc.)
- Injury to people and animals, due to rollover and movement of large objects (falling of trees, billboards, traffic signs, etc.)
- Environmental pollution,
- Damage in agriculture (removal of earth, uprooting trees, wind gusts, etc.).

Protection, rescue and relief concept

The protection, rescue and relief concept in the Municipality of Ajdovščina in the case of strong wind is directed to:

1. Closing public buildings: depends on weather forecasting and red alarm triggered by ARSO,
2. The rescue and relief to those who are exposed to an imminent life or other hazard due to direct consequences of such disasters: to provide immediate assistance for the improvement of living conditions (damaged roofs and other events which threat the safety of residential and commercial buildings),
3. Most urgent intervention to improve the situation, which is urgently needed to prevent and mitigate further consequences of the accident,
4. Chain accidents.

2.1. Responsible institutions in Civil Protection in Municipality of Ajdovščina

2.1.1. Available services, assets and resources

The Municipality of Ajdovščina

- **Mayor** delegates the protection, rescue and aid and eliminates the consequences. He decides on the use of budget funds, provides funding for the support of preparedness, proclaims the risk of natural and other disasters and performs other tasks within his jurisdiction.
- **Municipal forces for protection and rescue** and **civil protection authorities** (CP):
  - *CP Commander* delegates operative professional work of members of the Civil Protection and other forces for protection, rescue and relief from municipal jurisdiction. He informs the mayor about the consequences and the situation in the affected area and gives opinions and proposals relating to the protection, rescue, assistance and disaster relief. He prepares a final report of the accident and

proposes it to the municipal council, and performs other tasks within his jurisdiction,
- *Deputy CP Commander,*
- *CP headquarters*.

Public services and other associations

Public services and other associations carrying out tasks of protection, rescue and relief are mainly:

- **Public fire service:** Fire and rescue center; 4 volunteer fire brigades: Ajdovščina, Col, Selo and Šmarje. They carry out firefighting and rescue tasks in case of fire; other tasks of protection, rescue and assistance for which they are equipped and trained.
- **Public health Service:** Ajdovščina Health Center. It carries out emergency medical service, rescue service, health care, and other tasks within its competence.
- **Police:** Police station Ajdovščina. It ensures the public order, tranquility and security. It protects the disaster area, allowing intervention to units, detects and investigates crimes and offenses related to the accident, identify persons, search for missing persons and investigate the causes of the accident: Police station Ajdovščina.
- **Associations:** speleological Society Danilo Remškar Ajdovščina, scouts Rod Mladi Bori Ajdovščina, Scouts STEG Ajdovščina - Šturje 1, Radioklub Ajdovščina, Josip Križaj Flying Club, Mountain Rescue Association of Slovenia, Tolmin Station Group Ajdovščina, Postaja Tolmin, Skupina Ajdovščina, Mountaineering Club Ajdovščina and Križna Gora.

Financial, Material and technical resources

Operators use their own equipment and the equipment they have for this purpose. Equipment, resources and means of assistance from municipal CP warehouses (food, drinking water, medicines, etc.), which are intended for free distribution and are provided on the basis of companies, public institutions and other organizations lists, are also at the disposal.

Municipality of Ajdovščina funds operational costs, cost of training, education, examination and exercise, and the cost of purchasing and maintaining equipment. Additional funds in accordance with the regulatory procedure are provided from the budget reserve funds. Activities by state administration bodies and public service are covered by themselves.

2.2. Early Warning and Disaster Preparedness

In the events when the Bora wind is starting to cause damage, which poses a threat to the population (for example, open roofs, flying objects, trees blocking the traffic, etc.), the affected area is closed and the emergency services are organized to monitor the situation. This is decided by the CP Commander. The emergency service and a hotline is organized by the public fire service in agreement with the commander of the CP.

Informing the public on the implementation of the plan is done after ARSO triggers red alert (some public institutions need to be closed) and in the hazardous events, such as damage to infrastructure (electrical, water and telecommunications installations or damage to buildings), which threatened the safety and well-being of the lives of people and animals.

2.3. Emergency Intervention Procedures in case of wind-related disasters

2.3.1. Activation of leadership, forces and resources

Forces and resources are activated according to the size of the effects of the disaster and its duration.

The *CP Commander* or the *Head of Intervention* **assesses the situation** in the affected area. After the first report and other requirements of the Head of Intervention, the bodies responsible for the activation of the municipal protection, rescue and relief forces and means, **analyse the situation**, the potential development and outcome of the disaster as well as the need for the activation of municipal protection, rescue and relief forces.

The *CP Commander* decides **when to activate the bodies** for the operational and professional leadership of protection, rescue and relief which are CP Headquarter members, responsible municipal officials and technical municipal staff, CP Support Service members, commission for damage assessment and other responsible persons or bodies.

If the events exceed the capacities of the municipal CP, the CP Commander asks for help from the neighbouring municipalities, municipalities of neighbouring regions (state aid) and neighbouring countries (international aid).

The management bodies for protection against disasters within the Municipality of Ajdovščina are:

- **The Municipal Council** prepares and implements regulations related to the protection against natural and other disasters in the municipality territory.
- **The Mayor** is the head of the protection, rescue and relief and recovery operations. He appoints the CP Commander as the operational and professional head of these operations.
- For the purposes of the protection against disasters, the **municipal administration bodies** carry out tasks according to their field of work and their competences. During interventions, the municipal administration bodies provide support to the CP management bodies and protection, rescue and relief forces in implementation of protection, rescue and relief measures.

The operational protection, rescue and relief bodies are the following:

- **CP Commander** is the operational and technical head of the disaster protection, rescue and relief operations.
- If CP Commander is absent, **CP Deputy Commander** holds all his powers and is responsible directly to the Mayor.
- **Civil Protection Headquarters** provide expert assistance in managing and performs other operational and technical tasks related to disaster protection, rescue and relief.
- **Head of Intervention** is generally the commander of the firefighting unit in charge of the area where the disaster has occurred, unless otherwise specified in Protection and Rescue Plans or by the CP Commander. If different units (firefighters, paramedics, police etc.) are involved in the operation, each of them is coordinated by their own head and a separate Directing Team of Intervention is formed. The Head of Intervention or the Directing Team of Intervention act in accordance with the CP Commander instructions.

The most typical protective measures in the case of strong wind are:

- protection of location/area,

- protection of infrastructural facilities and installations (care for water supply, electricity, etc.),
- preventive constructional interventions,
- preventive technical measures,
- traffic management,
- retreat of the endangered inhabitants and evacuation,
- setting a temporary accommodation for evacuated citizens,
- providing medical aid and transport to hospital,
- etc.

Personal and reciprocal protection

Personal and reciprocal protection includes all measures for the prevention and mitigation of disasters consequences that affected residents in order to protect their health and safety of their property.

Municipality of Ajdovščina is responsible for organizing, encouraging and guiding personal and reciprocal protection in the municipality. They organize appropriate advisory service, composed by volunteers, especially psychologists, sociologists, social workers, health professionals, and others.

Citizens must carry out the following activities:

- organize and carry out measures for personal and reciprocal protection (self-protection, self-help and reciprocal aid)
- maintain facilities to protect against hazards (shelter and other facilities)
- procure the means and equipment for personal and collective protection in the case of accidents,
- implement measures of protection and rescue.

Evacuation of vulnerable and affected population is carried out, if it is not possible with other measures to ensure their safety. If the risk is serious and imminent, head of intervention determines the area of evacuation in accordance with the nature and extent of hazard. Evacuation points are intended only for those residents who, after notice for evacuation cannot move by their own, with their own or public transport.

Damage assessment and mitigation of consequences

Damage assessment begins by a decision of the national Administration for Civil Protection and Disaster Relief. National and regional damage assessment commissions are evaluating the damage the event caused and preparing proposals for disaster recovery. Victims gather evidence of the damage they have suffered and submit evidence to the commission for evaluation and approval. Commission estimates property damage and other consequences of accidents, based on the methodology prescribed.

On the municipal level, the Mayor leads the disaster relief and together with the Municipal Council, in accordance with the provisions of the Public Finances, decides about the use of municipal funds for disaster relief.

On the national level, the Government of the Republic of Slovenia leads the disaster relief of major accidents. The use of state resources for the elimination of consequences of major accidents is decided by the National Assembly of the Republic of Slovenia.

2.4. Plan for Mobilization and Communication of Protection and Rescue Providers

The Plan for Mobilization and Communication of Protection and Rescue Providers specifies organization, communication and the activation of forces and rescue units also in the event of a landslide, wild fire and earthquake in the area of the Municipality of Ajdovščina. It defines emergency response and action activities in the event of all natural and other disasters.[1] In addition, it provides a detailed list of responsible people in the municipality of Ajdovščina with their active contact numbers in case of emergency.[2]

2.5. Recommendations Regarding the Institutional Preparedness

Wind Risk Project Action D.3. recommends measures to improve the preparedness of the Municipality of Ajdovščina in the case of strong wind. The report summarizes the Protection and Rescue plan and describes characteristics of the strong wind, scope and levels of planning, protection, rescue and relief concept, available services, assets and resources, observation, warning and alarming system, activation of leadership, forces and resources. administration and management, protection, rescue and relief, personal and reciprocal protection and damage assessment and mitigation of consequences.

To sum up, for a successful protection, rescue, relief, prevention, mitigation and disaster recovery, in the case of strong wind, it is necessary to:

- act in accordance with the Municipality of Ajdovščina Protection and Rescue Plan,
- act in accordance with the Municipality of Ajdovščina Plan for Mobilization and Communication of Protection and Rescue Providers,
- make sure that the participants in traffic are informed about the traffic conditions,
- take care of prevention: for example, maintain the infrastructure installations and therefor minimize the possibility of interrupted supply of electricity, plumbing and telecommunication connections,
- organize health care for people at risk and, and in accordance with the scale of the event to carry out the evacuation and setting up shelters (tents, caravans, containers), or perform relocation,
- inform and educate the public about the current events,
- in the case of infrastructure installations damage (electricity, water, telecommunications, sewer, roads, care), immediately proceed to their repair.

The report also touches the updated Natural and Other Risk Assessment in the Municipality of Ajdovščina (2016) and shortly presents Plans for Mobilization and Communication of Protection and Rescue Providers. These documents include recommendations for organizational measures and they demonstrate systematic linkages with the emergency units responsible for civil protection and disaster relief and early warning systems.

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[1] Municipality of Ajdovščina: Natural and Other Risk Assessment in the Municipality of Ajdovščina, May 2016, p.3.

[2] Municipality of Ajdovščina: Plan for Mobilization and Communication of Protection and Rescue Providers, July 2014, p.44-57.

3. Civil Protection and Emergency Response Procedures in Germany and the City of Essen

3.1. Responsible Institutions in Civil Protection in Germany

In the Federal Republic of Germany, civil protection takes place at three administrative and geographical levels; the national level (federal state), the regional level (Bundesländer) and the local level (counties and country free cities like the City of Essen).

Predominantly, civil protection belongs to the constitutional responsibilities of the 16 federal states (Bundesländer) of Germany. The Bundesländer have specific laws in which the responsibilities are separated into those of the municipalities, the counties and the federal state. In Germany and the Bundesland North-Rhine Westphalia, wind related hazards are understood as natural hazards, which are covered by the North-Rhine Westphalian 'law on fire safety, rescue and emergency services' (Gesetz über den Brandschutz, die Hilfeleistung und den Katastrophenschutz, BHKG). The BHKG therefore is the most important legal basis for civil protection on the regional and local level (cf. §1 BHKG).

The national level, i.e. the federal state comes into play in case of large-scale disasters. In such cases, the Federal Government coordinates the activities of the 16 Länder and e.g. supplies them with information and financially supports them so that necessary investments into buildings and technical infrastructure of emergency response can be preceded.

The actual emergency management, i.e. also disaster preparedness and response, lies within the responsibilities of the counties and country free cities like the City of Essen. The responsibility of the counties and country free cities is a) to prepare disaster prevention plans and b) to guarantee for the necessary technical equipment and personnel. On top of that, the municipalities are responsible for fire protection and management and are asked to set up local fire prevention plans. All levels closely collaborate with relief organizations and fire brigades. (Cf. Website BMI 2016b, Website BMI 2016c)

The following figure gives an overview of all institutions relevant for civil protection in Germany. Subsequently, a more detailed description of the most important institutions of each administrative level is given. For an in-depth description on civil protection (and its connections with spatial planning) in Germany, please see Wind Risk Prevention Project Report C.7/C.8.

Figure 3: Institutions in civil protection in Germany

Source: own depiction; see also Wind Risk Prevention Project Report C.7/C.8.

3.1.1. National Level – Disaster Response

In Germany, the national level of civil protection is responsible for disaster response actions. The main institution responsible for civil protection on the national level is the Federal Ministry of the Interior (BMI) and its executive agencies. (Cf. Website BMI 2016a) For the purpose of crisis management the BMI has a Communications, Command and Control Centre, which is the contact point for all matters of internal security, and national (as well as international) civil protection at ministerial level. This Control Centre has the tasks of sharing information among the Federal State, state security authorities and executive agencies. (Cf. Website BMI 2016b)

The executive agencies reporting to the Federal Ministry of the Interior are the Federal Office of Civil Protection and Disaster Response (BBK) and the Federal Agency for Technical Relief (THW) (cf. Website BMI 2016c). The BBK sees itself as a national service center for institutions and authorities at all administrative levels, as well as for organizations working in civil protection (cf. Website BBK).[3]

The Federal Agency for Technical Relief (THW) operates according to the Act on the Federal Agency for Technical Relief (THW-Gesetz). The operations comprise the management of disasters, public emergencies and large-scale accidents. The agency starts their operation at request from any administrative level or on behalf of the Federal Government. (Cf. Website BMI 2016d) The THW can be understood as "a cornerstone of civil protection in Germany [that] helps in case of natural disasters and accidents" (Website BMI 2016d).
Regarding resources, the THW consists of 668 local units, operated by volunteer forces. During and after a storm event, tasks of the THW are e.g. to clear roads from branches or to pump out flooded basements. (Cf. Website BMI 2016d)[4]

3.1.2. Local Level – Emergency Preparedness and Response

On the local level, there are three main groups of actors involved in emergency preparedness and response; the local administration, the emergency response units and the population i.e. inhabitants of a city.
For the local administration it is, respectively, the country administrator or major of a country free city who is responsible for several actions. The most important action is the constitution and administration of a 'mission control' and an 'action committee'. The 'mission control' is responsible for the operative-tactical risk management in case of an emergency or disaster. The main tasks of the 'mission control' are to coordinate the action forces, to coordinate and distribute resources and to define measures to be conducted. According to the BHKG, fire brigade units, ambulance corpses and emergency services constitute the 'action committee'. The 'action committee' is usually (on request) supported by approved aid agencies (e.g. the German Red Cross). The 'action committee' is coordinated by the 'mission control'. (Cf. §33f. BHKG)

Similar to the other Wind Risk Partner countries, municipal volunteer fire brigades may be requested in case of severe disasters. A prerequisite for volunteer assistance is, according to §3 (1) and (4) BHKG, a constant training and education of volunteer forces through the fire brigade. Furthermore, in case of severe damages, fire brigade units from other counties can be requested in order to help with civil protection actions in another (cf. §39 (1) BHKG).

[3] For detailed responsibilities of the BBK please see Wind Risk Prevention Report C.7/C.8.

[4] For further institutions involved in civil protection in Germany please see Wind Risk Prevention Report C.7/C.8.

The third group of actors relevant at the local level is the group of adult citizens. If instructed so by the action committee, e.g. the fire brigade units, any adult person is obligated to aid in case of an emergency in form of resources or manpower. (Cf. §43 (1-3) BHKG)

3.2. Early Warning and Disaster Preparedness

In Germany, the German Meteorological Service (DWD) is legally responsible for warning management. The DWD is an executive agency of the Federal Ministry of Transport and Digital Infrastructure (BMVI) and provides weather forecasting and warnings/alerts, which are a major component of disaster preparedness. (Cf. §4 (3) DWDG; Website BMVI 2016)

Warning procedures in Germany base on a three-tier system and can be described as follows. Ahead of a weather event, the DWD gives a preliminary weather alert, which bases on modeling and interpretation of meteorologists to several national, regional and local institutions. (Cf. DWD 2013: 3)
The German warning management system ‘SatWas’ is satellite-based and operated by the DWD. ‘SatWas’ functions as the official weather alert platform for the federal government, the Länder and the official public-sector broadcaster (TV and radio). (Cf. Website BBK BUND 2015) A second warning system ‘FeWIS’ is especially operated for Germany’s emergency response units and accessible by fire brigades, the THW, the federal police, the Federal State Ministries of the Interior and aid agencies.

Warnings of the first tier are spatially unspecific and given out by the early warning system (‘SatWas’ and/or ‘FeWIS’) 48-120 hours and at maximum five days ahead of a possible event. Warnings of the second tier take place 12-24 hours before an event. Warnings of the second tier come with warning reports and advance information but are still spatially unspecific, i.e. valid for the whole country. Warnings of the third tier are detailed, official weather alters, which are spatially specific relating to counties/administrative districts. These tier-three warnings are published 12 hours or less ahead of an event. In comparison to ‘SatWas’, ‘FeWis’ additionally gives out hourly information on possible magnitude and extent of an event so that emergency response units are able to prepare 48 hours ahead of an event. (Cf. DWD 2013: 11-13)

3.3. Emergency Intervention Procedures in case of wind-related disasters

In case of wind-related disasters, all administrative levels are involved in emergency management and emergency intervention procedures. For example, the Federal Government supplies the Länder with information and financial support while the Länder pass both (information and money) on to the counties and municipalities that are hit by the event; weighted according to the storm’s impact. Moreover, the approved aid agencies may be requested in order to support the emergency response process. (Cf. BMI 2016b, BMI 2016c) Nevertheless, emergency intervention mainly lies within the responsibilities of the local level, i.e. the counties and country free cities.

In the recovery phase, i.e. immediately after a wind-related disaster until up to several years, damages are estimated and removed. In the case of the City of Essen and summer storm Ela, institutions like the city’s parks commission Grün und Gruga take over and conduct clearing works. In severe cases, the Armed Forces (Bundeswehr) may be requested in order to secure safety and order, as was done by the City of Düsseldorf after summer storm Ela.

3.4. Recommendations Regarding the Institutional Preparedness

One major aspect of effective civil protection is that all involved institutions are prepared towards the upcoming challenges, meaning they know their responsibilities and tasks and have a good communication and cooperation amongst them.

Summer storm Ela in June 2014 in the City of Essen exemplified an overall well-working civil protection system in Germany. Nevertheless, each event brings new lessons learned and leaves room for improvement. The following recommendations are drawn regarding institutional preparedness and emergency management in case of summer storms in Germany:

- **Constant assessment and improvement of the warning management.**
  Ahead of summer storm Ela, the German Meteorological Service provided weather alerts in accordance with the standard three-tier warning procedures. Unfortunately, in comparison to winter storms, storm tracks of summerly thunderstorms are hardly predictable. This is why the magnitude of Ela became visible just a couple of hours before the storm hit. As this circumstance only leaves a short time window for reaction, further research is needed on both enhancing modeling techniques as well as behavioral protection measures.

- **Facilitation of good communication and cooperation between institutions.**
  Regarding good emergency management, communication and cooperation between all actors involved is crucial. Accordingly, both 'mission control' and 'action committee' have a central function throughout the whole intervention process and need to be sustained or even strengthened. Each city should therefore review internal and external communication and cooperation procedures and p.r.n. enhance these.

- **Provision of adequate financial means for emergency preparedness and management.**
  Financial means are a relevant factor for conducting good emergency preparedness and management procedures. In the case of summer storm Ela, the federal state of North-Rhine Westphalia set up immediate financial support for all municipalities and distributed it according to damage extents. Although short-term support was given by the federal state, long-term financial support was rather poor. In consequence, the City of Essen had (and still has) to pay for prevention measures (e.g. clearance and planting procedures), slowing down prevention and preparedness processes. It can therefore be recommended that federal state financial support is prolonged and extended to mid and long-term perspective.

- **Enabling of smooth emergency operations.**
  Regarding emergency operations, a smooth handling is essential in order to prevent further damages. There are three recommendations that can be given in order to smoothen emergency operations:
  i.) Keeping driveways of emergency response units' buildings free of trees: Summer storm Ela revealed that in some cases emergency response units were not able to conduction their operations as trees blocked the driveways of the garages. It can be recommended to clear these driveways of any nearby trees, e.g. by choosing a radius which is based on the height of an average tree. The City of Essen has successfully applied this method in other contexts (securing roads close to forests) with a radius of 30 m.
  ii.) Equipping fire brigades with adequate training and devices:

So far, German fire brigades are insufficiently equipped with devices for wind-related emergency operations. This problem became evident during summer storm Ela because the fire brigades did not dispose of a great enough number of chainsaws and also of an insufficient amount of fuel tanks in order to refill the chainsaws. The recommendation of increasing the number of devices of course goes hand in hand with the necessity for an adequate training of all fire fighters.

iii.) Prioritization of city roads for adequate clearance procedure:

Any disaster requires a plan on how to efficiently deal with damages. This especially applies to the priority in which clearance procedures should be conducted. Therefore, a recommendation is to prioritize city roads beforehand, so that emergency response units know where to start their actions. For summer storm Ela the City of Essen drew on existing prioritization strategies from the field of winter road maintenance (thawing salt plans). A strategy can e.g. be to first clear a north-south as well as an east-west axis and to quickly clear driveways to health facilities like hospitals.[5]

- **Enabling of smooth preparedness and prevention measures.**

  After a hazardous event, further prevention and preparedness measures are to be taken in order to increase the degree of preparedness before a next event. During this time, measures and strategies of prevention and preparedness are needed. In the following, three recommendations to the field of prevention and preparedness towards summer storms are drawn:

  i.) Implementation and maintenance of systems for systematization and monitoring of damages and clearance procedures:

  A monitoring system of all damages is a good option to systemize both damages as well as clearance activities. Grün und Gruga, Essen's parks commission, implemented a GIS-based city tree cadaster, which is constantly fed with information on damage types, status of clearance procedures and new plantings.

  ii.) Considering climate resistance of tree species in case of replacement plantings:

  For all replacement plantings it should be considered that climate change brings stress factors for trees, which differ throughout the tree species. The City of Essen therefore plants in accordance with the FLL guidelines (see Wind Risk Prevention Project Report D.5, chapter 2.2.4), which are freely accessed online.

  iii.) Conduction of periodical tree inspections for ensuring road safety:

  A regular inspection of city trees helps to identify infested trees, which have a higher risk of falling in case of a storm event. It can therefore be recommended to conduct periodical tree inspections, e.g. as proposed by the FLL (cf. FLL 2010), especially after an extreme storm event.

- **Secure long-term evaluation and monitoring for prevention and preparedness measures.**

  With every extreme event that takes place there are new lessons learned that help to improve institutional preparedness and emergency management. It is essential to evaluate and monitor prevention and preparedness measures in order to secure a long-term improvement of the overall system.

[5] For more detailed recommendations on clearance procedures please see Wind Risk Prevention Reports D.5 and D.7.

4. Civil Protection and Emergency Response Procedures in Croatia and the Central Dalmatia

Organization and activities of civil protection and protection and rescue in Croatia is regulated by Constitution of Republic of Croatia, Law of civil protection (before 2015 Law on protection and rescue), Assessment of vulnerability and other sub laws. Vulnerability assessment, and protection and rescue plans are delivered on national, regional and local level. National vulnerability assessment and protection and rescue plans serve as a basis for regional documents, while regional assessments and plans are basis for local level vulnerability assessment and protection and rescue plans.

On national level, vulnerability assessment was last delivered in 2009. The national vulnerability assessment deals with wind related events in the chapter on hazards of natural causes, among which we can find hazard of storms and hurricane. The strong wind can cause damages which are recognized in all areas of the country, but wind conditions are different for coastal, mountain and valley parts of Croatia. Also different winds are present in different seasons. Measures proposed in this document are mostly preventive measures.

Protection and rescue plan on the national level was delivered in 2010 and forms basis for protection and rescue plans on regional and local levels.

The system of civil protection in Croatia is organized at the local, regional and national level, and linking the resources and abilities of participants, task forces and citizens in a single unit to reduce the risk of disaster, providing rapid and optimal response to threats and hazards occurrence and mitigating the effects of major accidents and disasters.

4.1. Responsible institutions in Civil Protection

Measures and activities in the system of civil protection carried out by the following participants:

- Croatian Government,
- Central state administration body in charge of civil protection (The State Administration),
- Government bodies and other state bodies,
- The Croatian Armed Forces and Police,
- Local and regional (regional) governments.

Measures and activities in the system of civil protection carried out by the following operational power system of civil protection:

a. the headquarters of civil protection,
b. operating power firefighting,
c. operational forces of the Croatian Red Cross,
d. the operational forces of the Croatian Mountain Rescue Service,
e. Associations of citizens,
f. troops and commissioners of civil protection,
g. coordinators at the site,
h. legal persons in the system of civil protection.

Forces for protection and rescue in Croatia are organized in a rather complex manner following the conceptual method of using all available resources. Protection and rescue forces consist of legal and natural persons, preventive resources, executive bodies of local and regional government, central bodies of national dictorate and operative forces for protection and rescue.

Protection and rescue headquarters are organized in cities, municipalities, regions and on national level.

Protection and rescue is based on following activities:

- Observation and assessment of activities and situations that can lead to catastrophe and accidents;
- Prevention, organization and preparedness of measures and activities for incensement of preparedness;
- Continuous organization, preparing and training of protection and rescue forces;
- Alerting of civilians and dissemination of guidelines regarding possible threat;
- Early warning of civil protection forces;
- Activating of operative forces;
- Caring out protection and rescue tasks and activities in cooperation with responsible bodies of other states and international organizations based on international contracts.

The system of civil protection includes measures and activities (prevention, planning, organizational, operational, regulatory and financial) which regulate the rights and obligations of participants, organization and functioning of all parts of the system of civil protection and the connection of institutional and functional resources participants mutually complement each other in a single unit to reduce disaster risk and to protect and rescue people, material and cultural goods and environment on Croatian territory from the effects of natural, technical and technological major accidents and disasters, eliminating the consequences of terrorism and war destruction.

National level protection and rescue plan from natural, technical and technological causes proposes measures and actions for

- early warning,
- preparedness, organization and growth of operative forces,
- protection and rescue measures in cases of hazardous events.

Extreme weather conditions, primarily drought, hail, heat waves, storm and hurricane storm and strong wind, snowfall and other weather events are categorized as extraordinary events when power, intensity, consequences and incidence of force significantly exceed average values. These phenomena are more frequent and with greater intensity, occurring mainly as a result of global climate change, and on the Croatian territory, statistically speaking, the cause of the serious damage, mostly to material goods and the environment and to return to a multi-year follow-up of their frequency and amount of damage.

The natural causes are usually rarely causing human casualties, so they do not represent a priority interest for protection and rescue system, although strong and relatively short events can cause significant disruption to the normal way of life for families, individuals, certain population groups (eg, farmers) local communities and the economy in their area. Therefore, the system of protection and rescue is engaged during the events of this phenomena when responding with operational forces of protection and rescue after an emergency event and when mitigating and eliminate the consequences.

Extraordinary events of this kind to the fullest extent are local coverage, and affect mostly smaller areas. This is the reason why mainly from operational to tactical importance to the system of protection and rescue, and only rarely require the involvement of strategic levels of protection and rescue system, particularly for the duration of an emergency when responding operational forces of protection and rescue. The strategic level of protection and rescue system, based on the principles of solidarity, the operational and tactical levels of the system mainly include the reconstruction after the emergency and to the provision of financial assistance when damages exceed the financial possibilities of local communities and populations.

Table 2: Stakeholders of protection and rescue in preventive, reacting and recovery phases

Type of event	**Prevention**	**Planning and reacting/cooperation**	**recovery and reconstruction**
Storms and hurricanes with effect on transport, energy and buildings	DHMZ (State hydrological and meteorological service)	- central government body responsible for transport - central government body responsible for economy - central government body responsible for construction	In most cases, no significant recovery activity is necessary, and therefore will remain on the response of the leading bodies, except when plans specify different. In case of large-scale consequences law on natural disaster applies.

Source: Protection and rescue plan

4.2. Early Warning and Disaster Preparedness

Early warning is based on prediction and assessment of high probability of occurrence of hazardous event. In the case of high probability, endangered communities are imposed to change of routine and start of activities in case of disaster.

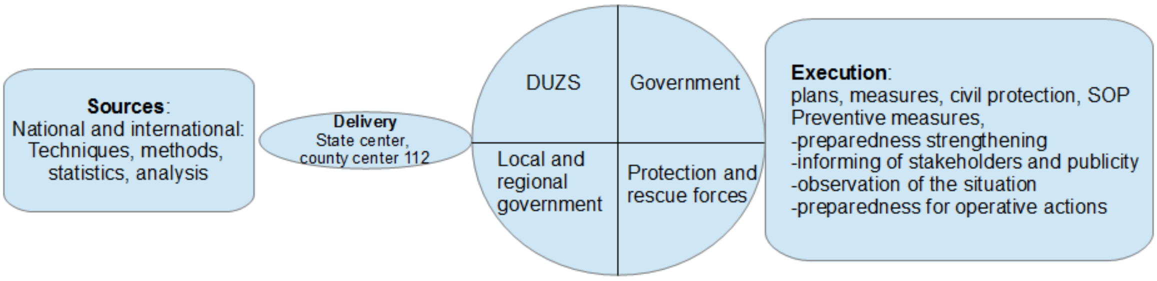
Good early warning system depends on good prediction and good communication channels. That is why activities of scientific communities are important in assessment of probability of occurrence of disastrous events. On the other hand, good function of communication channels from responsible decision makers, operative forces and general public is essential in preparedness for the events.

The information flow in early warning system is shown in Figure 4. The sources of predictions are national and international models and techniques and method for statistical analysis and data analysis based on which warnings are issued.

Warning is delivered to state and regional stakeholders: national protection and rescue directorate, public authorities, local and regional government and other protection and rescue forces.

The alarmed bodies then carry out measures and plan for protection and rescue, civil protection, standard operative procedures, protocols.

Figure 4: Information flow of early warning



Source: Protection and rescue plan

The national protection and rescue plan, among risks of natural causes, deals with risk from extreme weather conditions. Warnings are responsibility of Meteorological and hydrological service. Warnings are given on the basis of national and international models (METLAB, ECMWF, EU-METNET, WMO, EUMET-SAT), meteorological observations, data transfer and analysis. It is important to say that final decision on whether to give warning or not is decision of expert in duty, and not on strictly defined thresholds.

4.3. Emergency Intervention Procedures in case of wind-related disasters

Operative action in case of extraordinary events caused by extreme weather conditions includes following activities:

- timely delivery of information to relevant institutions about possible emergence of extreme time event, type of event, and areas that are most likely to be affected,
- informing citizens about the procedures and measures for health protection, life and property protection (systems of public warning used are local radio, Internet, and other suitable methods of transferring instructions on procedures essential for survival during the event as well as measures to be implemented after its completion),
- advising on the implementation of measures of personal and mutual protection,
- preparedness of emergency services, according to their functional areas,
- activities of the leaders of local and regional (regional) self-government,
- activation of Staff of protection and rescue and civil commands protection of local and regional (regional) governments,
- operation of other operational and rescue forces, according to plans for protection and rescue, the requirements of the leaders of units local and regional (regional) governments, with the harmonization of staff protection and rescue.

In addition to the prior review of operational activities, the State Protection and Rescue Directorate in cooperation with other central bodies state administration, administrative organizations and scientific institutions:

- discusses the procedures for obtaining a warning about the possibilities of the emergence of extraordinary events caused by extreme weather conditions, their delivery and use,
- adopts standard operating procedures and instructions for citizens' activities on the strategic level of protection and rescue.

Carriers of planning protection and rescue at the operational and tactical levels are required to apply preliminary data and measures while creating their own protection and rescue plans, plans civil protection and standard operating procedures.

Wind related disastrous events are relatively rare and do not cause damages as other hazards, so are not considered priorities in civil protection. Such events risks can be reduced by imposing urban planning, building norms and organization rules as preventive measures and civil protection only deals with interventions during the event.

4.4. Plan for Mobilization and Communication of Protection and Rescue Providers

Protection and rescue plan proscribes preparedness, activation, mobilization and growth of operative forces. Preparedness of protection and rescue providers includes preparedness of staff, material, communication and transportation means and proscribed procedures. Preparedness time for operative forces is 1 to 3 hours. Activation is use of prepared operative forces. The mobilization is the planned action of calling members of task forces who are deployed to specific solutions, particularly people allocated to civil protection and duty staff divided into finished operating power. Mobilization is the act of merging people with equipment and resources, while taking into account the priorities, dynamics and places of forces and means gathering.

Physical persons and protection and rescue forces mobilization is not planned, because they are self-activated. Every person is legally obliged to give help in case of emergency and people are included in self-protection and protection of family members immediately. Legal people mobilization is more flexible and depends on specific situation and danger to specific activities. Table with response time of mobilization of specific forces is given in Table 3.

Table 3: Time of mobilization of operative forces for protection and rescue

No.	Civil protection and operative forces	Time of reaction	
		Min	Max
1	Physical people	Immediately	
2	Legal people	1 hour	Several days
3	Leaders of public local and regional self-government	Immediately	15 minutes
4	Operative forces of public local and regional self-government	30 minutes	2 hours
5	Central government body	30 minutes	8 hours
6	Departments and units of corporate and central government bodies that deal with protection and rescue in its regular activities	Immediately	3 hours
7	Firefighting headquarters and unit	Immediately	1 hour
8	Departments and units of State dictorate for protection and rescue (DUZS)	Immediately	2 hours
9	Headquarters for protection and rescue		
	- operational and tactical levels	30 minutes	4 hours
	- strategic level	2 hours	6 hours

10	Services, headquarters and units of civil protection	30 minutes	12 hours

Source: Protection and rescue plan

There is no specific mobilization plan in case of wind related events.

4.5. Recommendations Regarding the Institutional Preparedness

Extraordinary Events of this type are complex causes the formation, but also demanding height damage caused, although a formal legal point of view, usually cannot be categorized as events which the Croatian Government may declare a disaster and major accident. The current Law on Protection from Natural Disasters is regulated by way of participation of local communities and state financing damage from natural disasters.

Legal provisions require a thorough reconstruction, and should establish a new overall solution at the state level. It is necessary to systematically cover all extraordinary events caused by extreme weather conditions on the way to treat the full, and that based on this approach ensure equal access to any extraordinary event of this kind. Special emphasis should be focused on pushing methodology of establishing ways for timely implementation of preventive measures, the construction of the necessary infrastructure and operational rescue capacity, investing in early warning systems, their construction, upgrading and development, protection and informing citizens especially in the more engaged role of the insurance industry in the proceedings compensation for damages after emergency.

Certain extraordinary events caused by extreme weather conditions can be mitigated, in terms of consequences, by planning and implementation of appropriate preventive measures, organizational modules and timely preparation, including information of individuals and local communities. So, depending on the specific conditions of each individual event, relatively successfully and investments acceptable economic power and interests of local communities, within especially elaborated and implemented conditions consequences of the events of this kind can be controlled.

Enhancement of the institutional preparedness and emergency plans can be achieved on following aspects:

- preparedness,
- fast response,
- communication.

Better preparedness can be achieved by engagement of additional forces in periods of the year when more wind related events are expected. Periods when additional forces are required can be predicted because occurrence of high wind in Croatia, especially in Dalmatia is seasonal and periods of the year when wind is more destructive are known.

Preventive measures as most stressed out measure in documents can be revised and upgraded with more recent scientific discoveries and results of wind force analysis.

Fast response can be enhanced by better cooperation between state meteorological service and amateur meteorological organizations that can offer better coverage of observational data.
Use of traditional communication means can be enhanced by use of modern communicational tools, such as social media, internet, messaging applications.

5. Conclusion

Wind Risk Project Action D.3. recommends measures to improve the preparedness of all studied area in Slovenia, Germany and Croatia in the case of strong wind. The report summarizes the civil protection and emergency response procedures in all three countries, with emphasis on institutions and civil protection responsible, warnings and preparedness, emergency intervention procedures and also provides recommendations regarding the institutional preparedness.

To sum up, for a successful protection, rescue, relief, prevention, mitigation and disaster recovery, in the case of strong wind, it is necessary to:

- act in accordance with the municipal and national Protection and Rescue Plans,
- act in accordance with the municipal and national Plan for Mobilization and Communication of Protection and Rescue Providers,
- take care of preparedness and prevention measures: for example, maintain the infrastructure installations and therefor minimize the possibility of interrupted supply of electricity, plumbing and telecommunication connections, implement and maintain systems for systematization and monitoring of damages and clearance procedures, consider climate resistance of tree species in case of replacement plantings, conduct periodical tree inspections for ensuring road safety,
- secure long-term evaluation and monitoring for prevention and preparedness measures,
- provide weather alerts in time for participants in traffic, elderly people and children, civil protection forces, etc.,
- inform and educate the public about the current events,
- make sure the communication and cooperation between institutions involved in civil protection runs smoothly and is in time of disaster wind event enhanced,
- organize health care for people at risk and, and in accordance with the scale of the event to carry out the evacuation and setting up shelters (tents, caravans, containers), or perform relocation,
- provide adequate financial means for emergency preparedness and management,
- in the case of infrastructure installations damage (electricity, roads, water, sewer, telecommunications), immediately proceed to their repair,
- enable smooth emergency operations by keeping driveways of emergency units' buildings free of trees and other obstacles, equipping fire brigades with adequate training and devices and prioritizing city roads for adequate clearance procedure.

The report also shortly presents Plans for Mobilization and Communication of Protection and Rescue Providers in Croatia and Slovenia study areas. These documents include recommendations for organizational measures and they demonstrate systematic linkages with the emergency units responsible for civil protection and disaster relief and early warning systems. They also reveal the importance of technical, financial and logistical factors in protection mechanisms.

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WIND RISK

Task D – Action plan

Action D.4: Recommendations concerning additional building code, rules and regulations

For the Wind Risk prevention project

University of Ljubljana
Technical University of Dortmund
University of Split
Municipality of Ajdovščina

Chapter D.4 – Recommendations concerning additional building code, rules and regulations

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1. Introduction to current building code, rules and regulations

The focus of Action D.4 lies on the development of recommendations from a structural point of view, concentrating on a reduction of roof wind damage in the three partner countries Slovenia, Germany and Croatia. At the initial stage of the project action D.4 report, the adequacy of the existing codes, rules and regulation will be checked. It should be noted that roof and roof cladding are often left to the builder himself rather than be the focus of the design engineer. The report of Action D.4 also contains recommendations for transport and infrastructure but not in such extension.

For wind damage reduction we have to consider many factors such as roof slope, climatic conditions and the architectural features of the environment when making roof. The most important climatic factors affecting the roof and the choice of roof cladding are the wind and snow load.

Further, as for use of different materials for roof cladding, we distinguish many sorts of them. Their properties in combination with the influence of architectural, climate and economy factors affecting the structures and determine which of cladding is appropriate for roof.

The aim of this report is basically development of the specific recommendations concerning additional building code, rules and regulations to reduce wind damage in the three partner countries, which need to be simple to use in everyday life.

2. Building code in European Union

Since March 2010 the Eurocode norms are mandatory through all of the countries of the European Union. Each of the countries has its own part of code that regulates coefficients due to countries own local properties.

EN 1991-1-4 is the part of eurocode that concerns the influence of wind to the buildings during windstorms. The approach in the design of buildings is in short presented additionally.

Basic wind speed

The fundamental value of the basic wind velocity, $v_{b,0}$, is the characteristic 10 minutes mean wind velocity, irrespective of wind direction and time of year, at 10 m above ground level in open country terrain with low vegetation such as grass and isolated obstacles with separations of at least 20 obstacle height (terrain corresponds to terrain category II in Table 1). The basic wind velocity is calculated from expression:

$$v_{b,0} = c_{dir}\, c_{season}\, v_{b,0} \;,$$

where:

$v_{b,0}$ is the basic wind velocity, defined as a function of wind direction and time of year at 10 m above ground of terrain category II,

v_0	is the fundamental value of the basic wind velocity, assigned by the National wind map, which is provided in National Annex,
c_{dir}	is the directional factor,
c_{season}	is the season factor.

The influence of surrounding terrain

The mean wind velocity $v_m(z)$ at a height z above the terrain depends on the terrain roughness and orography and on the basic wind velocity, v_b, and it is determined by using expression:

$$v_m(z) = c_r(z)\, c_o(z)\, v_b\ ,$$

where:

$c_r(z)$	is the roughness factor (it exist 5 category of terrain, see Table 1
$c_o(z)$	is the orography factor.

The roughness factor $c_r(z)$:

The roughness factor $c_r(z)$ accounts for the variability of the mean wind velocity at the site of the structure due to: (i) the height above ground level and (ii) the ground roughness of the terrain upwind of the structure in the wind direction considered.

$$c_r(z) = k_r \ \ln\left(\frac{z}{z_0}\right) \qquad \text{for} \qquad z_{\min} \le z \le z_{\max},$$

$$c_r(z) = c_r(z_{\min}) \qquad \text{for} \qquad z \le z_{\min},$$

where:

z_0	is the roughness length,
k_r	is the terrain factor depending on the roughness length z_0 calculated using

$$k_r = 0.19 \left(\frac{z_0}{z_{0,\mathrm{II}}}\right)^{0.07},$$

where

$z_{0,\mathrm{II}}$	=0.05 m (terrain category II, see Table 1),
$z_{\min}$	is the minimum height (see Table 1),
$z_{\max}$	is to be taken as 200 m.

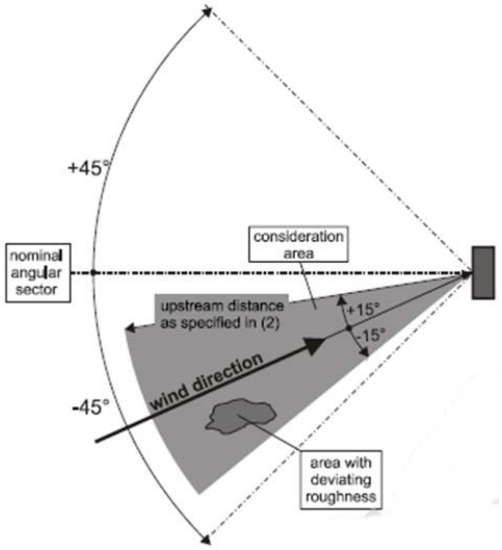
Table 1: Terrain category

Terrain category		z_0 [m]	z_{min} [m]
0	Sea or coastal area exposed to the open sea	0.003	1
I	Lakes of flat and horizontal area with negligible vegetation and without obstacles	0.01	1
II	Area with low vegetation such as grass and isolated obstacles (tree, buildings) with separation of at least 20 obstacle height	0.05	2
III	Area with regular cover of vegetation or buildings or with isolated obstacles with separations of maximum 20 obstacle heights (such as villages, suburban terrain, permanent forest)	0.3	5
IV	Area in which at least 15 % of the surfaces is covered with buildings and their average height exceeds 15 m	1.0	10

Source: SIST EN 1991-1-4:2005, 2005

The terrain roughness to be used for a given wind direction depends on the ground roughness and the distance with uniform terrain roughness in an angular sector around the wind direction. Small areas (less than 10% of the area under consideration) with deviating roughness may be ignored (see Figure 1).

Figure 1: Assessment of terrain roughness



Source: SIST EN 1991-1-4:2005, 2005.

When a pressure or force coefficient is defined for a nominal angular sector, the lowest roughness length within any 30° angular wind sector should be used. Further, when there is choice between two or more terrain categories in the definition of a given area, then the area with the lowest roughness length should be used.

The orography factor $c_o(z)$:

The orography factor $c_o(z)$ is defined as ratio between mean wind velocity at height z above terrain and mean wind velocity above flat terrain; that is $^{w_{\mathrm{m}}}/_{w_{\mathrm{mf}}}$.
The effects of orography may be neglected when the average slope of the upwind terrain is less than 3° or when the orography influences wind speed for less than 10 %. The upwind terrain may be considered up to a distance of 10 times the height of the isolated orographic feature. Due to great extent of numerical calculation of orography coefficients, further description is here omitted.

Wind dynamics

For wind turbulence is significantly that irregular change in wind speed and directions relies on statistical description. The turbulent component of wind velocity has a mean value of 0 and a standard deviation σ_{v} , the latter is determined using expression:

$$\sigma_v = k_r \, v_b \, k_l \; .$$

The turbulence intensity is defined by next expression:

$$I_v(z) = \frac{\sigma_v}{v_m(z)} = \frac{k_l}{c_0(z)\ \ln z/z_0} \qquad \text{for} \qquad z_{\min} \leq z \leq z_{\max},$$

$$I_v(z) = I_v(z_{\min}) \qquad \text{for} \qquad z \leq z_{\min}\ ,$$

where:

k_l is the turbulence factor,
c_0 is the orography factor,
z_0 is the roughness length (see Table 1).

Peak velocity pressure

Taken into consideration all of the values, peak velocity pressure can be calculated by following expression:

$$q_p(z) = [1 + 7 \cdot I_v(z)] \cdot \frac{1}{2}\rho \cdot v_m^2(z) = c_e(z) \cdot q_b\ ,$$

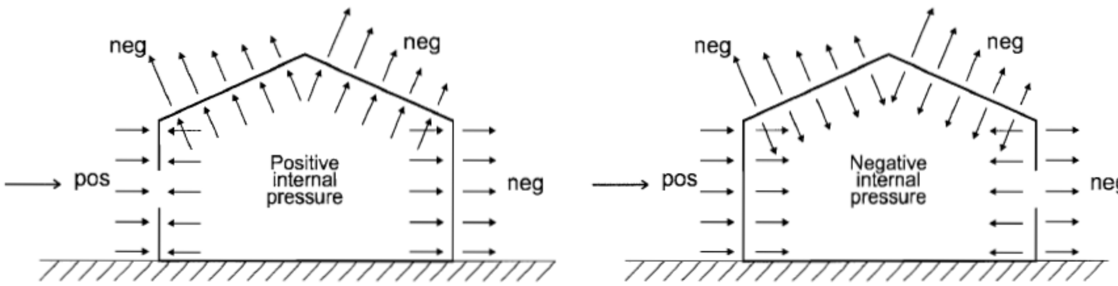
where

ρ is the air density, which depends on the altitude, temperature and barometric pressure to be expected in the region during wind storms,
$c_e(z)$ is the exposure factor and
q_b is the basic velocity pressure.

Wind pressure on surfaces

While calculating the wind pressure on surfaces, which is the ultimate wind load along with wind forces, external and internal pressure must be taken into consideration. The procedure is shown in Figure 2.

Figure 2: Internal and external pressure in buildings



Source: SIST EN 1991-1-4:2005, 2005.

Expression for calculating external pressure:

$$w_e = q_p(z_e) \cdot c_{pe}$$

where:

$q_p(z_e)$	is the peak velocity pressure,
z_e	is the external reference height,
c_{pe}	is the external pressure coefficient.

Expression for calculating internal pressure:

$$w_i = q_p(z_i) \cdot c_{pi}$$

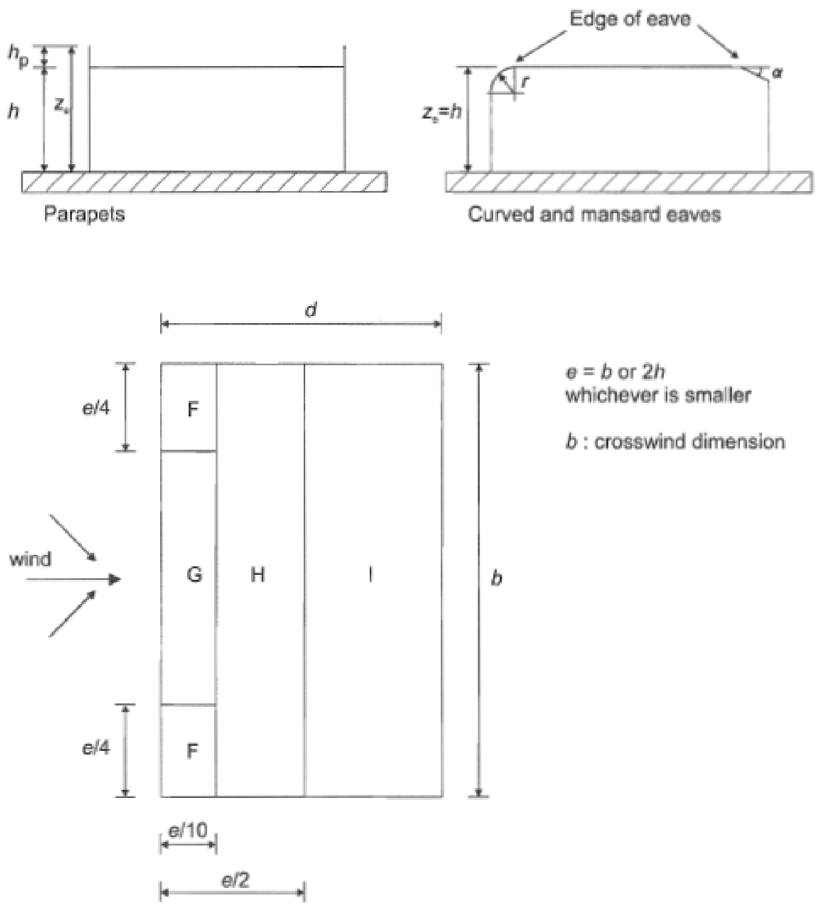
where:

$q_p(z_i)$	is the peak velocity pressure,
z_i	is the internal reference height,
c_{pi}	is the internal pressure coefficient.

The net pressure on the surface is calculated as the difference between the external and internal pressures, taking their positive or negative sign into the account.

The pressure coefficients vary due to the part of the structure and also are different on different parts on the same element. Further the key for the flat roofs is presented along with the table for coefficients values (see Figure 3 and Table 1). Key differs for different parts of buildings.

Figure 3: Division of flat roofs into subareas



Source: SIST EN 1991-1-4:2005, 2005.

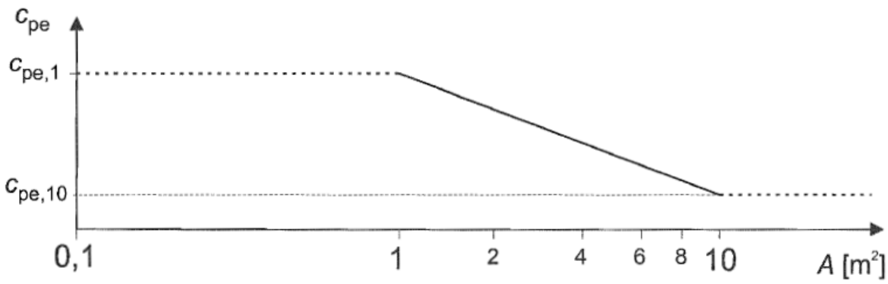
Table 2: External pressure factors for flat roofs.

Roof type		Zone F $c_{pe,10}$	F $c_{pe,1}$	G $c_{pe,10}$	G $c_{pe,1}$	H $c_{pe,10}$	H $c_{pe,1}$	I $c_{pe,10}$	I $c_{pe,1}$
Sharp eaves		-1,8	-2,5	-1,2	-2,0	-0,7	-1,2	+0,2 -0,2	
With Parapets	$h_p/h=0,025$	-1,6	-2,2	-1,1	-1,8	-0,7	-1,2	+0,2 -0,2	
	$h_p/h=0,05$	-1,4	-2,0	-0,9	-1,6	-0,7	-1,2	+0,2 -0,2	
	$h_p/h=0,10$	-1,2	-1,8	-0,8	-1,4	-0,7	-1,2	+0,2 -0,2	
Curved Eaves	$r/h = 0,05$	-1,0	-1,5	-1,2	-1,8	-0,4		+0,2 -0,2	
	$r/h = 0,10$	-0,7	-1,2	-0,8	-1,4	-0,3		+0,2 -0,2	
	$r/h = 0,20$	-0,5	-0,8	-0,5	-0,8	-0,3		+0,2 -0,2	
Mansard Eaves	$\alpha = 30°$	-1,0	-1,5	-1,0	-1,5	-0,3		+0,2 -0,2	
	$\alpha = 45°$	-1,2	-1,8	-1,3	-1,9	-0,4		+0,2 -0,2	
	$\alpha = 60°$	-1,3	-1,9	-1,3	-1,9	-0,5		+0,2 -0,2	

Source: SIST EN 1991-1-4:2005, 2005.

Values $c_{pe,1}$ and $c_{pe,10}$ present pressure on parts of buildings regarding the part area. The interpolation between values is presented in Figure 4.

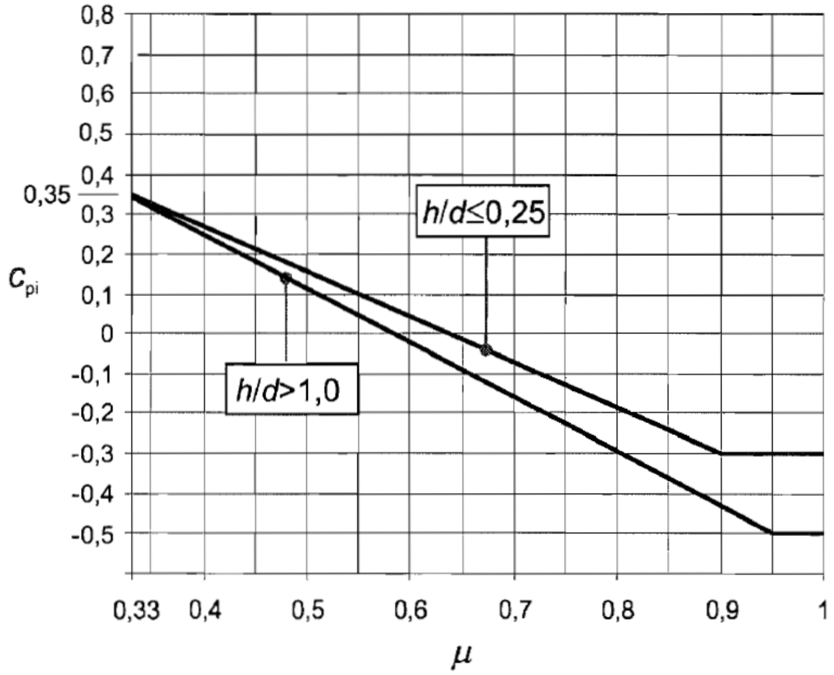
Figure 4: Interpolation of pressure coefficient values



Source: SIST EN 1991-1-4:2005, 2005.

Internal pressure calculation depends on the geometry of the building. For buildings that have windows and doors approximately equally arranged over all faces (no face has more than twice the area of the openings than other areas), the coefficient for internal pressure c_{pi} should be determined by using Figure 5 for each direction of the wind.

Figure 5: The determination of internal pressure coefficient



Source: SIST EN 1991-1-4:2005, 2005.

The parameter μ is calculated as

$$w_i = \mu = \frac{\sum area\ of\ openings\ where\ c_{pe}\ is\ negative\ or - 0{,}0}{\sum area\ of\ all\ openings}$$

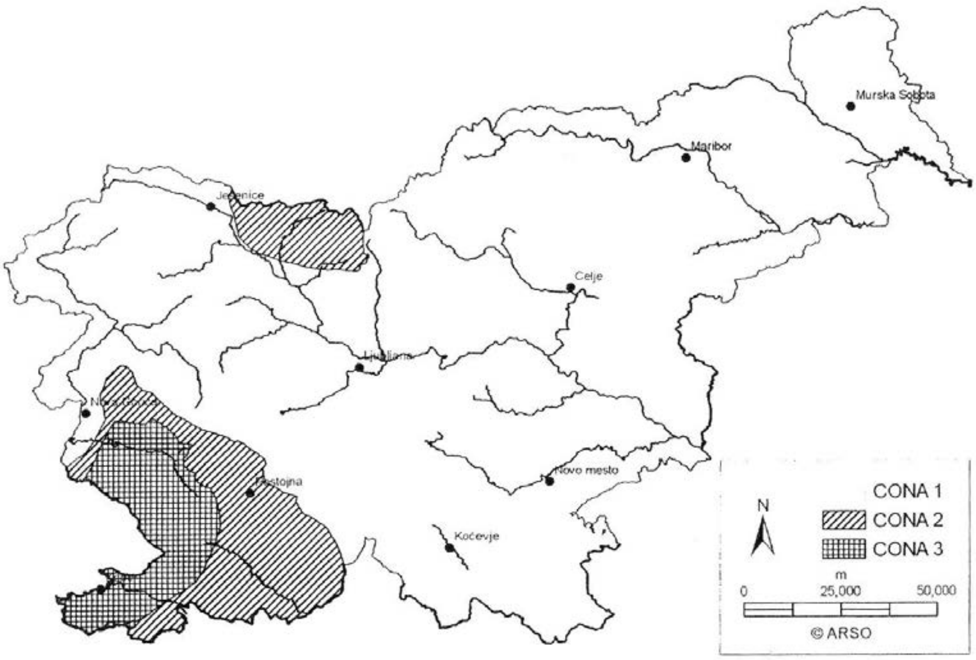
and the values between h/d ≤ 0,25 and h/d > 1,00 should be linearly interpolated.

2.1. National Annex for EN1991-1-4 and other legal documents and strategies in Slovenia

Building regulations in Slovenia are in the accordance with SIST EN 1991 supplemented by National Annex (NA). There is no legislation concerning protection of buildings during high wind, but only some measures issued by Administration for Civil Protection and Disaster Relief. One of the recommendations is using wind resistant roofing. If necessary, the roofing tiles have to be further fixed or weighted (Primorska region). This is also defined in Rescue and protective plans for each of the municipalities.

The building design should predict such actions on structures to left reserve capacity to handle extreme wind loading. As can be seen in Figure 6, the Slovenia is divided in three zones.

Figure 6: Basic wind speed map of Slovenia



Source: SIST EN 1991-1-4:2005, National Annex, 2008

For each of them, basic wind velocity, depending on altitude, is defined:

Zone 1 (the greater part of Slovenia):
20 m/s under 800 m
25 m/s between 800 m and 1600 m
30 m/s between 1600 m and 2000 m
40 m/s above 2000 m

Zone 2 (Trnovski gozd, Notranjska, Karavanke):
25 m/s under 1600 m
30 m/s between 1600 m and 2000 m
40 m/s above 2000 m

Zone 3 (Primorje, Karst and part of Vipava valley):
30 m/s

Due to SIST EN 1991-1-4:2005 National Annex for Slovenia, the pressure of wind calculation variables and coefficients, as well as the procedure of the calculation are as recommended in the EN 1991-1-4 code.

According to Article 80th of the Spatial Management Act, the municipal administrative body is obliged to issue location information, either to the investor or the project manager. In the request it is necessary to specify the purpose for which the location information is required. Regarding to the expressed purpose, the location information contains land-use data, location and other conditions as determined by municipal spatial management act and information data of spatial measures in treated area as well. The location information is valid until the change is made to the spatial planning document and it has a character certificate from the official evidence.

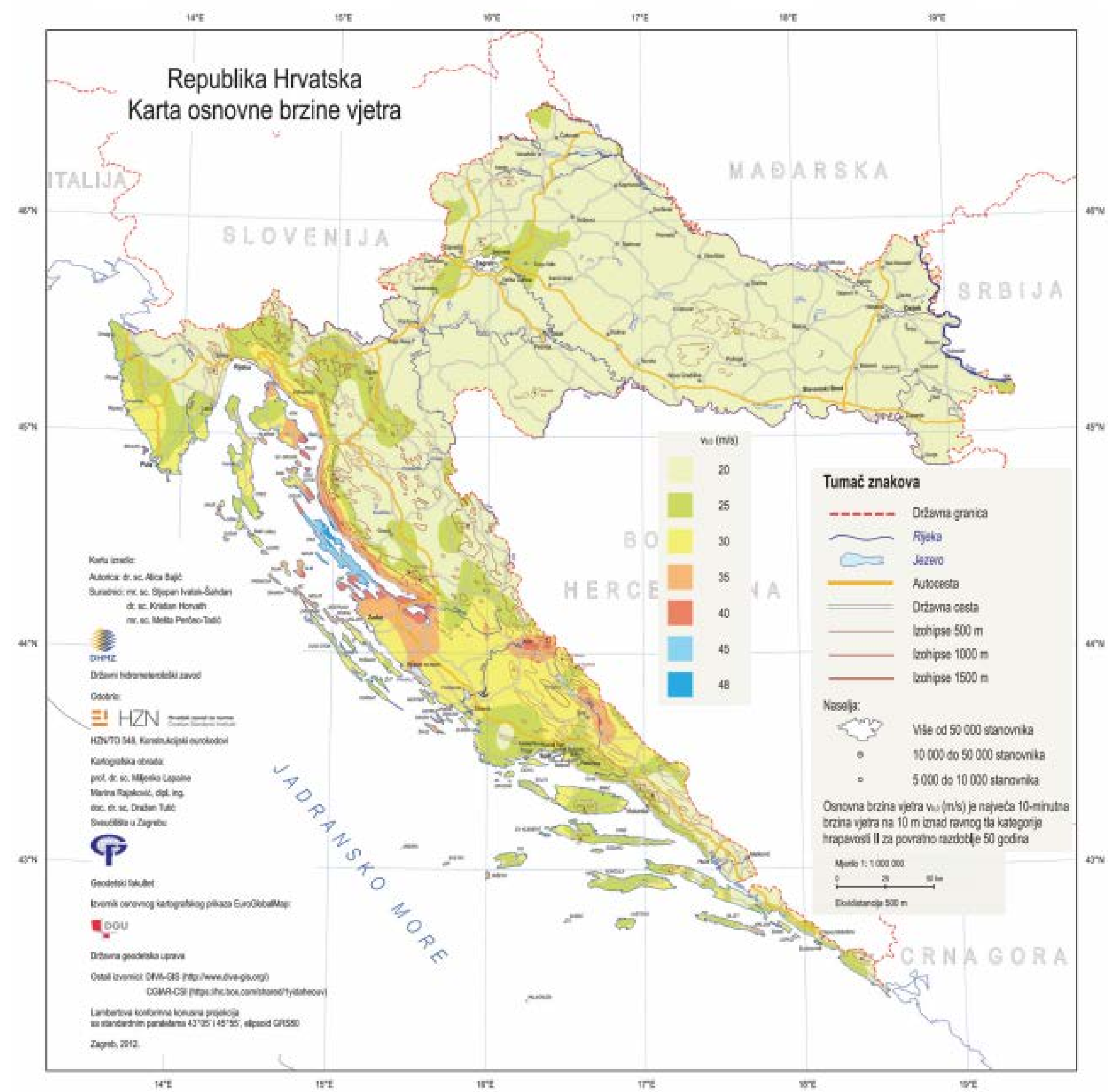
As mentioned above, the location information includes data on plot conditions, as determined by the municipal Spatial Acts (zoning laws), and data on the intended use of the area. A copy of the cadastral plan of the plot should be also attached to the application for the location information.

In accordance with the Spatial Management Act, the applicant is not obliged to obtain the location information any more. Also, according to the Construction Act amended in 2008, the location information is no longer a part of the project documentation for building permit. All data included in the location information have to be obtained ex officio by the local administration that issues the building permit. However, in practice obtaining the location information is still done by most applicants to provide an additional guarantee. Furthermore, the location information provides a clear list of project approvals that must be obtained in the process of obtaining the building permit for the area in question.

2.2. National Annex for EN1991-1-4 and other legal documents and strategies in Croatia

Building regulations regarding wind loads are defined by HRN EN 1991-1-4 regulation supplemented by currently valid national annex HRN EN 1991-1-4 :2012/NA :2012.
The National Annex document approves all design methods and design values set by basic Eurocode 1991-1-4. with exception to following articles.
In article 2.3. Basic wind speed, the zoning of Croatia due to wind speeds regime is given. Croatian territory, due to vast differences in wind regimes is separated in 7 wind zones, as shown in Figure 7.

Figure 7: Basic wind speed for Croatia



Source: HRV EN 1991-1-4:2012 / NA: 2012

Wind speed is defined as ultimate wind speed, averaged on 10-minute basis over class II terrain with 50-year return period. By regulation, lowest design wind speed is 20 m/s and

it is set in continental part of Croatia. Highest wind speeds are on coast, underneath Velebit mountains, where 3D topography of terrain is channelling bora wind. The highest design wind speed is 48 m/s. The design speed is corrected using equation for terrain height above sea level.
In article 2.8. it is stated that basic wind speed map does not include orography factor, which is a factor defined by leeward terrain wind profile. The procedure for defining it is stated in previous chapter of this report.

In article 2.26 wind pressure distribution along the walls for building with rectangular plan is given, and shown in Table 3.

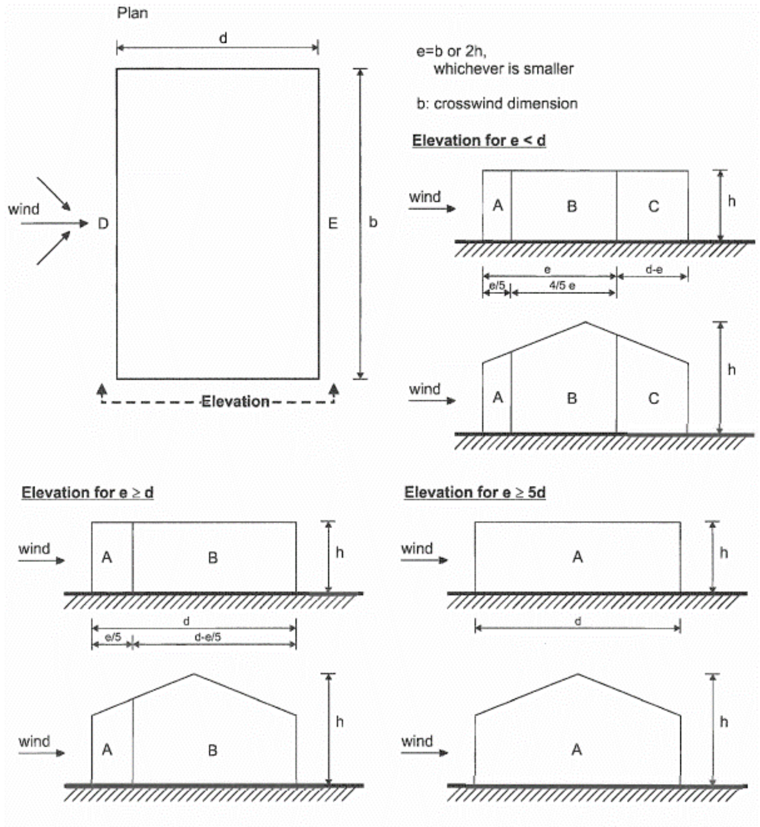
Table 3: Pressure distribution

Područje	A		B		C		D		E	
h/d	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$	$c_{pe,10}$	$c_{pe,1}$
≥ 5	– 1,4	– 1,7	– 0,8	– 1,1	– 0,5	– 0,7	+ 0,8	+ 1,0	– 0,5	– 0,7
1	– 1,2	– 1,4	– 0,8	– 1,1	– 0,5		+ 0,8	+ 1,0	– 0,5	
≤ 0,25	– 1,2	– 1,4	– 0,8	– 1,1	– 0,5		+ 0,7	+ 1,0	– 0,3	– 0,5
NAPOMENA: Za pojedinačne zgrade na otvorenome terenu u područjima u zavjetrini mogu nastupiti i veće sile. Međuvrijednosti se smiju linearno interpolirati. Za zgrade čiji je omjer h/d > 5, ukupno opterećenje vjetrom smije se temeljiti na odredbama iz točaka od 7.6 do 7.8 i 7.9.2.										

Source: HRV EN 1991-1-4:2012 / NA: 2012

where positions A to E are defined in Figure 8

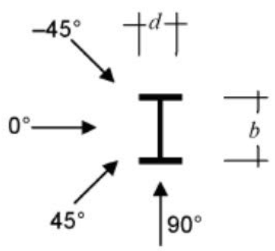
Figure 8: Pressure distribution positions



Source: HRV EN 1991-1-4:2012 / NA: 2012

In article 2.43. of NA document the force distribution coefficient are given for thin walled elements. Force is separated into 2 components, considering shape and aspect ratio of element. In Figure 9 the wind direction and shape dimensions are given, and in Table 4 the values of coefficients are given.

Figure 9: Thin walled sections, orientation



Source: HRV EN 1991-1-4:2012 / NA: 2012

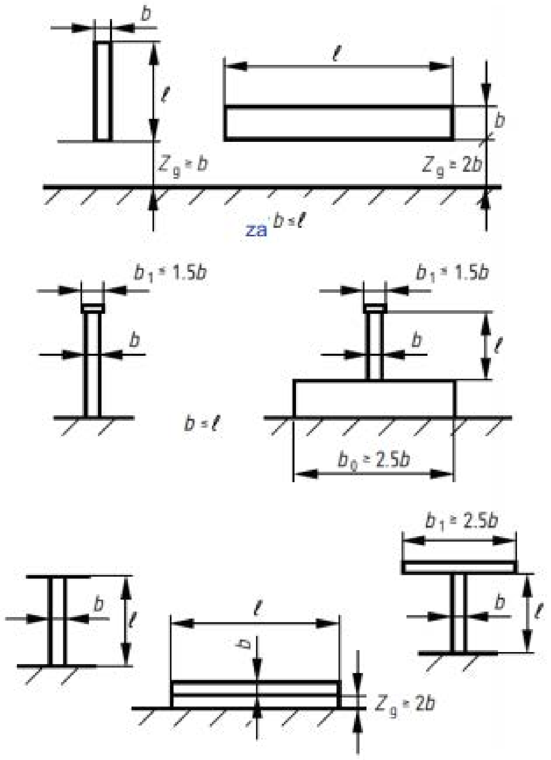
Table 4: Force coefficients

Redni broj	1 Oblik	2 Omjer stranica	3 Smjer vjetra	4 $c_{fx,0}$	5 $c_{fy,0}$
1		d/b < 0,1	0°	2,00	0
2		d/b = 1,0	0° 45° 90°	1,65 2,20 1,30	0 1,00 2,10
3		d/b = 1,0	0° 45° 90°	2,00 1,15 – 1,30	0 0,80 2,10
4		d/b = 0,5	0° + 45° – 45° 90°	2,00 1,80 1,30 1,75	2,00 1,60 – 0,40 2,50
5		d/b = 0,5	0° + 45° – 45° 90°	2,00 1,55 1,55 – 0,25	– 0,20 1,40 – 1,60 1,60
6		d/b = 1,0	0° 45° 90°	1,80 1,80 2,00	2,00 1,80 1,80
7		d/b = 1,0	0° + 45° – 45° 90°	1,90 1,40 0,70 – 0,20	– 0,20 1,40 – 1,80 1,90
8		d/b = 1,0	0° 45° 90°	2,00 0,85 0	0 0,85 2,00
9		d/b = 0,5	0° 45° 90°	2,00 1,80 0	0 1,20 1,60
		d/b = 0,66	0° 45° 90°	1,85 1,70 0	0 1,50 1,80
		d/b = 1,0	0° 45° 90°	1,70 1,50 0	0 1,50 1,70
10		d/b = 0,5	0° 45° 90°	2,10 1,80 0	0 1,20 1,40
11		d/b = 0,5	0° 45° 90°	1,80 1,80 0	0 1,0 2,4

Source: HRV EN 1991-1-4:2012 / NA: 2012

The article 2.50 is defining end-effect factor and design slenderness. The table given in NA is different than table from HRN EN 1991-1-4. The table is shown in Table 5.

Table 5: End-effect factor and design slenderness

Položaj konstrukcije, vjetar okomito na ravninu stranice	Proračunska vitkost **λ**
	$\lambda = (l/b)(2/c_{f,0})$ $\lambda = (2l/b)(2/c_{f,0})$ $\lambda = \infty$

Source: HRV EN 1991-1-4:2012 / NA: 2012

Technical regulations for buildings in Croatia are defined concerning main construction material. List of active technical regulations are:

- Technical regulations for masonry constructions (*Tehnički propisi za zidane konstrukcije)* OG 01/07
- Technical regulation for timbre constructions (*Tehnički propisi za drvene konstrukcije*) OG 121/07, 58/09, 125/10, 136/12
- Technical regulations for steel constructions (*Tehnički propisi za čelične konstrukcije*) OG 112/08, 125/10, 73/12, 136/12
- Technical regulations for composite steel and concrete constructions (*Tehnički propisi za spregnute konstrukcije od čelika I betona*) OG 119/09, 125/10, 136/12
- Technical regulations for concrete constructions (*Tehnički propisi za betonske konstrukcije*) OG 139/09, 14/10, 125/10, 136/12
- Technical regulations for aluminium constructions (*Tehnički propisi za aluminijske konstrukcije*) OG 80/13

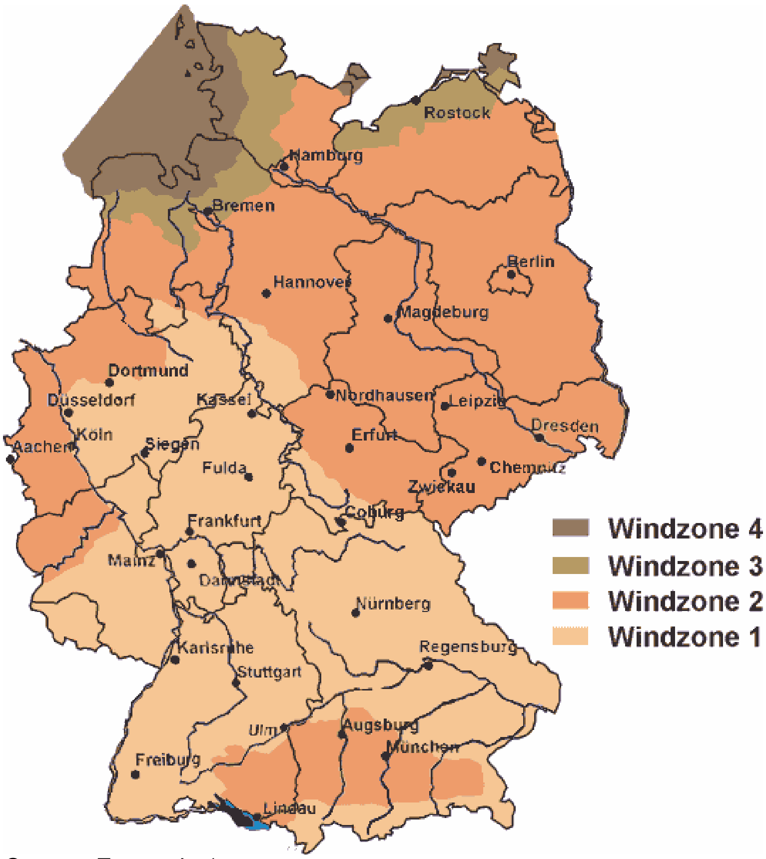
All these regulations follow HRN EN regulations, except for aluminium constructions because the EN is not completely adopted yet.

2.3. National Annex for EN1991-1-4 and other legal documents and strategies in Germany

In the field of building codes and regulations, also in Germany the main European norm concerning wind loads and the prevention of storm damages is Eurocode 1 (DIN EN 1991-1). DIN EN 1991-1 was transferred into the national DIN norm 1055, which is regularly revised in cooperation with the Germany Meteorological Service. Within DIN 1055, the specifics for each type of building, e.g. on the construction of the roofs, are given. Therein it is secured, that every newly built building is able to withstand a certain wind, snow and ice load; otherwise building permission will not be granted by the municipalities.

According to DIN 1055-4 there are four wind zones in Germany, ranking from zone one (inland regions with low velocity pressure on buildings) to zone four (mainly coast regions and islands with high velocity pressure on building). These four wind zones have the following spatial dimension in Germany (see Figure 10).

Figure 10 Basic wind speed map of Germany



Source: Eurocode 1.

The four wind zones represent certain thresholds on maximum velocity pressures (kN/m^2) for several building heights. Table 6 contains these thresholds according to DIN 1055-4.

Table 6 Wind Zones according to Wind Load Norm (DIN 1055-4)

Wind Zones		Velocity Pressure in kN/m^2 at a building height h* in the borders of:		
		$h \leq$ 10m	10m < $h \leq$ 18m	18m < $h \leq$ 25m
1	Inland	0.5	0.65	0.75
2	Inland	0.65	0.8	0.9
	Coast/Shore and Islands in the Baltic Sea	0.85	1.	1.10
3	Inland	0.8	0.95	1.10
	Coast/Shore and Island in the Baltic Sea	1.05	1.20	1.30
4	Inland	0.95	1.15	1.30
	Coast/Shore of the North Sea and Baltic Sea and Island in the Baltic Sea	1.25	1.40	1.55
	Island in the North Sea	1.40	-	-

**h = height of the building*
Source: Eurocode 1: Einwirkungen auf Tragwerke – Teil a-4.

Additionally, there are two norms specifying the wind loads from DIN EN 1991-1-4 to windows (DIN EN 12210) and roofs and building fronts (DIN EN 18531). (Cf. Website Baunetzwissen 2016)

Further information on the legislative situation in Germany can be taken from Wind Risk Prevention Project Report C.5.

3. Case studies

3.1. Case study: Ajdovščina

The Municipality of Ajdovščina is the center of the Vipava valley and marked by the local wind called Burja (bora wind).

Wind causes many inconveniences: uncovering roofs, lifting or carrying away the entire roof structures, breaking chimneys, poorly constructed buildings, billboards and traffic signs, roll communal containers, breaking branches and destroying trees, market the electrical wiring, causing high waves, snowdrifts, obstacle or even impossible traffic, carries the earth and causing damage to farmland. Appropriate measures and may prevent or mitigate the damage caused by strong winds. One of the consequences due to bora wind is shown in Figure 11.

Figure 11: Wind damage school in Ajdovščina Municipality

Source: Ajdovščina Municipality

Ajdovščina is considered to be in the third zone on the map (Figure 6) for determining fundamental value of the basic wind velocity (v_b). For only non-seasonal structures are taken into consideration, basic speed velocity is not reduced and its value remains at 30 m/s.

Ajdovščina belongs to III. category of terrain roughness as shown in Table 1Figure 6. Taking into consideration a 15-meter-high building (most buildings are lower than 15m), basic speed velocity is reduced for over 5 %.

In the north part of Ajdovščina terrain rises up and as Bora wind blows from the north-east, effect of those hills should be taken into account. Basic speed velocity is increased by around 8 % owing to effects of the orography.
The mean value of wind velocity is calculated to be approximately 30.56 m/s (110 km/h).

The turbulence intensity also influences wind speed and therefore peak velocity pressure. After calculating the turbulence intensity factor, peak velocity pressure may be determined and the top wind velocity can be estimated up to 50 m/s. Due to data obtained by Slovenian environment agency (ARSO), wind gusts in the Ajdovščina area never exceed 40 m/s, however, the question about time length of the problematic gusts is in place (with reducing the time interval to 1 s length, the average velocity of wind gust would increase dramatically).

Geometry and structure of the roof and orientation of the roof ridge are the only things that an engineer design to reduce wind load on the roof. Wind effect is reduced when the ridge orientation is rotated perpendicular to the wind direction and the pitch angle of the roof is around 20°, which is usual angle for residential houses but not for local industry.

3.1.1. Regional roofing types

The choice of a roofing type depends on various factors, such as roof slope, type of roof, functionality, aesthetics and also resistance to weather phenomena such as strong winds and hail.

There are different types of roofing, depending on the slope of the roof. In connection to the type of roofing, the slope can be divided into three groups shown in Figure 12 (in aspect to local wind conditions, roof with steep slopes (over 45°) do not come into consideration)

Figure 12: Types of roofing due to the angle of slope

Slope	Type of roof	Usual type of roofing
0°- 5°	Flat roofs	Membranes based on rubber, PVC or asphalt
6° - 15°	Low-sloped roofs	Metal roofing
15° - 45°	Mid-sloped roofs	Clay- and cement-based roofing

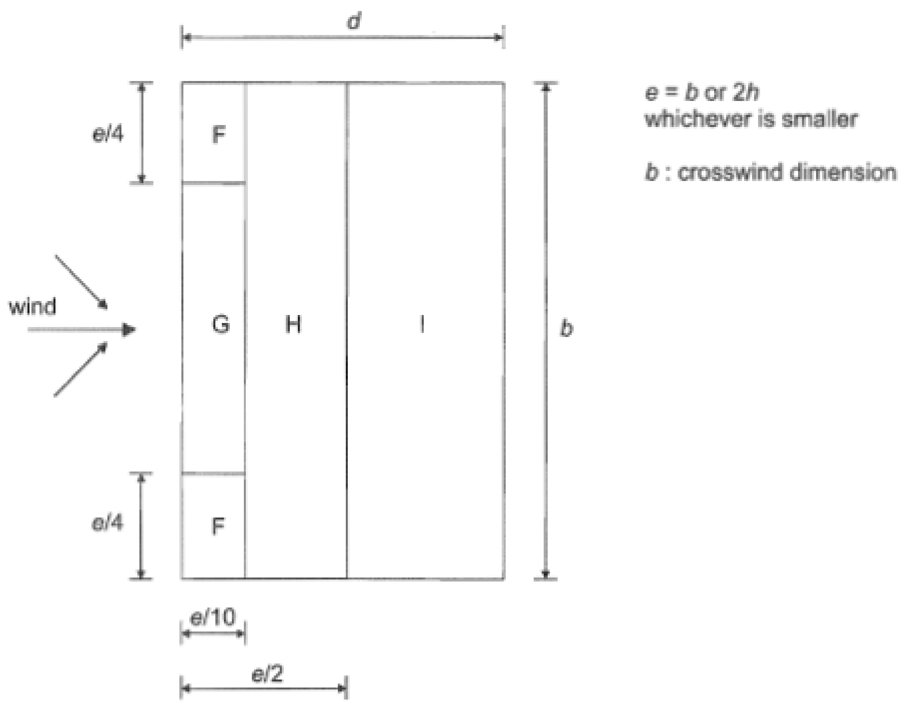
Source: SIST EN 1991-1-4:2005, 2005.

3.1.1.1. Flat roofs

In case of flat roofs, engineers and roof makers should pay attention to two very important wind factors – wind suction and windstorm repetitions.

Flat roofs are exposed to great wind suction, effect of which can be greatly reduced by building roof with either parapets or (curved or mansard) eaves. Wind suction is not equal on the surface of roof – instead the roof is divided into areas as shown in Figure 13. The most exposed area is the edge of the roof, therefore caution is necessary while making finishing details.

Figure 13: Flat roof divided into sections



Source: SIST EN 1991-1-4:2005, 2005.

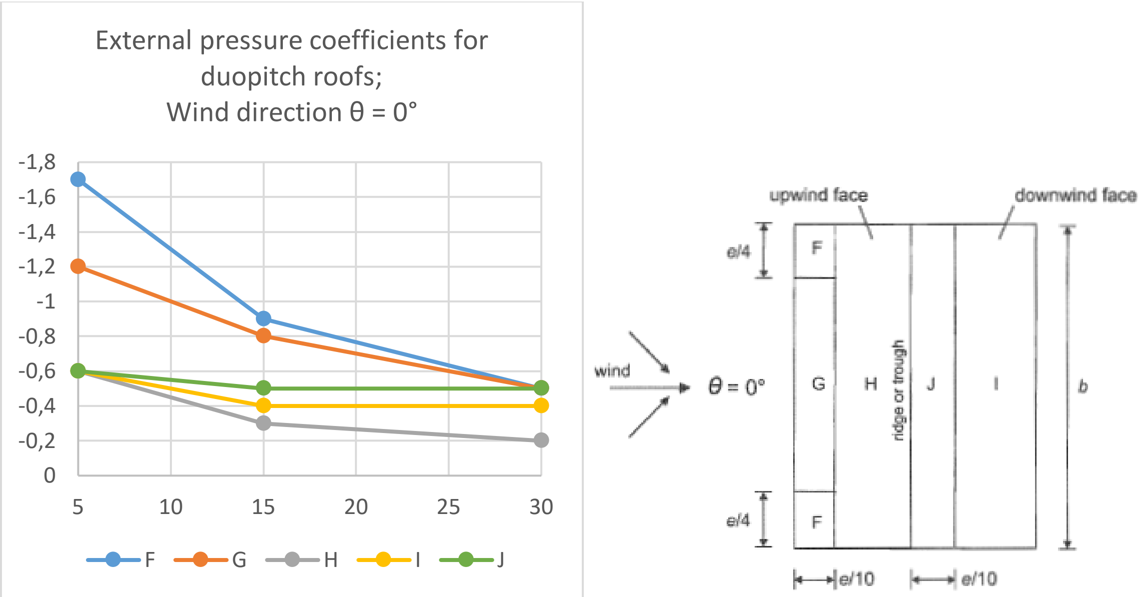
The second thing that should be taken into account is the repetition of the windstorms. This is especially problematic in case of torch applied bitumen membrane due to material fatigue in the area of panel overlaps and roof details.

There are some types of flat roof that have proven to be effective. PVC membrane roof is very resistant to the wind forces if the connection to the main bearing structure is made correctly. Weight of this roofing is small providing a good way for reconstruction of old and/or damaged roofs which bearing capacity does not support greater loads. Also the modern ways of fixing (such as induction based fixing) provide higher bearing capacity without reducing the hydro isolative properties of the roof. Green roofs as well as ballasted roofs are not suitable for reconstruction of roofs where the load-bearing construction has not been calculated to the loads as great as provided by the self-weight of the roof in combination with other loads such as wind and snow. Regardless, both of mentioned types are the most resistant to all of the weather conditions, including repetition of windstorms, high wind and hail.

3.1.1.2. Low-sloped roofs

This group of roofs seems the most problematic of them all, which results in the quantity of damaged roofs with metal coverage. The problematic part is a very low weight, large panels and insufficient design of load-bearing elements. Also the angle of slope is adding to instability of the roof. Due to the SIST EN 1991-1-4 standard, the greatest effect of wind is applied to the slopes between 5° and 15° as shown in Figure 14.

Figure 14: External pressure coefficients against roof inclination



Source:Self depiction after SIST EN 1991-1-4:2005, 2005.

Due to fact, that the weight of the roof does not provide enough force in gravity direction to oppose wind suction (which often coincides with wind pressure from below roofing), therefore the elements holding the roofing to its substructure and also the elements holding substructure in place, should be carefully designed. Also the fixing of edge trims should be calculated and afterwards carried out as designed.

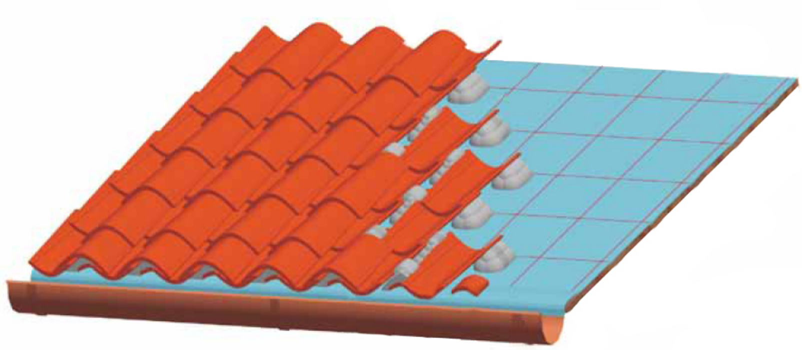
3.1.1.1. Mid- and High-sloped roofs

Roofs with slope inclination more than 15° are usually covered with clay or cement based roofing tiles. Similar to ballasted and green roofs, this kind of coverage provides resistance to wind suction by its weight. Though they are heavy, the tiles should still be fixed to the roof using already tested methods that have been proven to withstand the weather effects. Still the edge trims and other details should be carried out with caution.

For small residential buildings a regional roofing type named Korec is in use. There are several ways to fix roofing tiles to the structure. Fixing type affects the weight and exposure of the roof tiles as well as airflow underneath the tiles and therefore breathability of the structure.

The oldest still used type of fixing the tiles is by mortar. This has a large disadvantage in the amount of weight added to the construction, though this is not always bad regarding the negative wind pressure on the roof. The airflow under tiles is highly reduced, resulting in reduced pressure under the tiles and reduced breathability of the building. The most vulnerable part of the roof is the top layer of tiles, because it is not connected to mortar, therefore stones must be added to increase the weight and negate the wind suction. Durability is also one of the bad properties of mortar. Due to the repetition of exchanging high and low temperatures, the mortar gets burned out and therefore it does not stick to the clay roofing any more.

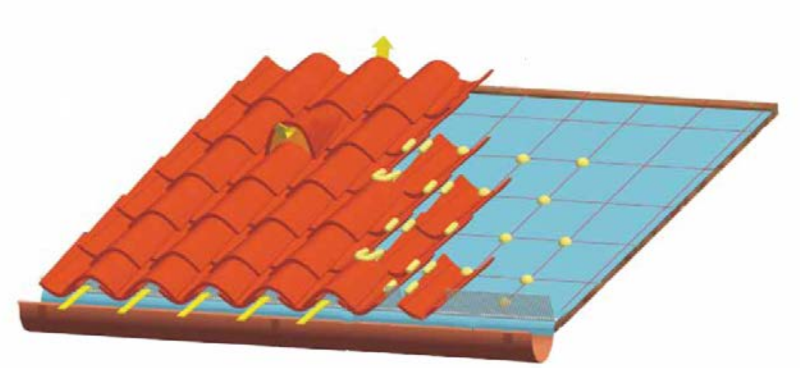
Figure 15: Fixing roof tiles for mortar



Source: Goriške opekarne, 2016.

Fixing by mortar is getting replaced with fixing by polyurethane foam. This method increases breathability of the building and connects the lower and the top layer of tiles and reduces the weight of the roof as well. Though it seems perfect solution (polyurethane foam is only UV light sensitive, which does not present a problem due to darkness in between the roof tiles and the secondary cover), this type of fixing is only in use for about two decades and the long term durability could be questioned and therefore tested.

Figure 16: Fixing roof tiles by polyurethane foam



Source: Goriške opekarne, 2016.

The remaining types of fixing tiles to the roof are made by screwing the tiles to the wooden substructure or by hanging the tiles to the wooden substructure either by steel components or directly hanging the specially designed tiles to the substructure. Though those types provide very breathable roofing, they are not suitable to use in Vipava valley because of forces that are affecting the roofing, taking pressure and suction interaction into the account. However, if using this type of attachment in Vipava valley, appropriate screws (made locally for this part of Slovenia) should be used and detailed calculations should be made.

Figure 17: Fixing roof tiles to wooden substructure

Source: Goriške opekarne, 2016.

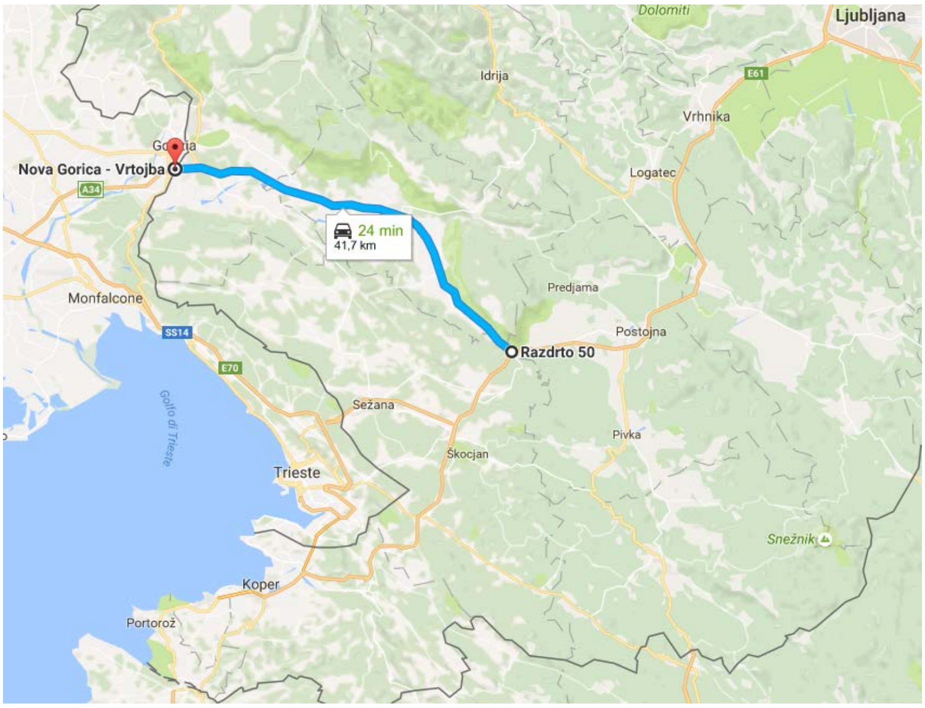
In general practice, problems occur when the roof is built by a non-local company. Most of Slovenia is set to be in Zone 1 of fundamental wind speed chart (see Figure 6), therefore in most of Slovenia wind is not considered as the main load, so the calculations of the wind effect on non-bearing parts of roof is rarely done. Static calculations mostly include only the calculation of main frame roof construction (mostly wooden). In the past, some incidents occurred with the wind tearing off whole roofing along with its wooden substructure, which also indicates that not enough roof parts were taken into engineering calculation.

There is also a problem concerning fixing the large area tiles with metal fasteners due to their ability to decrease hydro-isolative properties of the roofing. However, fixing with other ways rather than metal fasteners was proven to be inefficient. Due to the information we were able to get by contacting construction companies, there are options to get the study of the wind loads and the roof construction as well as the type and number of metal fasteners. There are also types of metal fasteners that can be welded using induction. Therefore, do not make a hole into the surface, increasing the hydro-isolative properties of the membrane, but greatly improving the membrane stability and wind resistance.

3.1.2. Transport management

The Bora wind also presents danger for transport. There are restrictions on the H4 expressway through Vipava valley (see Figure 18) for vehicles of certain type due to high wind speed.

Figure 18: H4 expressway



Source: Googlemaps, 2016.

The levels of road closure are displayed in Table 7.

Table 7: Levels of road closure

Wind speed [km/h]	H4 closed for:	Restrictions for other vehicles:
80-100	Campers, refrigerators and hooded vehicles up to 8 tons of mass	Speed limit 40 km/h
100-130	All campers, refrigerators and hooded vehicles	Speed limit 40 km/h
130-150	All campers, refrigerators, hooded vehicles and buses	Speed limit 40 km/h
> 150	All vehicles	/

Source: Traffic information center.

Because the H4 represents the main road through northern Primorska region and the main road towards Italy, the closure of the road results in high expenses for local and also international transport.

Motorway Company in the Republic of Slovenia (DARS) is already making studies for the past few years but due to very complicated orography and unpredictable properties of Bora wind, as well as the cost of investment, the company is in progress of building test zones in exposed areas of the H4 expressway (www.rtvslo.si, 2016). Those zones are designed for the following sections:

- Test zone 1: Lozice viaduct (area with the highest monitored wind gusts), in total length of 693,5 m,
- Test zone 2: section between Mlake shooting range towards Podnanos tunnel (complexity of the curved area of expressway), in total length of 620 m,
- and Test zone 3: section between Log and Zemon, in total length of 304 m.
-

Test zones are meant to provide important studies for building the wind barriers through all the problematic parts of H4 expressway in between the Nanos toll station and the Vipavski Križ cut-and-cover tunnel, in total length of about 21,5 kilometres on both side of the highway (partly also only on one side of the highway), making the investment worth about 32 million euros.

3.2. Case study: Split

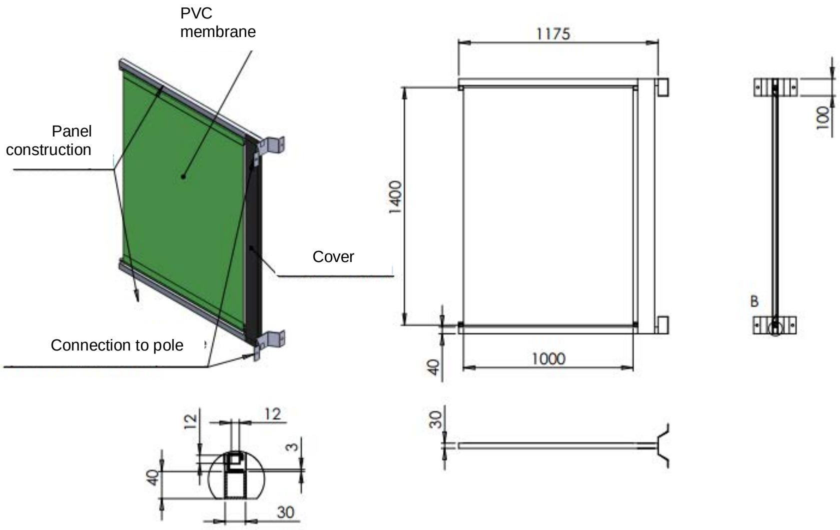
3.2.1. Installation of advertising panels on street lightning poles

The main task of this study is to develop an expert opinion on the possibility of using the existing lighting poles for the installation of advertising panels, thereby defining the maximum height of the installation of those panels. The load of the panel on the construction is not in the form of weight but in the form of aerodynamic forces that occur when wind affects the panel. Consequently, this study describes in detail the impact of panel mounting on the load and stability of poles.

According to the enclosed documentation, the poles planned for the installation of advertising panels have the KORS 2B-1200-3 type, have the height of 12 m, and are produced by Dalekovod d.o.o.. The poles are executed as octagonal truncated pyramids whose width at the base is 207 mm and 87 mm at the top (for the pole 12 m tall), and whose width at the base is 195 mm and 90 mm at the top (for the pole 10 m tall). All the wall thicknesses are 4 mm. The quality of the material is S235.

An advertising panel is designed as a fixed banner spread between two steel consoles. Advertising panel consoles have the rectangular cross section of 40x30 mm, and a wall thickness of 3 mm. They are attached to the lighting pole by clamps made of sheet steel with the height of 60 mm and a thickness 6 mm, and they are connected with bolts M14 that have the quality of 5.6. Material of the advertising panel canvas is PVC.

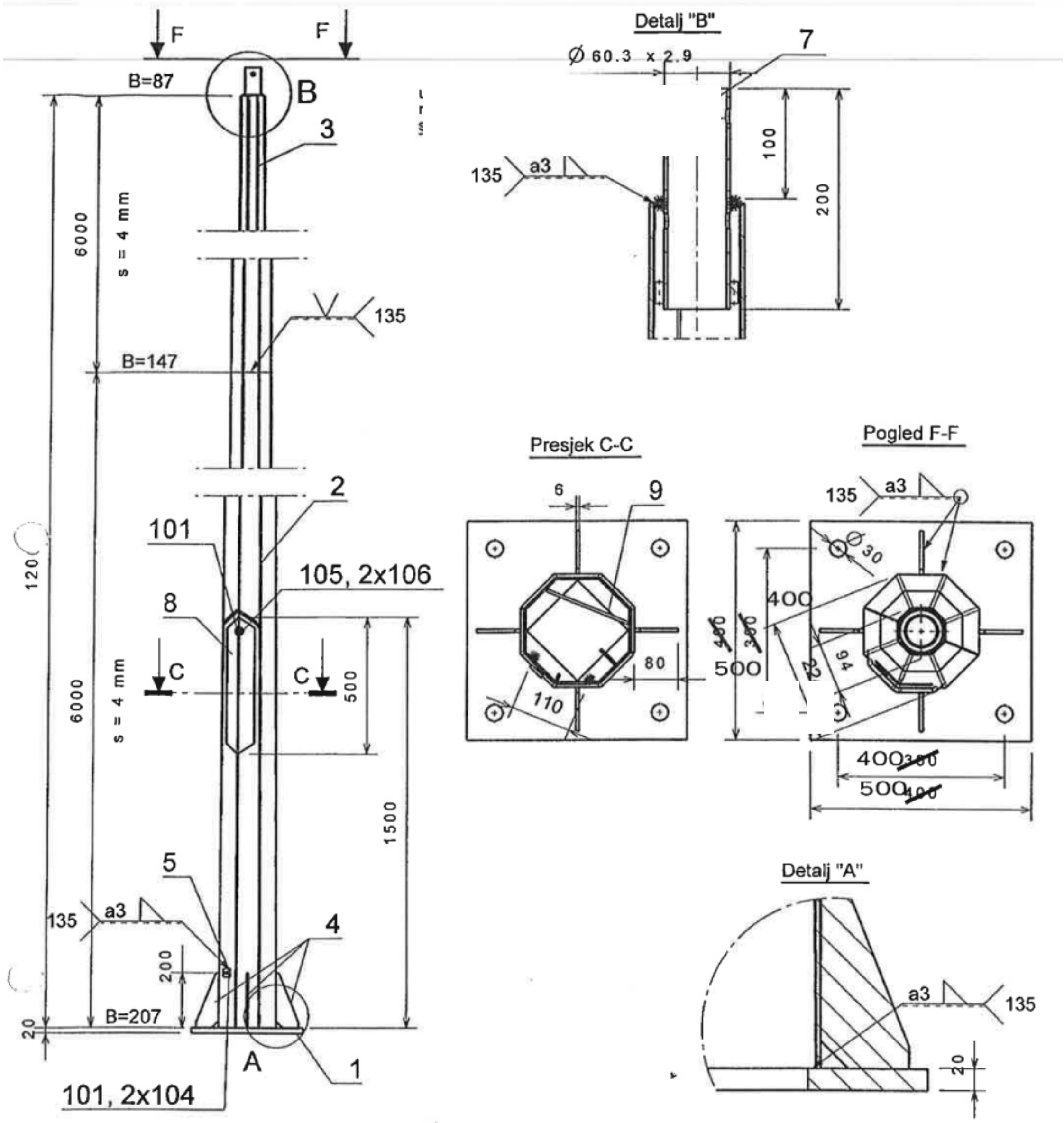
Figure 19: Advertising panel construction



On the top of the poles there is a luminaire of the type CX 200 basic from the Siteco manufacturer. The weight of the light source is 13.8 kg. Overall dimensions of the luminaire are 825x390x190 mm. The deleted area in the vertical plane is 0.14 m^2, according to the manufacturer's catalog. It is assumed that the direction of the axis of the luminaire corresponds to the axis of the advertising panel.

Wind load is defined according to the HRN EN 1991-1-4:2005 norm and the national annex (NAD) HRN EN 1991-1-4:2012/NA. According to the annex, the basic wind speed for the subject location is 30 m/s, but the norm leaves the possibility of using the wind speed obtained from the measurements on the site. The basic wind speed that amounts to 26 m/s is taken from the measurements carried out at the subject's location. The specified wind speed was measured as the largest statistically expected value of wind speed with a return period of 50 years, and is based on many years of measurements. The wind forces are defined from the geometry of the pole and pole additions.

Figure 20: Street lightning pole sketch



3.2.1.1. Load analysis

The weight of the lighting pole construction and advertising panel console is calculated in accordance with the submitted documentation. Steel parts are calculated with a density of 7850 kg/m^3. The weight of the luminaire at the top of the pole is 13.8 kg. The weight of the advertising panel is 8 kg.

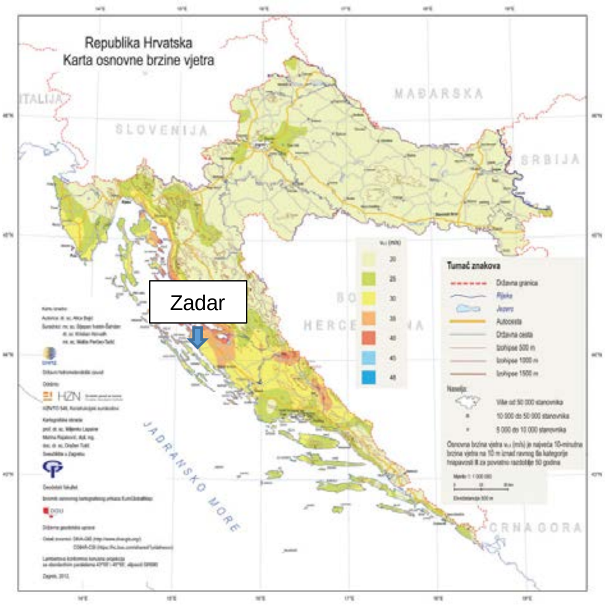
Snow load is ignored because of the small layout area. Temperature load does not generate forces in sections because of statically defined structure. Seismic load is

ignored due to the low mass of the pole and additional elements. Wind load is dominant on the construction of the pole and is carried out according to the norm HRN EN 1991-1-4:2005 and according to the national annex HRN EN 1991-1-4:2012/NA.
The locations of the lighting poles are near Zadar. According to HRN EN 1991-1-4:2005, the basic wind speed is given by the expression:

$$v_b = c_{dir} \cdot c_{season} \cdot v_{b,0} \qquad (1)$$

where v_b is the basic wind speed, determined as a function of wind direction and time of the year, 10 m above the ground that belongs to the terrain category II, $v_{b,0}$ fundamental value of the basic wind speed, c_{dir} direction factor and c_{season} season factor. According to HRN EN 1991-1-4:2012 NA, basic speed in Zadar measures 30.0 m/s. From measurements on the immediate subject's location, basic wind speed is estimated to be 26 m/s, and the same is used in the budget.

Figure 21 Map of the basic wind speed and location of project



Average wind speed v_m, described in t. 4.3.1 HRN EN 1991-1-4:2005 connects the basic wind speed with orthography and roughness of the terrain by forming a profile with medium wind speed with regard to height

$$v_m(z) = c_r(z) \cdot c_0(z) \cdot v_b \qquad (2)$$

where cr*(z)* roughness factor and $c_o(z)$ vertical indented terrain factor.
Terrain roughness factor is based on the logarithmic law described in t. 4.3.2. HRN EN 1991-1-4:2005 and confirmed in t. 2.10 HRN EN 1991-1-4:2012/NA and is described by the terms:

$$c_r(z) = k_r \cdot \ln\left(\frac{z}{z_0}\right) \qquad za \qquad z_{min} \le z \le z_{max}$$
$$c_r(z) = c_r(z_{min}) \qquad za \qquad z \le z_{min} \qquad (3)$$

where z_0 roughness length and k_r terrain factor dependent on the length of roughness z_0 that is calculated by the expression

$$k_r = 0.19 \cdot \left(\frac{z_0}{z_{0,II}} \right)^{0.07} \tag{4}$$

where $z_{0,II}$ = 0.05 is the referent height for the category II, z_{min} minimum height and z_{max} maximum height.

Five terrain categories described in Table 8 are used. In addition to the descriptions in the table, there are also the relevant parameters for those categories.

Table 8 Terrain categories and terrain parameters

Terrain categories		m	m
0	Sea or coastal areas exposed to the open sea	0.003	1
I	Lakes or flat and horizontally placed area with negligible vegetation and without obstacles	0.01	1
II	The areas with low vegetation, e.g. grass and isolated obstacles (trees, buildings) with a distance of at least 20 obstacle heights	0.05	2
III	The areas with permanent vegetation cover or buildings or areas with isolated obstacles with a gap of up to 20 obstacle heights (e.g. villages, suburbs, permanent forest)	0.3	5
IV	The areas with at least 15% of the area covered by buildings whose average height exceeds 15 m	1.0	10

In accordance to the suggestions from the norms, terrain category III is defined for the subject's location.

Coefficient c_o represents the impact of vertical indentation of the terrain near the area of interest.

Since there is no expressed indentation of the terrain at the subject's sites, the unit value is taken in accordance to t. 4.3.3. HRN EN 1991-1-4:2005.
Wind gusts are described with the turbulence intensity. Turbulence intensity function describes the change of turbulence intensity with regard to the height. For the turbulence intensity it is necessary to define a standard deviation of fluctuating velocity component. According to t.2.15. HRN EN 1991-1-4:2012/NA, standard deviation is given by the expression

$$\sigma_v = k_r \cdot v_b \cdot k_I \tag{5}$$

where k_I is the turbulence factor that equals 1. Turbulence intensity is defined by the expression

$$I_v(z)=\frac{\sigma_v}{v_m(z)}=\frac{k_I}{c_0(z)\cdot\ln(z/z_0)} \qquad za \qquad z_{\min}\le z\le z_{\max}$$
$$I_v(z)=I_v(z_{\min}) \qquad za \qquad z\le z_{\min} \tag{6}$$

Wind peak pressure is defined in t. 4.5. HRN EN 1991-1-4:2005 and is

$$q_p(z)=\left[1+7\cdot I_v(z)\right]\cdot\frac{1}{2}\cdot\rho\cdot v_m^2(z) \tag{7}$$

where ρ is the air density. According to t. 2.17. HRN EN 1991-1-4:2012/NA air density is taken as 1.25 kg/m^3.
Wind force F_w that acts on the structure or structural component may be directly determined according to t. 5.3. HRN EN 1991-1-4:2005 by using the expression

$$F_w=c_sc_d\cdot\sum_{elementi}c_f\cdot q_p(z_e)\cdot A_{ref} \tag{8}$$

where c_sc_d structural factor, c_f structural force coefficient or construction element and A_{ref} referent structural area or structural element.
According to t. 6.2. HRN EN 1991-1-4:2005 concerned poles meet the prerequisites for simplified determination of structural factors, and both of them amount to 1 in the product.
Shape coefficient c_f for the lighting pole is defined as a product

$$c_f=c_{f,0}\psi_\lambda \tag{9}$$

where $c_{f,0}$ is the force coefficient for the octagonal cross-section without the flow through the free end and ψ_λ is the end impact factor. End impact factor depends on the slenderness of the pole and amounts to 0.91 for the respective poles.
Shape coefficient without the end impact for the octagonal cross-section is defined in t. 7.8. HRN EN 1991-1-4:2005 and HRN EN 1991-1-4:2012/NA as

$$\begin{array}{lll} r/b<0.075 & \mathrm{Re}\le 2.4\cdot10^5 & c_{f,0}=1.45 \\ & \mathrm{Re}\ge 3.0\cdot10^5 & c_{f,0}=1.30 \\ r/\mathrm{b}\ge 0.075 & \mathrm{Re}\le 2.0\cdot10^5 & c_{f,0}=1.30 \\ & \mathrm{Re}\ge 7.0\cdot10^5 & c_{f,0}=1.10 \end{array} \tag{10}$$

where r is the radius of curvature at the corners, b a distance between the parallel sides of the octagon and Re Reynolds number described by the expression

$$\mathrm{Re}=\frac{b\cdot v_m}{\nu} \tag{11}$$

where v kinematic viscosity of the air that, according to HRN EN 1991-1-4:2005, equals 15x10^{-6} m^2/s. For the values of Reynolds number between the defined a linear interpolation between the defined values of the coefficient form is conducted.
Shape coefficient of the advertising panel is given in t. 7.12 HRN EN 1991-1-4:2005 for the fixed flag and amounts to 1.8. Shape coefficient of the luminaire is determined according to the recommendations of the manufacturer's brochure.

Shape coefficient c_f is defined by zones according to t. 7.2.2. HRN EN 1991-1-4:2005 and HRN EN 1991-1-4:2012/NA. The specified poles are thus divided into zones of 1 m.

3.2.1.2. Inspection of pole KORS 2B-1200-3 load

The wind load is the dominant load on the structure weighted by advertising posters and depends on the geometry of the pole. Wind load on the KORS 2B-1200-3 pole at the subject's location (Zadar) is defined in the following Table 9.

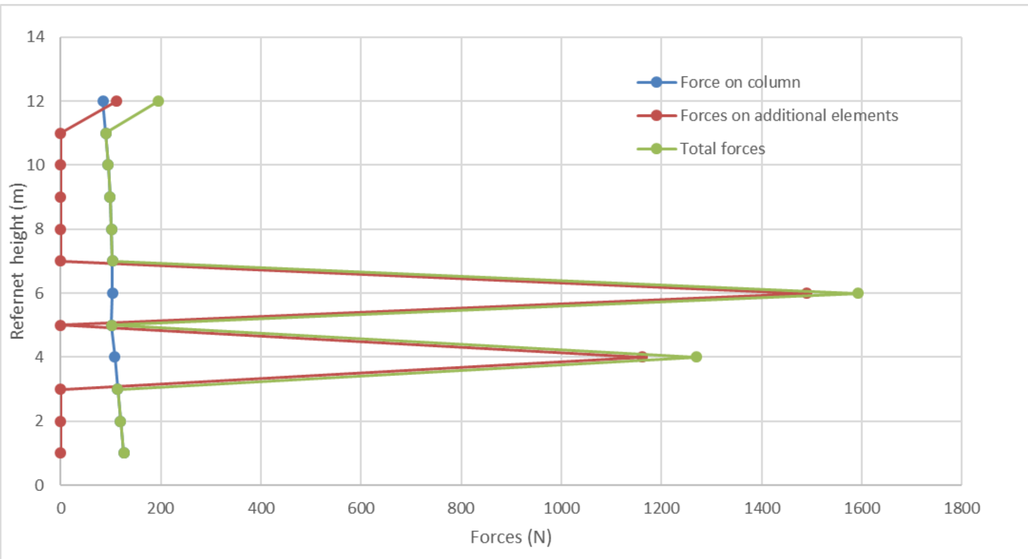
Table 9: The load on the KORS 2B-1200-3 pole

Segment stupa	*Refernetna visina [m]*	*Faktor hrapavosti*	*Srednja brzina vjetra [m/s]*	*Intnezitet turbulencije*	*Tlak od vjetra [N/m2]*	*Širina stupa [mm]*	*Reynoldsov broj*	*Koeficijent oblika*	*Površina stupa [m2]*	*Faktor učinka kraja*	*Sila na stup [N]*
1	1,00	0,6	14,5	0,355	461,109	207	200700	1,45	0,207	0,91	125,95
2	2,00	0,6	14,5	0,355	461,109	197	191004	1,45	0,197	0,91	119,86
3	3,00	0,6	14,5	0,355	461,109	187	181309	1,45	0,187	0,91	113,78
4	4,00	0,6	14,5	0,355	461,109	177	171613	1,45	0,177	0,91	107,69
5	5,00	0,6	14,5	0,355	461,109	167	161917	1,45	0,167	0,91	101,61
6	6,00	0,6	15,5	0,334	500,113	157	162086	1,45	0,157	0,91	103,60
7	7,00	0,7	16,3	0,317	533,957	147	159572	1,45	0,147	0,91	103,57
8	8,00	0,7	17,0	0,305	563,915	137	155021	1,45	0,137	0,91	101,94
9	9,00	0,7	17,6	0,294	590,835	127	148861	1,45	0,127	0,91	99,01
10	10,00	0,8	18,1	0,285	615,308	117	141388	1,45	0,117	0,91	94,99
11	11,00	0,8	18,6	0,278	637,766	107	132818	1,45	0,107	0,91	90,04
12	12,00	0,8	19,1	0,271	658,533	97	123313	1,45	0,097	0,91	84,29

Source: Self depiction

At the top of the pole is a luminaire, model CX200 of the referent surfaces of 0.14 m^2. According to the available documentation the luminaire shape coefficient is 1,2. The total force that occurs on the luminaire is 0.111 kN (see Figure 22).

Figure 22: The distribution of forces that occur when wind occurs

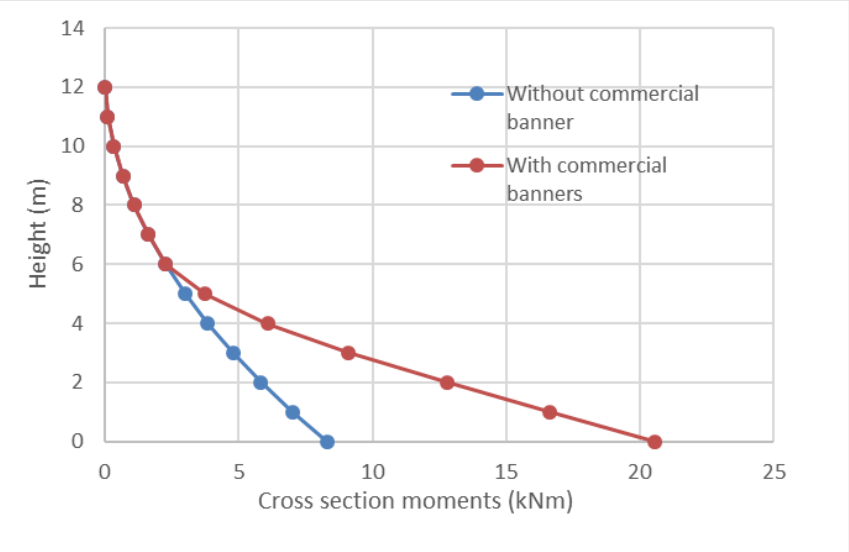


Source: Self depiction

The advertising panel has the area of 1,4 m^2. Since the surface of the advertising panel is PVC foil that is fixed at the top and bottom edges, the form coefficient is taken as the one for the fixed flag and equals to 1.8. Dynamic effects of wind on the flag are embedded in the shape coefficient. The total force which is induced in the panel equals to 16.1 kN. Uniform wind load is expected on the surface of the panel due to the ratio of the size of the panel and the turbulent wind vortices. The forces of the panel on a pole are equal for the upper and lower grip and amount to 0.58 kN. Lower grip of the force is 4m above the ground, and the upper is 5.4 m above the ground.

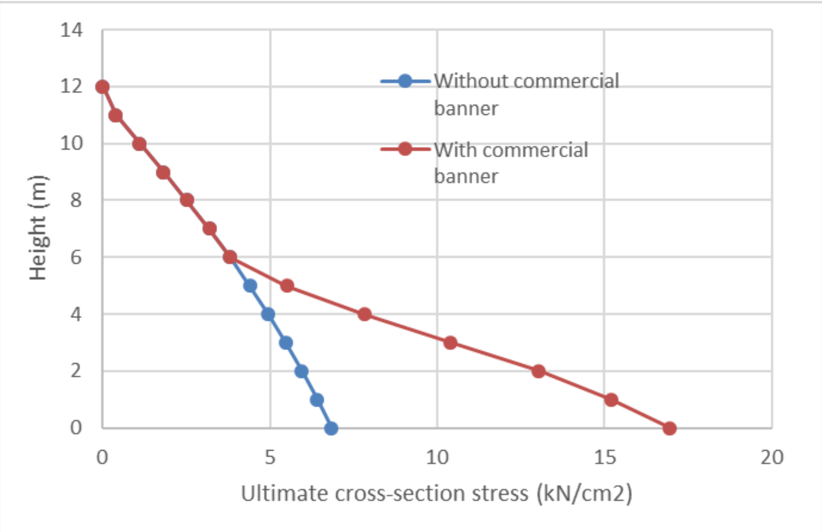
The introduction of one advertising panel leads to a change in distribution of torque and stress along the structural element. The distribution is shown in Figure 23, Figure 24, and Table 10.

Figure 23: The distribution of torque regarding the pole height



Source: Self depiction

Figure 24: The distribution of stress along the length of the pole



Source: Self depiction

Table 10: The distribution of torque and stress

	With commercial banner		*Without commercial banner*	
z / m	**M / kNm**	**s / kN/cm2**	**M / kNm**	**s / kN/cm2**
0	20.56	16.96	8.30	6.85
1	16.61	15.20	7.01	6.41
2	12.79	13.05	5.83	5.95
3	9.08	10.39	4.78	5.47
4	6.07	7.84	3.84	4.96
5	3.74	5.50	3.00	4.41
6	2.26	3.81	2.26	3.81
7	1.63	3.18	1.63	3.18
8	1.10	2.52	1.10	2.52
9	0.67	1.82	0.67	1.82
10	0.34	1.10	0.34	1.10
11	0.10	0.39	0.10	0.39
12	0.00	0.00	0.00	0.00

Source: Self depiction

Adding an advertising panel at the height of 4m above the ground increases the torque for +147% and the stress for +145%. The foundation and bottom part of construction of the pole is reinforced in order to take on the extra load.

3.3. Case study: Dortmund/Essen

As described in chapter 2.3, DIN 1055 is regularly revised in Germany, according to the state of the art in meteorological knowledge. Also, the types of damages from (winter) storms in Germany differ from the phenomena described for Slovenia and Croatia. Nonetheless, there are some (rather general) recommendations that can be drawn from the Wind Risk Prevention Project in order to support discussions further building codes, rules and regulations.

First of all, it is striking, that apparently there are no publicly available information on the methodology of defining the four wind zones of the German National Annex of Eurocode 1. So far, only meteorological experts are able to understand how the wind zones are calculated, and in consequence zoned and mapped. It should be in the interest of the EU and its Member States that the methodologies for all national annexes are transparently described and publically available, as these regulations effect any house owner.

Secondly, the wind zones of Germany and their thresholds so far (most likely[1]) solely focus on winter storms. But as summer storm *Ela* impressively revealed, Germany might have to face other types of storms in the present and future. Therefore, completely new discussions might need to be leaded by the experts. Meteorologists and civil engineers need to combine their knowledge on possible (new) requirements for buildings.

This task – including summer storm thresholds into wind zone maps – will be challenging, as described in previous Wind Risk Prevention Project Reports[2] as there are great differences in the characters of the events of summer storms (occurring April – September) and winter storms (occurring October – March). Summer storms are mainly convective events that last for several minutes up to some hours in strong cases like summer storm *Ela*. These storm types usually are of small geographic extent and unpredictable in their path. Winter storms on the other hands mainly result from meteorological depressions. They can last from several hours up to days and are of great geographic extent. In comparison to summer storms, winter storms have a precisely predictable storm path.

Nevertheless, wind zone maps should also include summer storms, as the intensity (wind speed) of a storm is more important than its duration regarding potential damages. Winds that endure only for a short time but with a very high wind speed and additionally unpredictable local turbulences can lead to high damages, as *Ela* impressively revealed. And that is why wind gusts – the extremes of the wind speed distribution – are crucial for the arising damages (cf. Becker & Hüttl 2014: 9).

It would therefore in conclusion be necessary to conduct further research on summer storms, their predictability and probability of occurrence. Only if further knowledge exists, spatial recommendations and therefore wind zone mappings can be adequately updated. The spatial distribution of (insured) losses is the best option to identify local patterns of wind risks. Here, access to the internal loss data, collected by reinsurance companies

[1] This statement cannot be proven as the methodology of wind zone mapping is not publically available (see first statement).

[2] See e.g. Wind Risk Prevention Report C.2/C.4.

like Munich Re or Swiss Re could be beneficial in order to validate the results of newly generated models.

Thirdly, the impact of climate change should be taken into close consideration when updating the wind zones and their thresholds in all partner countries. The dilemma is as follows: Building permissions, which are granted in the present, relying on the current wind zone maps, will need to face the climatic conditions of the future. It can generally be assumed that buildings are built in order to last several decades, i.e. up to 100 years. If climate change dramatically influences the frequency of occurrence and the magnitude of (summer) storm events, buildings should nowadays be prepared at best.

This recommendation again results in an urgent need for further research as the current state of research on frequency and magnitude of summer storms is still in early stages. So far, it is widely agreed that due to anthropogenic greenhouse gas emissions major changes in the atmosphere are taking place. These changes are in part associated with changes in the intensity and probability of occurrence of extreme wind speeds, caused by convective events, but due to the lack of research on the subject there are considerable uncertainties. Accordingly, statements on probable future scenarios are even vaguer.

For Germany and the challenge of dealing with summer storm phenomena, a research focus should be on the projection of possible future storm situation of both average (extreme) wind speeds (98^{th} percentile of days with strong wind) and even rarer occurring events like summer storm *Ela*.[3]

[3] For a deeper discussion on the impact of climate change on storms in Europe see Wind Risk Prevention Project Report C.1.

4. Conclusions/Recommendations concerning additional building code, rules and regulations to reduce wind damage

4.1. Redesign of wind charts and sleet charts

Concerning the existing wind charts there the basic wind speeds of the zones as well as the areas considered as zones. Additional measurements are needed in order to analyse the extent of the areas affected by high winds. Also the size of the card is not appropriate for the use of civil engineers due to the fact that one cannot precisely define the object location on a small map. So it would be greatly recommended that the map of basic wind speed would be integrated into applications that are in general use and therefore would be accessible to general population and made more useful as for their precision.

As for the sleet map, the situation is quite similar – the loads presented on current maps may be underestimated, and therefore new design of a map should be considered. In Slovenian Technical Committee for standards a new map of sleet zones is prepared to be implemented in National Annexes. Here, it has to be toted, that more systematically observation of sleet should be performed.

4.2. Changes of c_{dir} coefficient

Making alterations to EN 1991-1-4 regulation concerning wind loading would also be appropriate. Long term research has been conducting on differences in local winds, (in Croatia especially Bora and Sirocco which are two prevalent and dominant winds in the area). The EN 1991-1-4 defines coefficient c_{dir} that depending on wind direction and currently it is 1.0 irrelevant to actual wind direction. In numerous researches, it is found that Bora wind is stronger, more focused and gustier wind than Sirocco although both can achieve high mean wind speeds. The proposal is to increase this coefficient for Bora type winds, blow usually from the northeast direction, and Sirocco winds that blow usually from the south, to a value that yet should be defined.

4.3. Appendix to EC1

As for now, the EN 1991-1-4 standard apply to the loading of wind that shall be used while dimensioning structures, but no actual models are proposed to design of roofing and prescriptions of fasteners to use in applying the roof tiles to the substructure. With some appendixes we would provide a useful tool for engineers to use and also dimension parts of roofs that were not usually dimensioned. The appendixes should provide examples of all representative roof designs along with the guidelines for fixing and designing the fasteners with which the roofing will be fixed to the roof substructure and further on the substructure would be fastened to the main bearing system of the building. Also the guidelines for fixing the wooden bearing system of a roof to the main (reinforced concrete or steel) building bearing system should be presented. With dimensioning the roofing as well as the roofs substructure and other elements, the chance of damage is reduced in a large scale.

4.4. Reliability Driven Design

The reliability driven design is explained in standard EN 1990. As for our recommendation it is proposed to be mandatory for use in case of important structures (such as high buildings and high-voltage electricity pylons) that are built in areas with high wind or sleet loading, providing optimised results. The principle of design needs a lot of measurements and data regarding to wind speed, materials, snow and sleet loading and other parameters. For using mentioned design, more measuring should take place in critical areas and the data acquired should be available for general use.

4.5. Wind calculation report

Though the municipalities may add specific demands into their Spatial Plans, there is no practice of adding the demands that would include wind risk documents.

For now, no documents that are needed for gaining the building permit, do not include any special data about wind. It is recommended for the municipalities which are exposed to high winds to make the wind calculation report of roofs mandatory to include a report providing the information about wind loading, choosing of roof bearing system as well as the choosing of the roofing. Also the calculations to prove that the resistance to the wind load of all the components is ensured by the chosen type of the system and the prescribed system of fixing the parts together, should be provided and further on to be inspected by an expert.

4.6. Infrastructure

Regarding infrastructure also some changes should be made. As high-voltage electricity pylons are important part of the infrastructure, those should be calculated by the Reliability Driven Design (as proposed in the chapter 4.4). The data of wind load as well as the data of the sleet load should be obtained by updated wind and sleet charts, also taking into consideration also the coupled effect of both phenomena.

City trees may also be included into this chapter and the recommendations regard planting new trees in cities. The trees should be planted according to plans that should include the regulation of not planting the trees in the proximity of emergency stations driveways in order to keep the driveways clear and the emergency units able to respond in case of devastating wind storms.

4.7. Transport management

Transport management is a delicate matter and therefore should be studied by using test fields and additional measurements at the exposed parts of highways and local roads of great importance in an order to design and establish wind protection by using wind barriers to reduce high wind effect on transport and therefore reduce the losses of local and also international industry.

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WIND RISK

Task D – Action plan

Action D.5: Recommendations Concerning Forest Management

For the Wind Risk prevention project

University of Ljubljana
Technical University of Dortmund
University of Split
Municipality of Ajdovščina

Chapter D.5 – Recommendations Concerning Forest Management

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1. Introduction to Forest Management in the EU

The forests of the EU exceed an area of 161 million hectares and in total make up 4 % of the worldwide forest. These 161 million hectares correspond 38 % of the total area of the EU but are inadequately distributed. The countries Germany, Spain, Finland, Poland and Sweden together provide about two third of the total EU forest area. The countries Slovenia, Finland and Sweden each have more than 60 % of their total territory covered by forests. From 1990 until the year 2000 the total area of forests in the EU increased by about eleven million hectares due to both natural development as well as reforestation measures.

Unfortunately, the EU does not dispose a common forestry policy and also there is no official common definition of the term 'forest'. Nevertheless, for EU-wide statistics it is determined that 'forests are territories, whose area amounts more than 0.5 hectares, whereof at least 10 % have a canopy cover and in which trees are able to reach a height of at least five meters' (cf. Website European Parliament 2016).

In the EU there are many different forest types, reflecting the EU's geo-climatic diversity. Although the distribution of the different forest types depends on climatic conditions, soil types, altitude and topography, all types have in common that 88 % of their area are shaped by man. Only 4 % of the EU's forest area has never been formed by human interventions.
Therefore, it is little surprising that 134 of the 161 million hectares of forested area are used for timer production. Timber is widely used for energy generation (42 % of the EU's timber volume) but also for paper and panel industry. In total the forestry sector accounts for approximately 1 % of the EU's gross domestic product (GDP) and plays a great economic role, especially in rural areas. It is estimated that about 2,6 million people in the EU work in the forestry sector.
Besides their economical role, forests in the EU are also of great importance regarding the environment. "[T]hey help protect the soil (against erosion), form part of the water cycle, and regulate the local climate (mainly via evapotranspiration) and the global climate (in particular by storing carbon). They also protect biodiversity, by providing a habitat for numerous species." (Website European Parliament 2016)

But forests in the EU are threatened by various factors. Regarding abiotic factors, threats include (wild)fires[1], atmospheric pollution due to emission, drought and especially storms. During the last 60 years, two storms a year have hit EU forests on average and caused significant damage. Furthermore, about 6 % of the forested areas in the EU are, on top, affected by biotic threats like insects or diseases. (Cf. Website European Parliament 2016)
With continuing climate change, the threats to Europe's forests are becoming even more severe. "Climate change is likely to affect the forests' rate of growth, their range, the range of certain parasites, and even the frequency and intensity of extreme weather events." (Website European Parliament 2016) It is therefore the aim of the Wind Risk Prevention Project to give recommendations concerning forest management in the EU with a focus on adaptation to storms.

[1] Especially in the Mediterranean

This report is structured as follows: First, general information is given on the status quo of forests in the three partner countries Germany, Slovenia and Croatia. Subsequently, common forests risk factors towards storms are discussed (see subchapter 1.1). In subchapter 1.2 aims, strategies and measures of good forest planning and management are provided. In subchapter 1.3 the legal and strategic framework of forest management in the EU are investigated via a presentation of various legal documents, strategies and actions. In subchapter 1.4 an interim conclusion is drawn.

The subsequent chapters of this report deal with the forest management strategies in Germany (chapter 2), Slovenia (chapter 3) and Croatia (chapter 4). Within these country-specific chapters, first prevailing legal documents and strategies shall be displayed before the actual situation within the case study areas is explained and finally recommendations are given.
Last, a mutual chapter comprises the recommendations given by the partners and gives a final set of recommendations concerning forest management and storms in the EU (see chapter 5).

Before examining forest risks factors towards storms, the following table gives an overview on basic forest data in the three partner countries of the Wind Risk Prevention Project. It can be seen that although Germany has the greatest total area of forest with more than 11 million hectares, both Slovenia and Croatia have higher percentages of land area covered by forest and other wooded land.

Table 1: Basic data on forests in Germany, Slovenia and Croatia (2015)

Country	Land area [1,000 ha]	Forest[a]		Other Wooded Land (OWL)[b]		Forest and OWL	
		[1,000 ha]	% of land area	[1,000 ha]	% of land area	% of land area	Forests and OWL per inhabitant [ha]
Germany	34,861	11,419	32.8	0	0.0	32.8	0.14
Slovenia	2,014	1,248	62.0	23	1.1	63.1	0.62
Croatia	5,596	1,922	34.3	569	10.2	44.5	0.59

Note:

[a]***Forest***: *land spanning more than 0.5 ha with trees higher than 5 meters and a canopy cover of more than 10%, or trees able to reach these thresholds in situ.*
[b]***Other Wooded Land (OWL)***: *land not classified as 'forest', spanning more than 0.5 ha, with trees higher than 5 meters and a canopy cover of 5-10%, or trees able to reach these thresholds in situ; or with a combined cover of shrubs, bushes and trees above 10%.*

Source: own depiction following FOREST EUROPE 2015: 243, 244.

1.1. Risks Factors for Forests towards Storms

Storms can cause both direct and indirect damages to forests. Direct damages embrace damages to trees, e.g. if branches break down or whole trees become uprooted. Indirect damages on the other hand also embrace economic costs and the reduction of the stock diversity, which is increasing the risk for consequential damages. (Cf. Albrecht et al. 2008: 1)

1.1.1. The Hazard Component

As was discussed in report C.1, scenarios on future storm occurrence are highly uncertain. Unfortunately there is no clear trend in the development of storm pathways or their intensity. It even cannot be proven that there is a general causality between the frequency of storms and climate change, due to a lack of data. (Cf. Albrecht et al. 2008: 2f.)
The European Environmental Agency (EEA) states that it is likely that the strongest, most damaging storms will increase in Europe in the future (cf. EEA 2012: 70-72). Researchers from Germany furthermore assume assumed that there will be a decrease in storms during the summer and an increase of storms during the winter months, especially in the months December till February. Also a slight shift in occurrence of winter storms towards the autumn (months October, November) can already be noticed. For the future, researchers are still expecting the most damaging winter storms from a western direction. (Cf. Albrecht et al. 2008: 2f.)

Hence, the main challenge forest management has to face is that storms have a great impact on forests but are unpredictable in their character and occurrence. ALBRECHT et al describe the dilemma of forest management as follows: ‘In case the intensity of storms is increasing, the controllability of damages by silvicultural measures is going to decrease. For the occurrence of damages caused by extreme wind speed is less dependent on the silvicultural condition of the forest stands than on the storm tracks’ (own translation following Albrecht et al. 2008: 3). Researchers also fear that the slightest change in storm activity may lead to disproportional, so far unpredictable damages. (Cf. Albrecht et al. 2008: 3; Kaulfuß 2012: 1)

1.1.2. The Vulnerability Component

Nevertheless, potential damages by storms can be lowered by knowing general vulnerability factors and by addressing these through silvicultural measures. Therefore, several general parameters determining a forest’s (or tree’s) susceptibility towards storms are investigated. Of course the following parameters do not mean to be a concluding list of risks parameters, especially because forest types and tree species vary throughout Europe and the local conditions (e.g. soil quality etc.) need to be taken into account. Nevertheless, the following parameters generally determine forest’s (or tree’s) strength to withstand storms (cf. Kaulfuß 2012: 1). The parameters investigated are:

- tree species,
- tree height and age,
- tree location,
- forest (stock) structure,
- thinning and
- tree health

Subsequently, attention is drawn on general advices for the planning and management of forests in subchapter 1.2 as these are the main determinants of a forest's susceptibility towards storms (cf. Hein et al. 2008: 4).

Tree Species

The species of a tree has great influence on the tree's stability. Species can be divided in deciduous trees and coniferous trees (conifers). During the winter, deciduous trees shed their leaves and therefore provide less windage in case of a storm than conifers, which are evergreen. Furthermore, many conifers are shallow-rooting plants, meaning their roots grow flat and not very deep, which gives them less hold in the ground. Within the coniferous trees, spruce trees, fir trees and Douglas fir trees are at highest risk as their crowns provide the larges windage. (Cf. Albrecht et al. 2008: 3; Kaulfuß 2012: 1)

Figure 1: Susceptibility of selected tree species towards storms

Strong susceptibility	Spruce Tree
↓	Fir Tree
	Douglas Fir Tree
	Pine Tree
	Beech Tree
Weak susceptibility	Oak Tree

Source: Own depiction following Website waldwissen.net 2013

Not only is the species of a tree relevant when determining the risk towards storms but also the composition of the whole forest. Forests should generally consist of several different tree species (mixed forests), because a forest is already stabilizing if e.g. different coniferous tree species are admixed. A noticeable stabilization can be reached if at least 10-20 % of all trees within a forest are deciduous trees. (Cf. Kaulfuß 2012: 1)

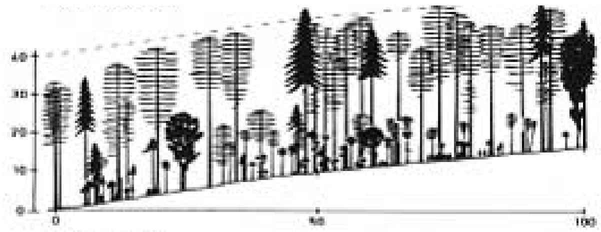
Tree Height and Age

Both the height of a tree and its age define further risk factors towards storms. It can generally be stated that the higher a tree is, the more susceptible it is to high wind speeds. A tree with a height of about 20 meters (solely above ground) has a multiple risk of storm damage. From a height of about 30 meters, the risk towards damages from storms stays about the same.
A similar rule applies to the age of a tree. The older a tree is, the higher is the risk of damages from storms. Analyses of *Kyrill* in Germany show, that especially trees of the age classes 60-120 years were damaged. (Cf. Kaulfuß 2012: 1)

Forest (Stock) Structure

The stock structure is one of the most important determinants of the susceptibility of a forest towards storms. As already mentioned, the cultivation of different tree species is of importance for the stabilization of a forest. Furthermore, forests should be cultivated in a 'multilayered' way. This means that the forest should consist of different tree species with different ages, different heights and different stadiums of growth (trunk circumferences) according to Fig. 2.

Figure 2: Scheme of an ideal multilayered forest



Source: Baron et al. 2005: 4, following Köstler 1956.

The major advantage of a multilayered forest is that the wind load of every single tree is reduced and so is the risk of storm damage. Moreover, the younger and lower trees mark the potential of a new generation of forest, in case a storm damages the older and higher trees. (Cf. Kaulfuß 2012: 1)

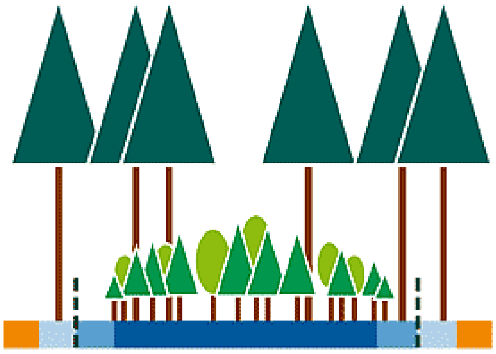
Thinning

In forest management it is necessary to select single trees within a forest that get the chance to broaden their root territory and grow (so called ‘future-trees’) while other trees will be cut back. This silvicultural measure needs to be proceeded while trees are still young and do not yet suffer from restrictions in their root development. Important criteria of choosing these ‘future-trees’ are the development of the tree’s crowns, their health (see below) and a strait stand. (Cf. Hein et al. 2008: 3)
The procedure of choosing ‘future-trees’ while cutting back others is called thinning and aims at a reduction of the competitive pressure on the forest and at carefully developing single trees that will become main sources of stability and growth within a forest. Unfortunately, besides the above mentioned chances, thinning entails also risks for forests, especially regarding their susceptibility towards storms. For right after the thinning the forest is weakened for several years as the ‘future-trees’ stand solitarily and lack the cover of other trees’ crowns. (Cf. Kaulfuß 2012: 1)

Rejuvenation

Closely linked with the tree structure is the procedure of rejuvenation, which is a silvicultural measure that further stabilizes a forest. One procedure used for rejuvenation is called ‘advance planting’ and means that younger trees are planted under the old stock, so that the younger trees are protected. Furthermore, due to the shadow of the old stock, rival vegetation will be kept low which gives the young trees an advantage in growth. A disadvantage or risk factor is, that in case of drought the old stock and the advanced planted young trees compete for water. (Rothkegel et al. 2011: 1) An advantage of rejuvenation is that in case of storm damages to the old stock, the advanced planted mixed species can be used for a quick reforestation (cf. Albrecht et al. 2008: 3). Fig. 3 depicts the strategy of advance planting.

Figure 3: Strategy of advance planting



Source: Rothkegel et al. 2011: 1

Tree Health and Growth Conditions

The health of trees is another relevant factor when assessing the risks of a forest towards storms. Especially trees with rot tend to fall or break when a storm hits.
Furthermore, the tree location is of importance because if the soil is plane, the roots of the trees are not able to grow, hence, have less hold and are less resistant to storms. The same applies to wet or acid soil. (Cf. Kaulfuß 2012: 2)

1.1.3. The Coping Capacity Component

Besides the hazards and vulnerability components, also the coping capacity of a system determines the damages that arise from storms. In forest management, especially the monitoring of forests (before and after a storm) is affecting the capacity to cope with storms. If data and knowledge exist on the state and structure of a forest and are constantly monitored and reported, adequate strategies and measures can be implemented to maintain and foster (more) resilient forests.[2] (Cf. Website UNFCCC 2016)

Further measures that account for the coping capacity may also take place after a storm event. For example, the entering of a forest can be prohibited for a certain amount of time in case there is a justified risk, e.g. of loose branches falling and potentially causing injuries. An example how this may be implemented can be taken from the German Federal Forest Law. Therein in § 14 (2) the entering of forests may be restricted, 'especially for […] the protection of visitors or for the prevention of significant other damages.'[3] (Cf. § 14 BWaldG)

1.2. Good Forest Planning and Management

The previous subchapter clarified hazard and vulnerability components of forests towards storms. In order to meet these components adequately, good forest planning

[2] See also chapter 1.3.2. for UNFCCC REDD+ Programme.
[3] See also chapter 2.1.1. for the Federal Forest Law (BWaldG).

and management should be promoted in order to increase the coping capacity and to reduce the risk of forests towards storms.

In forest planning HEIN et al. plead for a stronger awareness of potentially hazardous natural events. They especially see a need for deriving sophisticated maintenance and usage concepts for different stocks referring to their level of risk. These concepts should be designed in a manner that allows adjustment in case of changing climatic conditions and changing levels of risk. Furthermore, the researchers demand for a long-term assessment of all above mentioned risk factors (see chapter 1.1) and a debate on potential adaptation strategies. (Cf. Hein et al. 2008. 4f.)
Currently the researchers see no reason to doubt that deciduous trees have advantages regarding their stability towards storms. Nevertheless, it needs to be kept in mind, that there also are other climatic factors influencing the suitability of a tree species, e.g. its resistance to drought. Therefore, it constantly needs to be surveyed how future changes influence forests. (Cf. Hein et al. 2008: 1)

In forest management the overall goal should be to develop and manage structurally diverse, native tree species that are designed stable and 'aerodynamic', best in mixed forests (cf. Kaulfuß 2012: 2; Albreicht et al. 2008 4) as to promote risks prevention. These mixed forests should be managed according to flexible strategies that allow regular adjustment, e.g. by revising the rating of the climate resistance capacity of a tree species (cf. Hein et al. 2008. 1).

Some general guidelines for good forest management can be derived from the literature. First of all, it is advisable to create a mixture of different tree species; in best case deciduous trees are admixed with coniferous trees. Secondly, thinning and rejuvenation are measures that lead to stabilization of the forest but should be conveyed carefully because both can increase the risk of the forest towards storms. Moreover, an active shaping of the edge of a forest is advisable so that it rises in slight slope and is more wind permeable than if the edge consists of old stock trees of the same height and species. Also, the prevention of trunk violation (and hence growth of rot and fungi) should be enhanced via good forest work. (Cf. Kaulfuß 2012: 2)

Regarding timber production and management, two guiding principles may be stated. Firstly, new models should be introduced that promote a relatively fast achievement of production aims so that trees are still young and do not fall under the risk category of tree age (cf. Hein et al. 2008: 1). Furthermore, a constant usage of trees fit for cutting is necessary so that the inventory (and therein the damage potential) does not enlarge disproportionally. (Cf. Kaulfuß 2012: 2)

1.3. Legal Documents, Strategies and Actions for Forest Management in the EU

In the following subchapters, legal documents, strategies and actions concerning forest management in the EU are introduced. It will be shown that there is a common EU reference framework (1.3.1). Furthermore, the common EU agricultural policy on co-financing forestry measures as well as current research activities and the main funding structures of the EU are introduced (1.3.2). Moreover, EU directives directly or indirectly linked to forest management (1.3.3) and other measures with an impact on forestry are outlines (1.1.4).

1.3.1. EU Framework

Since 2013 the European Commission has a new European Union Forestry Strategy (COM(2013) 0659). This EU Forestry Strategy proposes an EU-wide reference framework for sectoral policies with an impact on forests. Sustainable forest management is one major guiding principle of the EU Forestry Strategy. Furthermore, it promotes the multifunctional character of forests, efficient usage of forests as resources and the EU's global responsibility in forest management.
Besides the guiding principles, the EU Forestry Strategy contains a strategic component and gives e.g. criteria for a sustainable forest management. Concrete measures regarding the timber sector are outlined in a blueprint (SWD(2013) 0343). (Cf. Website European Parliament 2016)

Informally, the initiative FOREST EUROPE of the Ministerial Conference on the Protection of Forests in Europe is also serving as a European framework. FOREST Europe is operating at a pan-European level and promotes dialogue and cooperation in forest policies in Europe. FOREST EUROPE develops common strategies and contributes to implement common guidelines, criteria and indicators. Although all political decisions and resolutions are taken voluntarily by its signatories, FOREST EUROPE remains the main political initiative on forests, forest protection and sustainable forest management in Europe. The (voluntarily) commitment of the ministers functions as a coherent EU framework, which is then adapted by each member to their national circumstances. (Cf. Website foresteurope 2016)

1.3.2. EU Policy, Research Activities and Funding

The main source of EU funding in the forestry sector (approx. 90 %; € 5.4 billion 2007-2013) is the European Agricultural Fund for Rural Development (EAFRD), basing on the Common Agricultural Policy (CAP). Within the EAFRD funding period 2015-2020, funding is rewarded for measures under the topic 'development of forested areas and improvement of the viability of forests'. (Cf. Website European Parliament 2016)
In detail, the following subtopics are funded:

- afforestation and creation of woodland,
- establishment of agro-forestry systems,
- prevention and restoration of damage to forests from forest fires,
- natural disasters and catastrophic events,
- investment to improve the resilience and environmental value of forest ecosystems and
- investment in forestry technologies and in processing, promotion and marketing of forest products." (Website European Parliament 2016)

Furthermore, the conservation of forests as well as forestry services, environmental services and climate services may be funded. Also non-forestry measures are financed within the EAFRD, e.g. Natura 2000 or Water Framework Directive related measures. (Cf. Website European Parliament 2016)

Besides the EAFRD the EU funds research projects on forests, especially in the Horizon 2020 Programme and under the cohesion policy of the European Regional Development Fund. Exemplary topics within the latter are ‘fire prevention, renewable energy production, climate change preparations’ etc. (Cf. Website European Parliament 2016)

Funding opportunities with an indirect impact on the forest sector are e.g. the REDD+ Programme, which seeks to reduce emissions ascribable to deforestation. Moreover, the Solidarity Fund[4] finances measures in Member States which experienced a natural disaster. These natural disasters may e.g. be storms or forest fires. Finally, the FLEG II Programme finances research projects in the EU’s eastern neibhbourhood countries under the Neighbourhood Policy. Measures shall “promote good forestry governance, sustainable management of forests and forest protection” (Website European Parliament 2016).

1.3.3. EU Directives with an Impact on Forest Management

There are several EU directives which are (indirectly) attributed to forest management.
Directive 1999/105/EC regulates the marketing of forest reproductive materials. Its purpose is stated in numbers 2 and 3:

> *(2) Forests cover a large area of the Community and fulfil a multifunctional role based on their social, economic, environmental, ecological and cultural functions; there is a need for specific approaches and actions for the different types of forests, recognising the wide range of natural, social, economic and cultural conditions of the forests in the Community; both the restocking of these forests and new afforestation require a sustainable forest management in relation to the Forestry Strategy for the European Union as set out in the Council Resolution of 15 December 1998;*
>
> *(3) Forest reproductive material of tree species and artificial hybrids which are important for forestry purposes should be genetically suited to the various site conditions and of high quality; the conservation and enhancement of biodiversity of the forests including the genetic diversity of the trees is essential to sustainable forest management; (Directive 1999/105/EC)*

Furthermore, Directive 2000/29/EC on “protective measures against the introduction […] of organisms harmful to plants or plan products and against their spread within the Community” aims (among other things) at preventing forests from biotic threats like insects and diseases. (Cf. Directive 2000/29/EC)

Directive 2009/28/EC aims at increasing the energy production from renewable energy sources by 20 % until the year 2020. It can be expected that the demand for forestry biomass production will increase due to this EU energy policy. (Cf. Directive 2009/28/EC) As the updated EU climate and energy framework sets an even higher target of meeting 27 % of total energy consumption by 2030, further increase is to be expected. (Cf. Website European Parliament 2016)

[4] (Council Regulation (EC) No 2012/2002)

1.3.4. Other EU Measures with an Impact on Forest Management

Additionally to the EU framework, EU policy, research projects, funding opportunities and EU directives, there are several other strategies and measures within the EU that have an impact on forest management. These are listed in the following.

- The EU's environmental policy, under which the Natura 2000 nature protection network was established, comprises about 37.5 million hectares of forests, especially protected within Natura 2000 areas.
- In the EU's Biodiversity Strategy[5] it is registered that until the year 2020, forest management plans need to be set up for publicly owned forests.
- Within the EU's new Environment and Climate Action Programme[6] (LIFE Programme; 2014-2020) one main priority is set on a rational use of forests.
- Since the year 2008 there is a European ecolabel[7] that tags sustainably produced timber. Moreover, the marketing of illegally harvested timer shall be regulated by partnership agreements between timber-producing countries and the EU in the so called FLEGT Action Plan[8]. The EU also aims at "reducing tropical deforestation by at least 50 % by 2020" (Website European Parliament 2016).
- Finally, there is an EU's Civil Protection Mechanism[9] that can be deployed whenever a severe crisis affects a Member State and is overstraining the state's ability to cope with the crisis. This Protection Mechanism can e.g. be used for fighting forest fires or storms. Furthermore, there is a EU-wide monitoring system for forest fires called European Forest Fire Information System (EFFIS).
  (Cf. Website European Parliament 2016)

1.4. Interim Conclusion on Forest Management in the EU

FOREST EUROPE stays the main political initiative on forest protection and sustainable forest management in Europe. Due to the commitment of all EU member states, a coherent, informal framework exists that helps to promote the (formal) European Union Forestry Strategy. According to the European Parliament, "[d]iscussions are under way on a legally binding agreement on forest management and sustainable use." (Website European Parliament 2016).

Besides all national and EU-wide actions, the EU furthermore participates in various international processes and discussions on forests, forest protection and sustainable forest management. Of particular relevance is the United Nations Framework Convention on Climate Change (UNFCCC). (Cf. Website European Parliament 2016)

In May 2013 the European Parliament and the Council adopted Decision 529/2013/EU *on accounting rules on greenhouse gas emissions and removals resulting from activities*

[5] (COM(2011) 0244)
[6] (Regulation (EU) No 1293/2013)
[7] (COM(2008) 0400)
[8] (Regulation (EU) No 995/2013)
[9] (Decision 1313/2013/EC)

relating to land use, land-use change and forestry and on information concerning actions relating to those activities. (Cf. Decision 529/2013/EU) With this Decision, the EU took first steps to explicitly integrate forestry into its climate policy (cf. Website European Parliament 2016).

These formal and informal strategies, policies, research fields, funding structures and measures all prove that the EU is actively encouraging forest protection and sustainable forest management. In the following chapters it shall therefore be investigated, how forest management is applied in the three Wind Risk Prevention Project partner countries and how it is currently dealt with the hazard storm. Recommendations on forest management will be drawn for each of the partner countries (Germany, Slovenia and Croatia) and shall be abstracted to the EU level.

2. Forest Management in Germany

In the last 25 years, Germany had to face several winter storms with hurricane strength[10] that led to large damages, especially to the forestry sector. The most recent storm *Kyrill* (January 2007) destroyed about 10 % of the forests in the Ruhr Area and led to costs of some € 2 billion. *Kyrill* was a very typical winter storm phenomenon (depression), lasting for several days with a great geographic extent and peak wind gusts of 144 km/h in Germany. (Cf. Deutsche Rückversicherung 2015: 21; DWD 2014: 7; Website GDV 2007)

Nonetheless, the case study of the TUDO does not address winter storm *Kyrill* but a very different storm phenomenon; summerly thunderstorm *Ela*, that occurred in June 2014 and which is comparable to supercells that periodically occur in North America. The damage pattern of *Ela* was quite different from any winter storm, as it caused damages mainly to city objects, structures and functions due to trees and branches falling on roads, overhead lines and roofs.[11] (Cf. DWD 2015: 4, 11)

The focus of chapter 2 is therefore on strategies of city tree management rather than on forestry management. Additionally to tree management strategies, the legal documents and strategies concerning forest management are outlined in subchapter 2.1 in order to gain comparability between the Wind Risk partner countries. Subsequently, the consequences of summer storm *Ela* to city trees in the case study City of Essen are investigated in detail. Recommendations for a future management of city trees will be given in subchapter 2.3.

2.1. Legal Documents and Strategies Concerning Forest Management in Germany

2.1.1. Laws and Directives in Forest Management

Federal Nature Conservation Act (Bundesnaturschutzgesetz, BNatschG)

The Federal Nature Conservation Act is the major law for nature and landscape protection in Germany. It was introduced in the year 1977 and last updated in 2015.
In § 5 the fields of agriculture, forestry and fishery are addressed. It is generally stated that all measures of nature protection and landscape conservation shall be performed in a compatible way, aiming at a preservation of Germany's special cultural landscape.
Subparagraph § 5 (3) contains the guiding principle for forestry in Germany. Therein is stated that forest should be maintained in a 'sustainable, close-to-nature way without clearcuttings or wider deforestation'. Furthermore, it is positioned that a sufficient share of trees within a forest needs to be domestic tree species. (Cf. § 5 (1, 3) BNatschG)

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[10] *Daria*, *Vivian* and *Wiebke* in 1990, *Coranna*, *Verena* and *Lore* from 1992 till 1994, *Lothar* in 1999 and most recent *Kyrill* in January 2007 (cf. DWD 2015).

[11] A comparison between winter storms and summer storms can be found in report C.2/C.4.

*Federal Forest Law (*Bundeswaldgesetz, BWaldG*)*

The Federal Forest Law inured in 1975 and aims at preserving forests and promoting forestry in Germany. The BWaldG is concretized for every federal state of Germany in so called State Forest Laws (see following subchapter for State Forest Law North-Rhine Westphalia). According to the BWaldG, 'forest' is defined as follows: 'Within the meaning of this law, forest is any area stocked with forest plants. Also clearcuttings or sparsely vegetated areas, forest roads, […] as well as further areas attached to or servient for forest.' (§ 2 (1) BWaldG, own translation)

Of special relevance for forest management is section II of the Federal Forest Law. The contents of the paragraphs of this section are summarized in the following table.

Table 2: Summary of paragraphs of the Federal Forest Law, Section II

§ 9 Preservation of Forest	(1) Forests are to be preserved and only to be cleared or converted to another usage according to the state forest law. The permission shall be denied if the preservation of the forest is predominantly for the public benefit, for the productivity of the ecosystem, for silvicultural production or for recreational purpose for the public.
§ 10 Afforestation	(1) Afforestation requires the permission of the appropriate authority according to state forest law. The permission can only be denied, if requirements of the regional planning are opposed to it.
§ 11 Management of Forest	(1) The forest shall be managed orderly, according to the scope of its intended purpose. Forest owners need to be obliged by federal state law that in case of deforestation or sparsely vegetation, forests 1. need to be afforested in an appropriate period of time, 2. need to be complemented, in case natural growth stays fragmented unless a conversion to another usage was permitted or would be legitimate.
§ 12 Protected Forest	(1) Forest may be declared protected forest (*Schutzwald*) if e.g. hazard prevention is needed. This especially applies for the protection against harmful environmental impacts, erosion by water and wind, drying up, harmful draining of rain and avalanches. (3) Clearcuttings requires special permission in a protected forest by the appropriate authority.
§ 13 Recreational Forest	(1) Forest may be declared recreational forest (*Erholungswald*) if required so by general good, if its recreational function needs to be protected, maintained of fostered. (2) The federal states may enact instructions on 1. the management of the forest […] 4. the behaviour of the visitors.
§ 14 Entering of Forests	(1) The entering of forests for recreational purposes is permitted. […] Entering is at one's own risk. This especially applies to forest typical hazards. (2) The federal states regulate the details. They may restrict the entering of forests especially for measures of forest protection, forest management, for the protection of visitors or for the prevention of significant other damages.

Source: own translation following §§ 9-14 BWaldG.

*State Forest Law (*Landesforstgesetz Nordrhein-Westfalen, LfoG NW*)*

The State Forest Law North-Rhine Westphalia (LFoG) specifies the regulations of the Federal Forest Law (BWaldG). In § 1 a and § 1 b LFoG the terms 'sustainable forest management' and 'orderly forestry' are defined. The definitions can be translated as follows: 'Sustainable Forest Management is featured by a maintenance strategy that aims at preserving biological diversity, productivity, the capacity of rejuvenation, vitality and which seeks also at fulfilling these important ecological, economic and social functions in the future, without harming other ecosystems.' (§ 1 a LFoG NW)

The indicators of an 'orderly forestry' are defined as:

1. 'forestry being construed for a long-term usage.'

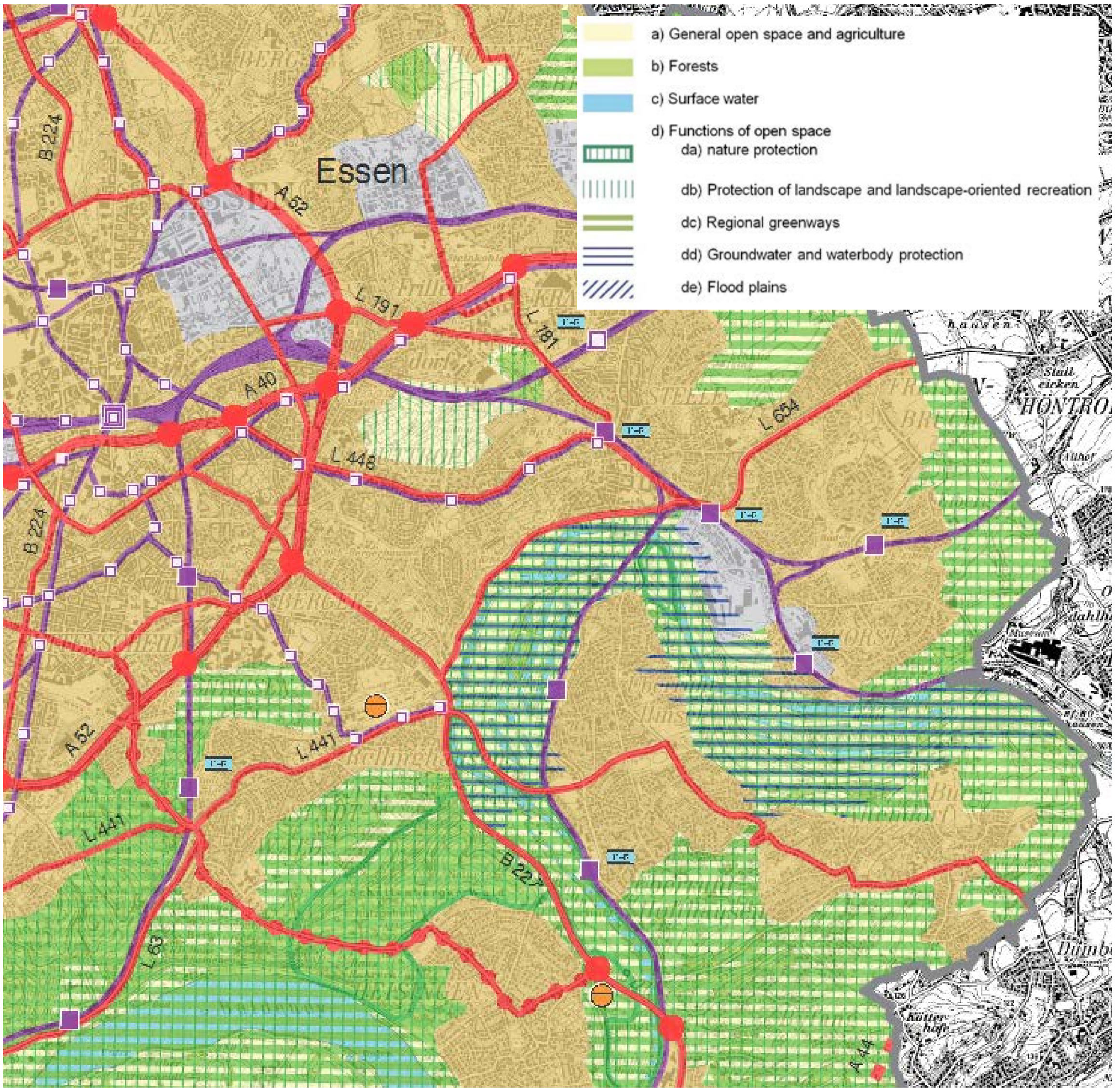
2. 'the protection of sustainable timber production and the maintenance of the forest ecosystem as the habitat of a biodiverse flora and fauna by working towards healthy, stable and diverse forests.'
3. 'avoidance of extensive clearcuttings.'
4. 'choosing native tree species and the usage of convenient seeding materials as well as natural rejuvenation in order to preserve genetic diversity.'
5. 'an adequately opening and infrastructure provision whilst maximum conservation of the resources landscape, soil and stock.'
6. 'carefull actions, especially in rejuvenation, utilization of wood and transport of timber.'
7. 'application of stock- and soil-protecting techniques.'
8. 'the application of native plant nutrients for the preservation or improvement of soil fertility.'
9. 'broad abandonment of pesticides.'
10. 'working towards game density that are adequate to the forest stocks and their rejuvenation rate as well as measures of game bite prevention.'
11. 'sufficient scope of old and deadwood amounts for securing the habitats of wildlife animals, plants and other organisms.' (§ 1 b LFoG NW)

Furthermore, the LFoG NW contains the tasks and principles of the silvicultural development planning in § 7 and § 8. Therein it is arranged that all regional requirements and measures are to be displayed in the (legally binding) regional plans.
The following information should be reported in the regional plans:

- Description of the current state of the forest, especially regarding area, structure, opening, ownership and silvicultural consolidations,
- description of the forest functions, especially the relevance of the forest for an economic use, environment protection and the recreation of the population,
- description and explanation of the intended state,
- declaration of public measures necessary for reaching this intended state,
- depiction of areas in which an increase of forest area is intended as well as those areas in which no increase in intended. (§§ 7-8 LFoG NW)

Fig. 4 shows an excerpt from the regional plan valid for the City of Essen. The key contains the different land-use categories in the field of open space. As can be seen, there are several agricultural and silvicultural areas designated. All forest and other open space areas also have a special function. The areas in the very east of Essen e.g. are designated as general open space and agriculture areas, having the function of partly being protected landscape (category *db*) and being regional greenways (category *dc*). Another example is that in the area along the river *Ruhr* there are several surface waterbodies that function as protected landscape (category *db*), regional greenways (category *dc*) and protected groundwater and waterbodies (category *dd*). (Cf. Bezirksregierung Düsseldorf 2000)

Figure 4: Excerpt from the regional plan valid for the City of Essen



Source: Bezirksregierung Düsseldorf 2000.

2.1.2. Strategies and Guidelines in Forest Management

Besides the aforementioned formal documents on forest and tree management in Germany, there also are informal strategies and guidelines that have an impact on forest management, which are introduced below. The Sustainability Policy for Germany and the Forest Management Strategy focus on broader forest management aims and measures, while subsequently two documents from the field of city tree management are introduced.

Sustainability Policy for Germany (Nachhaltigkeitsstrategie)

In the year 2002 the Federal Government of Germany published an extensive document called ‘Perspectives for Germany’, comprising a sustainability policy for Germany. It also contains a subchapter on 'Sustainable Forest Management', which is introduced in excerpts in the following:

> 'In Germany, forestry is the second largest land use which generates the most important renewable raw material; wood. Forestry is legally obliged to be sustainable. This includes the provision of timber on the one hand and securing the protection and recreational functions of the forest on the other hand. In order to preserve biodiversity and the stability of the silvicultural ecosystems, the Federal Government aims at a close-to-nature forestry on the entire forested area of Germany. […] Besides a forest's function of being a natural resource, forests meet various additional functions that people are aware of or use unconsciously, especially in densely populated Germany. These various other functions range from soil and groundwater protection, protection of the environment, the function of being a habitat for a rich variety of flora and fauna to the functions of recreation and quality of life. […]
> Over the centuries forests did not only experience significant changes, but also they were strongly exposed. Exposures embrace the large-scale forest destruction caused by the World Wars as well as damages caused by air pollution. Germany's high level development of transportation networks and infrastructures has resulted in even more pollution. This circumstance leads to concern because the forests remain the last enclaves, not only for many plants and animals, but also for the stressed citizens that hope for recreation, relaxation and nature experiences in the woods. […]
> The aim of a sustainable forest management in Germany needs to be the harmonization of the variety of demands of society towards forests as well as the needs of forest owners while preserving and enlarging forests as contiguous natural habitats for the people.' (Cf. Die Bundesregierung 2002: 235f.)

Forest Management Strategy North-Rhine Westphalia

The full title of the forest management strategy of the state North-Rhine Westphalia is ‚Forest and Forest Management in Climate Change – Adaptation Strategy for North-Rhine Westphalia' (*Wald und Waldmanagement im Klimawandel – Anpassungsstrategie für Nordrhein-Westfalen*).
More specific than any other document this strategy gives analyses of the status quo of forests in the federal state, including a discussion of impacts on forests due to climate change. Most importantly, the document contains aims and approaches of adapting forest and forest management to climate change. Moreover, measures for adaptation of the forests as well as sustainable forest management are outlined.
Exemplarily, a summary of climate change induced changes in storms and the impacts on forests in North-Rhine Westphalia and the catalogue of adaptation measures are presented in the following.

Storm as an Impact of Climate Change in North-Rhine Westphalia
Although projections on changes in wind fields and wind speeds are highly uncertain currently, the IPCC is expecting an increase in strong storms for Middle Europe. For North-Rhine Westphalia a realistic scenario projects an increase in the number of storm days (more than 89 km/h wind speed) of 28 % and an increase in the number of hurricane days (more than 130 km/h wind speed) of 60 %. (Cf. Kropp et al. 2009: 80)

The main impact of climate change on forests and the various tree species is the change in location conditions. Forests stocks are increasingly endangered by extreme events like storms, insect calamities, frost damages and forest fires.
The most recent forest inventory shows a trend to a higher percentage of deciduous trees and mixed forest in North-Rhine Westphalia. It can be assumed that an increase in

location-adapted, close-to-nature mixed stocks with higher percentages of deciduous trees leads to a higher stability, adaptive capacity and distribution of risks of forest. (Cf. MKULNV 2015: 17)

Adaptation Measures for Forests and Forest Management
The adaptation measures given in the forest management strategy for North-Rhine Westphalia embrace four main tropics and all in all 18 measures, which are introduced in Tab. 3.

Table 3: Climate change adaptation measures for forests in North-Rhine Westphalia

Forest and Forest Management	
	Advancement and integration of information instruments and planning instruments for forest management
	Development of a silvicultural concept for climate-plastically forests
	Increase of monitoring and management in forest protection
	Advancement of silvicultural crisis management
	Adaptation of game management and hinting in forest
	Adaptation of forest work and forestry techniques to changed requirements
	Securing forest road construction and maintenance for forest management
Biodiversity in Forest and Forest Protection	
	Advancement of nature reserve areas for forest protection
	Adaptation of demands in the field of nature protection to forest management
	Improvement of the closeness to nature of forest water bodies and water regime
Cluster Forestry and Timber Production	
	Support of private and public forests in adaptation of forests and forest management
	Depiction of resource supply for timber industry in changed forest management
	Monitoring and increase of climate protection services of forest and through timber utilization
Forest and Society	
	Improvement of the information basis on climate change
	Expansion of research and knowledge management in the field of forest and forest management
	Adaptation of silvicultural work and health protection
	Qualification and protection of personnel capacities for forest management in climate change
	Enhanced communication of climate change in the forest within silvicultural environmental education and public relations activities

Source: MKULNV 2015: 30-48.

Fig. 5 gives an example of the structure of these adaptation measures. For each measure, information on the background, aims and actions, implementation strategies and first approaches are given.

Figure 5: Adaptation measure 'advancement of silvicultural crisis management in climate change'

Background	Due to climate change, the risk of extreme weather events like storms and large-scale windfalls increases. In combination with inadequate stock (choice of tree species, stock structure) and an increased risk of insect calamities, silvicultural catastrophes become more likely. An advanced silvicultural crisis management becomes necessary.
Aims and Actions	▪ Advancement of concepts and instrument in risk assessment, risk minimization and coping (prognosis models for storm susceptibility of forest locations and forest stocks, recommendations for adaptation of forest stocks, optimization of infrastructure and logistics for damage accomplishment like distribution of wood stack yards. ▪ Preparation of guidelines with binding procedures for silvicultural crisis management and implementation of a central information offering in case of a crisis. ▪ Preparation and stocking of suitable infrastructure for storm damage coping (road network, emergency spots, wood stack yards, train connections).
Implementation	State forestry administration in cooperation with administrational organisation in the field of hazard prevention (Ministry of the Interior, district governments, emergency operators) as well as with privately and publicly owned forest.
Approaches	Guidance for storm damage accomplishment, IT system for forest path navigation, modelling of storm risk.

Source: MKUNLV 2015: 33.

*Technical Regulations on Road Construction; Section Landscape Conservation (*Richtlinie für die Anlage von Straßen, Teil Landschaftspflege ; RAS-LP*)*

The technical regulation on road construction, section landscape conservation (RAS-LP) is an example of an indirectly binding document with an impact on tree management. It was published by the Federal Ministry for Transport, Building and Housing in 1999 after being developed by the Research Association Landscape Development and Landscaping, short FLL (*Forschungsgesellschaft Landschaftsentwicklung Landschafts-bau e.V.*) in cooperation with the road construction administrations of all federal states. The RAS-LP aims at the consideration of nature protection and landscape conservation in planning and construction of roads. (Cf. RAS-LP 4)

Of special interest for city trees is subsection 4 on the Protection of Trees, Vegetation Stock and Animals in Buildling Measures (*Schutz von Bäumen, Vegetationsbeständen und Tieren bei Baumaßnahmen, RAS-LP 4*). It provides contents on how to set up groundworks when working at construction sites, on tree protection measures during construction management as well as on further constructional measures and gives reference to other technical guidelines and norms. (Cf. RAS-LP 4)

*FLL Guideline on Tree Inspection (*FLL-Baumkontrollrichtlinie*)*

Another FLL guideline which is essential in city tree management is the guideline on tree inspection (*Baumkontrollrichtlinie*). The reason for this guideline is that in Germany there is a 'legal duty to maintain safety on roads' (*Straßenverkehrssicherungspflicht*), meaning that wherever there is road traffic, regular tree controls need to be conducted in order to ensure safety to those using the roads. (Cf. Braun 2005: 186)

The FLL guideline on tree inspection aims at a regular control of all trees, that that need to be inspected according to the 'legal duty to maintain safety on roads'. It basically is an instruction on how these controls should be conducted and, if necessary, how pruning measures of trees should be conveyed.
According to the FLL the inducement to this guideline is that despite their important function within an agglomerated area, city trees are strongly stressed and endangered by external influences. Due to these external factors, trees might become a hazard themselves, e.g. by falling. In order to maintain 'security on roads' and to prevent damages to persons and objects, regular controls of all city trees are necessary. The guideline also contains principles on how controls should be conducted after extreme events like storms or sleet. For example, after a storm event, additional controls become necessary in order to check if damages to trees arose and which measures need to be conducted in order to remove these damages. (Cf. FLL 2010)

2.2. Case Study: City of Essen and Summer Storm *Ela*

First, there is a general description of the tree situation and tree distribution in North-Rhine Westphalia and the case study City of Essen. Subsequently, summer storm *Ela* and its consequences will be described from the perspective of forest management. Last, recommendations on how to proceed with trees after a storm like *Ela* will be given, focusing on replacement plantings.

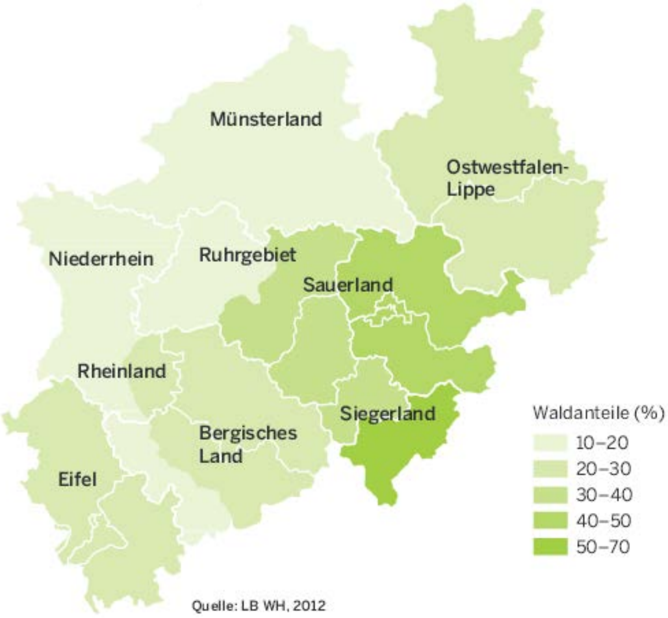
2.2.1. Tree Situation and Distribution in North-Rhine Westphalia and the City of Essen

In North-Rhine Westphalia, 27 % of the total area is covered by forests. 57 % of the forest trees are deciduous trees and 43 % are coniferous trees. The most common tree species are spruce (30 %), beech (19 %) and oak (17 %). About 67 % of the forest is privately owned, 13 % are state and 4 % are federal forest. (Cf. MKULNV 2015: 7)

The distribution of trees in North-Rhine Westphalia can be seen in Fig. 6. It becomes apparent that the highest land-use percentages of forests are to be found in the south of the federal state, in the *Sauerland* and *Siegerland*. The area surrounding the City of Essen averagely attains a rate of 10-20 % of forested land. (Cf. MKULNV 2015: 8)

The City of Essen has more than 3 million trees in municipal forests which extend over some 1,750 ha. These forests are predominantly mixed deciduous forests. The future strategy of the city is to maintain these forests in their close-to-nature character, their layered structure and their native tree species. (Cf. Website Essen.de 2016a)

Figure 6: Distribution of forest in North-Rhine Westphalia



Source: MKULNV 2015: 8.

In total, there are more than 2,6 million trees in Essen, which off 2,2 million stand within forests. There are about 60,000 city trees that stand along roads. These city trees are of diverse species, age and need to deal with various stress factors. The most common problems of city trees are that there is not enough soil and space for root growth, that the soil is contaminated and that there is insufficient water and nutrient supply. (Cf. Website Essen.de 2016b) Further information on stress factors for city trees are outlined in subchapter 2.2.3.

2.2.2. Summer Storm *Ela* from the Perspective of Forest and Tree Management

Brief Summary of Summer Storm Event Ela

From Sunday, June 8th until Tuesday, June 11th 2014, summer storm *Ela* hit large parts of North-Rhine Westphalia. The storm emerged from local thunderstorms that transformed into several multi-cell thunderstorm clusters above northern France. On Whit Monday (June 9th) these multi-cell clusters transformed into a mesoscale convective complex (MCC). MCC are characterized as the strongest thunderstorm complexes possible, as they are the most widespread and durable types of thunderstorm known.

Geographically *Ela* was broader than any thunderstorm before and therefore large areas of North-Rhine Westphalia were affected simultaneously. As an MCC it also was more intense and long-lasting than any event before. Furthermore, all thunderstorm concomitants (heavy precipitation, strong wind gusts and hail) occurred simultaneously, further increasing the damages. (Cf. Deutsche Rückversicherung 2015: 16, 20; DWD 2015: 4, 11)

In total there were six fatalities, 30 seriously and 37 slightly injured persons caused by summer storm *Ela* in Germany. In some parts of the country there were blackouts as

trees fell into power supply lines. Also flights needed to be cancelled at Düsseldorf International Airport and at several smaller airports. The GDV recorded a number of 350,000 damages caused by summer storm *Ela*.
In total the property damages associated with *Ela* are estimated € 650 million. Thereof € 400 million are related to property insurances and € 250 million to vehicle insurances. According to these high damage costs, summer storm *Ela* was ranked second most expensive storm in the last 15 years. The total damages in Middle Europe by *Ela* were estimated € 2,1 billion. (Cf. Deutsche Rückversicherung 2015: 23, 28; DWD 2015: 2; DWD 2014: 7f.; GDV 2015: 3)

Damage Hot Spot : City Trees

Regarding the damage pattern of *Ela* with a focus on city trees, it is especially to be mentioned that most damages caused by storm *Ela* are associable with the high wind speeds of the extreme event, rather than other factors, e.g. hail (cf. Deutsche Rückversicherung 2015: 21).

The peak wind gusts of *Ela* in the case study City of Essen was of hurricane force strength with 144 km/h. As explained in Wind Risk Report C.2/C.4 summer storm *Ela* therefore reached the same peak wind speeds as recent German winter storms with the difference that the average wind speeds were lower. It can therefore be assumed that the intensity (wind speed) of a storm is more important for the amount of damages than its duration. Winds that endure only for a short time but with a very high wind speed can lead to high damages and that is why wind gusts – the extremes of the wind speed distribution – are crucial for the arising damages. (Cf. GFZ, DWD 2014: 9; DWD 2015: 13ff.)

The major difference between German winter storms and summer storm *Ela* was that damages occurred to city trees rather than to forest trees. One main reason is that the city trees were in full leaves when the storm hit and therefore had a broad crown with enormous windage. On top, some local heavy precipitation events caused further damages as inundations occurred due to manholes congested by tree leaves. (Cf. Deutsche Rückversicherung 2015: 21f.)

Figure 7: Impressions from summer storm *Ela*

Source: Website Essen.de 2014. © Peter Wieler, Peter Prengel, Peter Prengel.

The falling trees and branches caused indirect damages to houses, roads, technical infrastructure, parking cars and other city objects. Moreover, direct damages arose when roof tiles got unroofed by the hurricane force wind speeds. The severe damages became even more visible the next morning, when road and rail traffic were extremely restricted and thousands of people were not able to get to their work places. Especially the German Rail had serious problems in overcoming the damages as one third of the whole rail network was unusable. Moreover, most rail tracks needed to be closed in the Ruhr Area and especially in Düsseldorf and the central Ruhr Area up to more than 800 emergency operations were conducted per 100,000 inhabitants. All in all, the police in North-Rhine Westphalia had more than 5,000 weather related operations in the night of June 9th/10th 2014. (Cf. Deutsche Rückversicherung 2015: 22)

Priorities in Approaching and Coping with Damages

Immediately after the event, different institutions started removing the damages of summer storm *Ela*. The main actors during the first hours and days were *Grün und Gruga*, (Essen's parks commission being responsible for all urban green spaces as well as all city trees,) and the fire brigade Essen. Their prior aim was to restore the constitutional order of the city. In order to do so, the very first action was to clear the most important roads so that emergency response units were able to use a north-south as well as an east-west axis to get to their operating sites.
In a second step, entrances to hospitals, fire brigade and police stations were cleared and the evacuation of about 12,000 people that were trapped on an open-air festival ground was started. (Cf. Haering 2015: 44f.)

After these very first response measures, a systematic approach was chosen in order to remove all trees and branches from the main municipal roads, train tracks and houses. The focus was on removing very acute damages that had a high risk of injuring people, e.g. on unconsolidated crown branches as well as on highly damaged trees. All further priorities were set by an action committee. The action committee ordered to remove damages according to the following list of priorities:

a. Main municipal roads,
b. roads with overhead lines for trams,
c. roads used by public transport systems (e.g. busses),
d. roads leading to schools, kindergartens or daycare centers.
(Cf. Haering 2015: 46f.)

In the following weeks, months and even years, each city tree in the City of Essen needed to be checked for potential risks according to the FLL Guideline on Tree Inspection in order to regain safety on roads (*Straßenverkehrssicherungspflicht*).

Areas with damages of minor priority, e.g. damages in forests or on urban green spaces were simply closed for the public for an indefinite period of time in order to prevent further damages. In some forests of the city, accessing the areas off the paths is still prohibited, as Fig. 8 shows.

Figure 8: Warning sign in Essen's forests

City of Essen

Danger to life off the paths!

In this forest you are now allowed to use the secured primary paths.

Please do not leave the paths in no event. On the non-secured side paths there is still danger to life due to falling branches.

The prohibition of entering forests, which was issued after storm *Ela*, is still in force besides for the above mentioned exception.

Further information at: www.essen.de/waldwege

Source: own photograph (11.01.2016) and own translation.

Referring to chapter 1.1.3 it needs to be stated that the coping capacity component for city trees differs from the coping capacity component for forests. As the damage pattern between winter storms and summer storms differs distinctly, the coping capacity for city trees and damages from summer storms is mainly shaped by an adequate early warning system. The early warning can e.g. help to prevent damages to lives and assets so that the population of a city is able to take precautionary measures (e.g. stay at home during the storm; park the car in a garage; etc.).

As the example of summer storm *Ela* in the City of Essen showed, also the immediate response capacity supports the reduction of (further) risks. By removing very acute damages within the first hours after the storm, *Grün und Gruga* contributed to prevent unconsolidated crown branches from falling and potentially injuring people. Additionally, rescue measures, as conducted by Essen's fire brigade, increase the coping capacity of a system.

2.2.3. Replacement Planting after a Storm Event

As marginally addressed, city trees – especially if these are roadside plantings – face various aggravated conditions of growth. There are three main influences that are affecting the growth conditions: anthropogenic factors, biotic factors and abiotic factors.

Table 4: Factors influencing growth conditions of city trees

Anthropogenic factors	
	public claim to open space
	area available for tree crown growth
	size of planting pane
	soil conditions
Biotic factors	
	pathogens
Abiotic factors	
	city climate
	climate change and requirements to draught resistance and winter hardiness

Source: Haering unpublished: 3.

Especially the city climate is a challenging factor for tree growth. The high rate of sealed ground, lesser precipitation infiltration, low humidity, heat emission, increased average and night temperatures due to urban heat islands, as well as increased pollutant concentrations lead to aggravated growth conditions for city trees. And with respect to climate change, these climatic conditions are expected to become even more extreme. Especially trees along roads (roadside plantings) are vulnerable to these abiotic factors. But also the residents of a city are aggravating tree growth conditions, e.g. by destroying roots when conducting constructional measures. (Cf. Haering unpublished: 4f.)

After summer storm *Ela*, *Grün und Gruga* worked with a decision support list for assessing each tree on either to preserve or to log it. The list consists of six topics to be assessed (green = positive factor; red = negative factor). After the assessment, trees are classified according to four priority classes. Trees of class 1 would need to removed immediately, class 2 trees need to be removed within two weeks, class 3 trees need to be removed within six months and class 4 trees could stay in place for about 1-4 years. (Cf. Haering unpublished: 14, 16)

- recent storm damage
  - without damage
  - slight damage
  - medium damage
  - severe damage
- vitality of the tree
  - healthy
  - poor health
  - diseased
  - dying
- capability of separation/partition of the tree species
  - effective partition capability (plane, common hornbeam, lime, maple, beech, oak, ginko, pine, yew)
  - weak partition capability (buckeye, cottonwood, ash, birch, willow, fruitwood)
- pre-existing defects/disease
  - without damage
  - slight damage
  - medium damage
  - severe damage
- other aspects
  - natural monument

- historic tree
- alley tree
- habitat tree
- last tree residents interests
- replacement planting impossible
- ‘wrong’ tree species
- replacement planting more economic

(Cf. Haering 2016: 13)

The advantage of class 4 trees is that they stay in place until a replacement planting will be conducted within the next 1-4 years. This goes along with the positive side effects of low expenditure for management and control measures, no different usage of the space and at the same time there is no direct threat to security. The only disadvantage is that the placeholder tree only has low effect of greening. (Cf. Haering unpublished: 17)

For replacement plantings, *Grün und Gruga* made use of a so called ‘List of City Trees’, which is shortly explained in the following subchapter.

2.2.4. Wind Resistance of City Trees

The GALK (*Gartenamtsleiterkonferenz*), a German conference of parks commission managers, published a so called ‘List of City Trees’ (*Straßenbaumliste*) in 2012, comprising all 171 German city tree species and assessing these according to their location demands. The aim of the GALK was to summarize the knowledge and research data on growth, resistance, height and applicability of trees within urban areas. Furthermore, the list shall be understood as a contribution to adapting to the changing conditions due to climate change and to promoting sustainable tree species. (Cf. Website GALK 2012)

Figure 9: Excerpt from the GALK ‘List of City Trees’

GALK e.V. Deutsche Gartenamtsleiterkonferenz

GALK-Straßenbaumliste
Abfrage vom 21.06.2016
Arbeitskreis Stadtbäume

Nr.	Botanischer und deutscher Name	Höhe (m)	Breite (m)	L1*	L2*	Verwend-barkeit	Bemerkungen
1	Acer buergerianum syn. A. trifidum, Dreizahn-Ahorn, Dreispitz-Ahorn	8-10 (15)	4-6	mittel	○ – ◑		aufrechter Wuchs, locker verzweigte Äste, auf geschützten Standorten ausreichend frosthart, im Straßenbaumtest 2 seit 2007/08
2	Acer campestre, Feldahorn, Maßholder	10-15 (20)	10-15	mittel	○ – ◑	geeignet mit E.	eiförmige, unregelmäßige, im Alter mehr rundliche Krone, verträgt trockene Böden und hohen Versiegelungsgrad, guter Bodenbefestiger für Ufer bzw. Hanglagen
3	Acer campestre 'Elsrijk', Feldahorn	6-12 (15)	4-6	mittel	○ – ◑	geeignet mit E.	wie die Art, jedoch gerader durchgehender Stamm, im Wuchs schmaler und gleichmäßiger, gebietsweise Frostschäden in der Krone, mehltaufrei
4	Acer campestre 'Huibers Elegant' syn. A. campestre 'Elegant', Feldahorn	6-10	3-5	mittel	○ – ◑		sehr regelmäßiger, aufrechter Wuchs, gilt als mehltaufrei, im Straßenbaumtest 2 seit 2007/08
5	Acer monspessulanum, Französischer Ahorn, Burgen-Ahorn, Dreilappiger Ahorn	5-8 (11)	4-7 (9)	mittel	○ – ◑		breit eiförmige, rundlicher Krone, auf geraden, durchgehenden Stamm achten; Blüten werden stark von Insekten angeflogen, wärmeliebend, für trockene Standorte geeignet (Weinbauklima), gebietsweise Frostschäden, im Straßenbaumtest 2 seit 2005
6	Acer opalus, Schneeball-Ahorn	8-10 (20)	5-8	mittel	○		offene, breite, kegelförmige Krone, stadtklimafest, im Straßenbaumtest 2 seit 2007/08
7	Acer platanoides, Spitzahorn	20-30	15-22	gering	○ – ◑	geeignet mit E.	rundliche, dicht geschlossene Krone, blüht vor dem Blattaustrieb, sehr frosthart, empfindlich gegen Bodenverdichtung, Honigtauabsonderung
8	Acer platanoides 'Allershausen', Spitzahorn	15-20	-10	gering	○ – ◑	geeignet	stark verzweigte, dichte, geschlossene Krone, gut geeignet für frostgefährdete Lagen, Honigtauabsonderung, im Straßenbaumtest 2 seit 2005

Source: GALK 2016: 1.

The 'List of City Trees', as shown in Fig. 9, comes with a broad database behind each entry. Therein detailed information on each tree species are given, including planting and management strategies. Fig. 10 gives an example of a database behind the tree species listed as number 7, a species of Norway maple.

The GALK database is built as a profile on all different tree species. Detailed information is given on the origin, expected height and width, leave shape and colour etc. of the tree.
Furthermore, pictures of the tree in every season as well as in sapling and old tree status.

The most relevant information is given at the end of the three-page-profile. There, soil demand, climatic demands, pests and diseases, the need for special treatment in sapling age as well as exceptions in maintenance are displayed. (Cf. Website GALK 2016)

For city tree species number 7, a Norway maple, it can for example be seen that the soil demands are very low but that the species is susceptible towards soil compaction. In the field 'climatic demands' it is stated that this tree species is very frost-hardy, heat-tolerant, drought-resistant and wind-proof. Tree number 7, Acer Platanoides, can therefore be understood as a climate (change) proof tree species.

Figure 10: GALK database tree species

Nummer	7
Name	Acer platanoides, Spitzahorn
Herkunft	Europa, nach Osten bis zum Ural, im Süden bis zum Kaukasus, Kleinasien und Nordpersien
Höhe	20 bis 30 m
Breite	15 bis 22 m
Lichtdurchlässigkeit	gering
Lichtbedarf	○ – ◑
Wuchsform	rundliche, dicht geschlossene Krone
Wachstum	schnell
Blätter	sommergrün, gegenständig, bis 20 cm breit, 5-7-lappig, bogig gezähnt, Milchsaft führend
Rinde	Zweige hellbraun, Winterknospen rot bis violett, Borke schwärzlichgrau, längsrissig
Blütenbaum	ja
Blütenfarbe	gelbgrün
Fruchtschmuck	nein
Herbstfärbung	goldgelb
Foto belaubt	
Quelle	Gerhard Doobe, Hamburg
Jahr	2012
Foto Jungbaum	
Quelle	Steffen Löbel, Dresden
Jahr	2013

Source: Website GALK 2016.

According to the GALK, the most important assessment criteria for the planting of city trees are:

a. morphologic and physiologic characteristics (growing power, crown-, trunk- and root-formation, habitus etc.)
b. location demands (climate, soil, water, need of light)
c. horticultural effort (improvement of the growing conditions, maintenance costs)
d. experiences on live expectancy, resistance towards environmental emissions, extreme growth conditions)
e. road safety (security in stand and breakage)
f. regional exceptions (e.g. regional constraint in usability)
g. usage possibilities in special cases.

The following tables give an overview on explicitly wind susceptible and wind resistant tree species in Germany, according to the GALK.

Table 5: Wind resistant tree species according to the 'List of City Trees'

Acer platanoides `Cleverland`	Conical Norway Maple
Acer platanoides ‚Emerald Queen'	Norway Maple
Acer platanoides ‚Farlake's Green	Norway Maple
Acer platanoides ‚Globosum'	Spherical Norway Maple
Acer platanoides ‚Royal Red'	Redleaf Norway Maple
Alnus glutinosa	Black Alder
Alnus incana	Grey Alder, White Alder
Alnus x spaethii	Alder, Purple Alder
Carpinus betulus 'Frans Fontaine'	Pillar European Hornbeam
Crataegus crus-galli syn. C. prunifolia ‚Splendens'	Cockspur Hawthorn
Fraxinus excelsior ‚Diversifolia' syn F. excelsior 'Monophylla'	Single-leaf ash
Populus tremula	European Aspen, Aspen
Sorbus latifolia 'Hend Vink'	Devon Whitebeam
Tilla x euchlora syn. Tilia x europaea ‚Euchlora'	Tilia Europaea

Source: GALK 2016.

Table 6: Explicitly wind susceptible tree species

Acer platanoides ‚Sommershade'	Norway Maple
Acer saccharinum syn. A. dasycarpum	Silver Maple
Liriodendron tulipifera	Tulip Poplar
Robinia pseudoacacia Robinie	Black Locust

Source: GALK 2016.

2.3. Recommendations for Forest Management in Germany

One of the main challenges for both forest management as well as city tree management in Germany is the global climate change. Trees have to face more and more aggravated growth conditions, e.g. a general decrease in precipitation while heavy precipitation increases. Especially in densely populated urban areas, the risks for urban heat islands increases and trees have to face heat waves and draught periods. (Cf. Haering unpublished: 21)

Another major challenge for city trees is the occurrences of summer storms like *Ela* that are nearly impossible to project but nevertheless will probably occur more often due to changing climatic conditions, triggering thunderstorms. (Cf. DWD 2015: 25) Leading Federal Agencies expect that events will appear more often the more extreme they are. Despite some periodical fluctuations a nearly linear increase in the probability of occurrence of extreme wind speeds is projected. The most significant trends were projected in winter storms so that it is stated that between 2070 and 2090 the number of winter storms will be doubled in comparison to the reference period 1961-1990. (Cf. DWD/BBK/THW/UBA 2012: 65, 70)

Good practice examples need to be established and further research has to be conducted on good forest and tree management. There already are some decent legal documents and strategies in Germany that address the above mentioned challenges.

Strategies exist for every administrative level, e.g. the German Sustainability Policy (national level), the Forest Management Strategy North-Rhine Westphalia (regional level) and the FLL Guidelines on Tree Inspection (local level). Of high relevance is furthermore the GALK 'List of City Trees' that gives good advice on the climatic and other location related factors of different tree species.

A good practice example for Germany is the Forest Management Strategy of North-Rhine Westphalia. It explicitly addresses the challenges resulting from global climate change and gives various examples and strategies for adaptation measures. An advantage of such a forest management strategy on the regional level is that the authorities of the local level have an adequate framework and set of measures which they can adapt and enhance according to the local circumstances. Furthermore, it needs to be stressed as a good example that the Forest Management Strategy of North-Rhine Westphalia already identifies the most relevant stakeholders for the implementation process of forest management measures. This simplifies the question of responsibility on the local level.

Besides the good practice examples that exist in Germany, chapter 2.2 also revealed some demands for further development in the field of forest management. Most importantly, there is a need for a stronger awareness of potentially hazardous natural events. As also claimed by HEIN et al., sophisticated maintenance and usage concepts need to be derived for the different existing (and future) stocks, paying special attention to their varying level of susceptibility towards storms and other climate change stress factors.
Moreover, the example of summer storm *Ela* impressively showed that Europe will have to face new types of storm events that need to be dealt with and adjusted to. It may therefore be demanded that a debate on the higher administrative levels (national level, EU) needs to take place and that forest management strategies should be expanded also to city tree strategies.

3. Forest Management in Slovenia

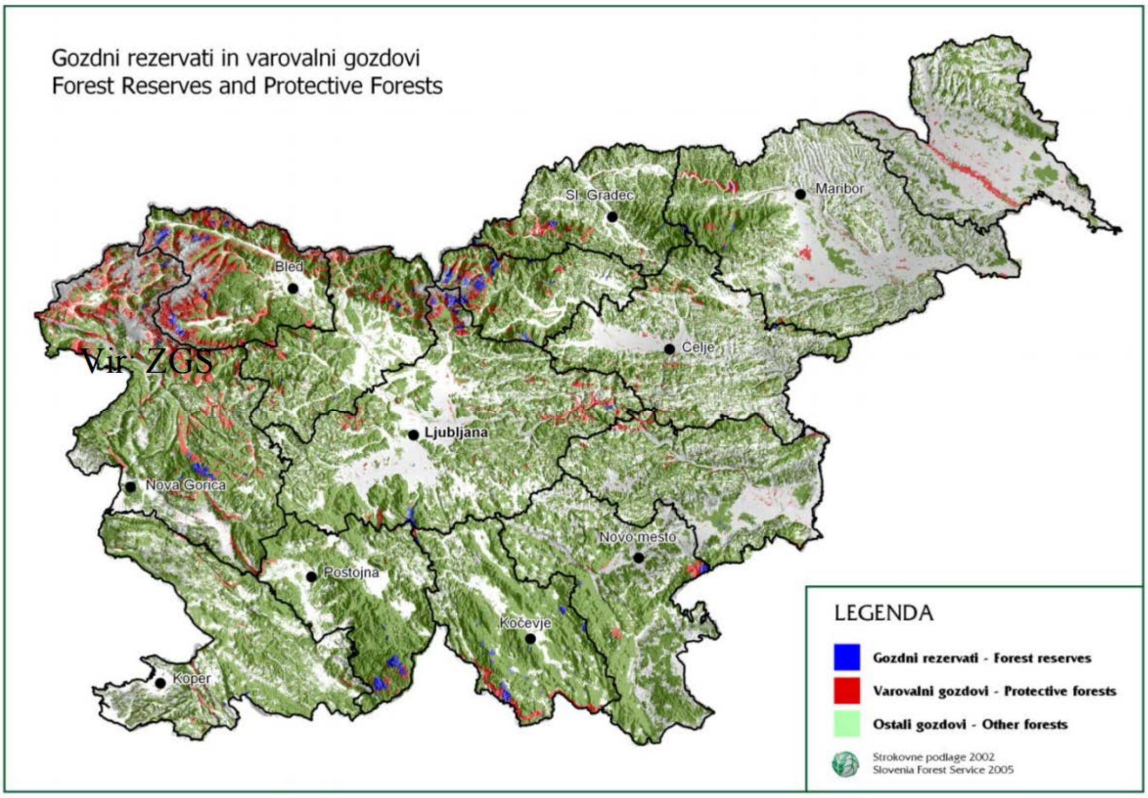
Slovenia belongs to the most forested countries in Europe. By the 1,184,526 ha of forests, the Slovenia is covered more than a half of its territory (forestation amounts to 58.4 %). Most Slovenian forests are located within the area of beech, fir-beech and beech-oak sites (70 %), which have a relatively high production capacity. The 71 % of forests in Slovenia are in private property and 29 % of forests are public (owned by the state or communes). Larger and undivided forest estates of state-owned forests enable good professional management (Website Slovenia Forest Service).

Slovenian forests are divided into three main categories, which have different legal status:

- protective forests
- special purpose forests (e.g. forest reserves)
- other forests (versatile forests)

The forest reserves and protective forests are presented in following figure.

Figure 11: Forest reserves and protective forests



Source: Slovenia Forest Service.

This chapter is divided into four subchapters. In first chapter, the legal documents and strategies concerning forest management in Slovenia are presented. In second and third subchapters we describe case studies, City of Ljubljana and Ajdovščina; and in final subchapter the main recommendations for Slovenia are given.

3.1. Legal Documents and Strategies Concerning Forest Management in Slovenia

Forest management and forest use in Slovenia are directed by The Ministry of Agriculture, Forestry and Food as the supreme state institution in the field of forestry and by the Slovenia Forest Service as a public forestry service. Main national documents that serve as the basis for forest treatment and management in Slovenia are (Slovenia forest service, 2016):

- **Rural Development Programme 2014–2020**: On the 13th of February 2015 the European Commission officially approved Slovenia's Rural Development Programme (RDP) for the period 2014–2020. Slovenia is thus in the first group of Member States that will be able to implement the measures of the new programme period. This confirmation ensures 1.1 billion euros for the development of Slovenian agriculture and rural areas, with 838 million euros coming from the EU budget.

- **The Forests Act** (RS Official Gazette, no. 30/93). It regulates protection, silviculture, exploitation and use of forests on the basis of forest management plans;

- **Decree on protective forests and forests with a special purpose** (RS Official Gazette 88/05, 56/07, 29/09, 91/10, 1/13 in 39/15)**:** This regulation defines protective forests and forests with special purpose with emphasized research function, mode management of these forests, the operators of the regime and the obligator to provide funds for the costs arising from the specific management arrangements.

Besides, there are acts regulating the sphere of nature protection, environmental protection, space management, protection of plants, hunting and wildlife, building and construction, information of public interest and media.

The procedure of adopting forest management plans, as defined by Forest Act, enables co-operation of forest owners and the public in public debates. Thus everybody has the possibility of giving argumentative remarks and suggestions regarding a forest management plan which is in the case of forest management units at the end of the procedure adopted by the Ministry of Agriculture, Forestry and Food. In the case of forest management regions forest management plans are adopted by the government of the Republic of Slovenia.

In accordance with professional foundations provided by the Slovenia Forest Service, forests are managed by forest owners, who are private owners (approximately three quarters of Slovenian forests are in private property), local communities and state. Therefore, the decisions on the measures for forest protection against high wind are left to the forest owners. There are no special measures to be taken in forest during high wind.

The responsibility for fallen trees due to high wind is also left to the owner by the help of institutions which are competent for reducing damage, such as firefighters, public companies, and local government. This depends on where the tree had fallen.

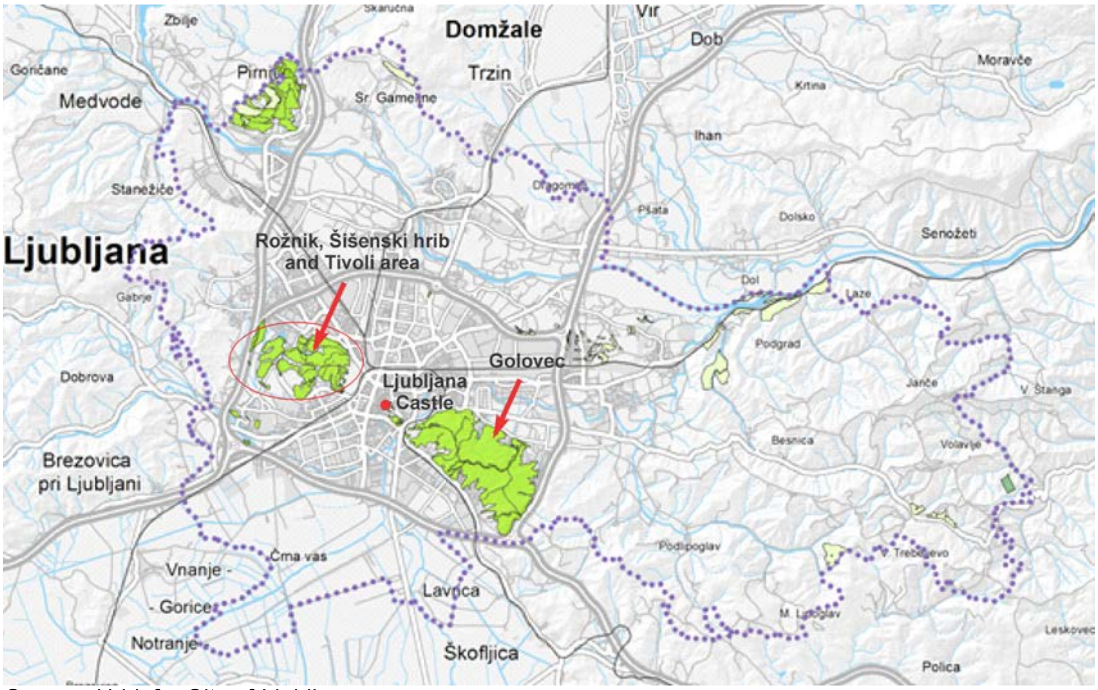
3.2. Case Study: City of Ljubljana

For the Ljubljana case study, we present two main areas, which were most affected during sleet and high wind in February 2014. These two areas are:

- Rožnik – Šišenski hrib (Šiška Hill) - Tivoli area
- the slope below Ljubljana castle.

Both locations are presented in following figure.

Figure 12: Presented locations for Ljubljana case study



Source: Urbinfo, City of Ljubljana

The greatest damage to forests arose as early as in January 31st when all of the urban forests were hit by snow, sleet and wind. In the Rožnik area it was damaged between 30 to 40 % of forest. There were also a lot of damaged roads, which were closed due to pedestrian safety. Consequently it was damaged a lot of infrastructure and public lighting. The public services started with sanitation of the urban forest immediately after sleet event, on February 1st.

For the acceptance of the draft decision on use of budget reserve for the purpose of sanitation of green areas, infrastructure and public lighting in the Municipality of Ljubljana presents legal basis following regulations:

- Public Finance Act
- City of Ljubljana Statute

- Decree on the budget of City of Ljubljana for 2014.

The City of Ljubljana provided fund for sanitation for green urban areas (urban forests), infrastructure and public lighting. It is presented in following table.

Table 7: Provided fund for sanitation for green urban areas.

	(EUR) without VAT	(EUR) with VAT	(EUR) with VAT
Green urban areas	1.309.833,51	288.163,37	1.597.996,88
Infrastructure	337.604,65	74.273,02	411.844,66
Public lighting	270.000,00	59.400,00	329.400,00

Source: City of Ljubljana; VAT: Value Added Tax (22 %)

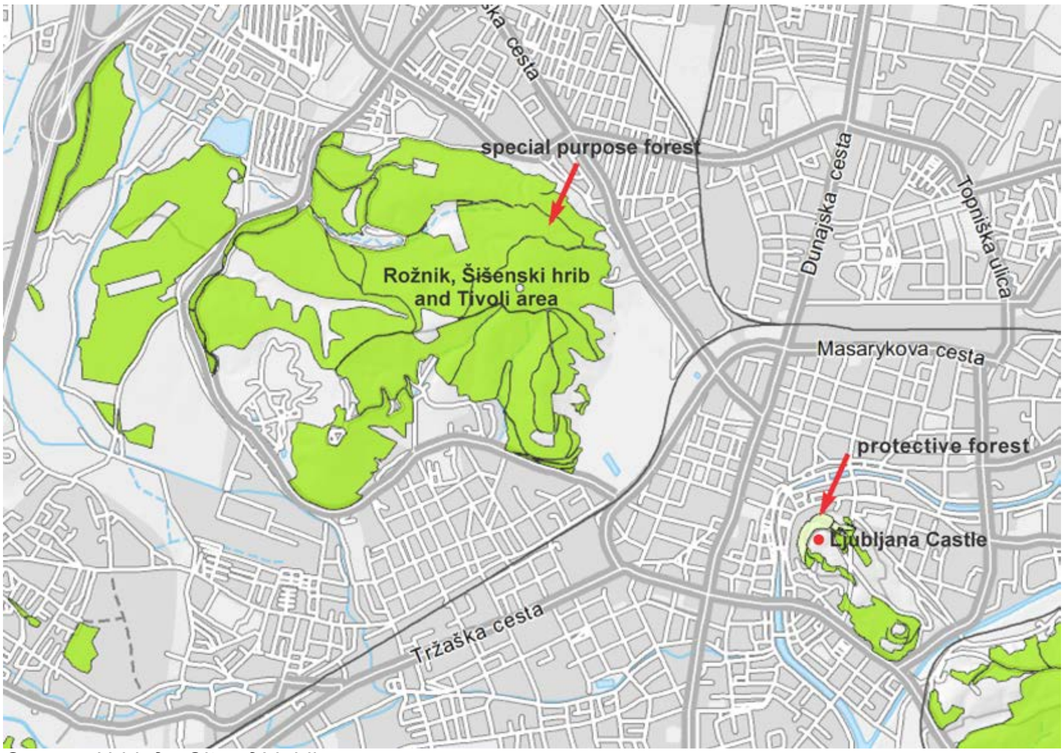
The total amount of provided budget was 2.339.274,54 EUR with VAT.

3.2.1. Rožnik – Šišenski hrib - Tivoli area

Rožnik is a hill in the Rožnik District and Šiška District northwest of the Ljubljana city center. Extending from Tivoli Park, it is popular hiking, running, and excursions destination for residents of Ljubljana.

Tivoli City Park (Tivoli area) is the largest park in City of Ljubljana. It is located on the northern outskirts of the center district, stretching to the Šiška District to the north, the Vič District to the south, and Rožnik District to the west. Several notable buildings and art works stand in the park. Since 1984, the park has been protected as part of Tivoli-Rožnik area-Šiška Hill Landscape Park. It has a name of special purpose forest.

Figure 13: Special purpose forest in Rožnik area



Source: Urbinfo, City of Ljubljana

The consequences of sleet in Cankar Peak are presented in following figure.

Figure 14: The consequences of sleet in Cankar Peak (Rožnik area)

Source: City of Ljubljana

The sanitation was made by dredger. The most damaged trunks and branches were sawn and driven to the compost. Many of less damaged trees were eliminated for sale. The places were planted by new young trees. The comparison, before and after sanitation of the main road is presented in following figure.

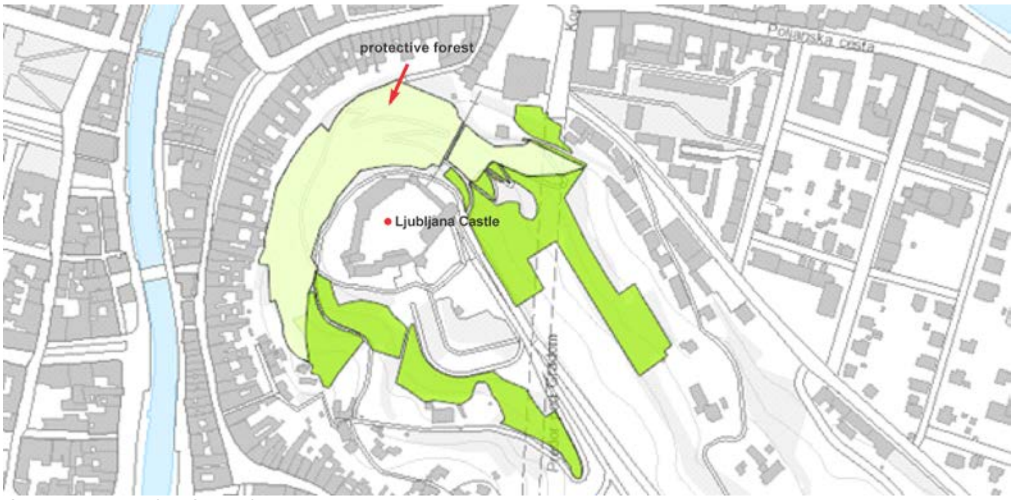
Figure 15: Before and after sanitation in Rožnik area

Source: City of Ljubljana

3.2.2. The slope below Ljubljana Castle

Ljubljana Castle is a castle complex standing on Castle Hill above the downtown of Ljubljana. The critical slope occurred after sleet event in February 2014 below Ljubljana Castle. It is presented in following figure.

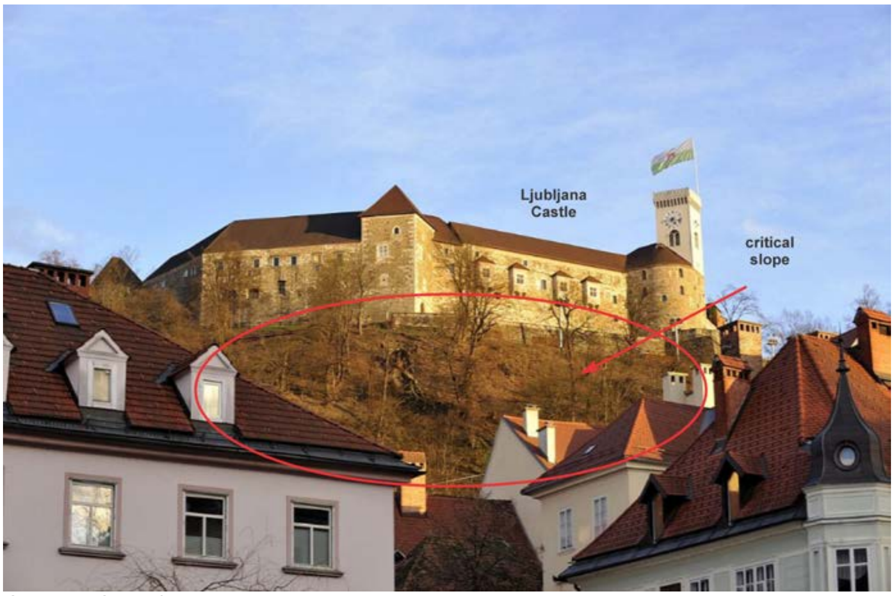
Figure 16: The critical slope below Ljubljana castle



Source: Urbinfo, City of Ljubljana

The situation was critical because the slope slipped down and threatened the historical buildings below the castle. The critical slope with its consequences is presented in following figure.

Figure 17: The critical slope below Ljubljana castle



Source: City of Ljubljana

The clearing and removing of damaged trees was due to steep terrain and, sometimes due to poor accessibility of equipment extremely difficult. It was taken away 352 m^3 of timber and 2,900 meters of volumes of branches. The logs and branches were taken out by tractors and forestry trucks. Most of the work has been finished in two months. The sanitation of potential landslides was in the final stage after almost three months. In the sanitation has been involved at least 65 people of various professions and used over 30 of different vehicles and machines.

Due to dike deformation in the road area the slope was reinforced by reinforcing meshes and vegetation zones. Before the sanitation of the entire area was made, the double binding of fallen trees was carried out as a preventive protection against potential slipping.

Figure 18: The double binding of fallen trees

Source: City of Ljubljana

The sanitation started by setting of temporary safety nets which stopped any rolling stones.

Figure 19: The temporary safety nets

Source: City of Ljubljana

The logs and branches were taken out by dredgers, tractors and forestry trucks.

Figure 20: The temporary safety nets

Source: City of Ljubljana

The sanitation made by reinforced mesh and vegetation zones on area below Ljubljana castle is presented in following figures.

Figure 21: The reinforced slope

Source: City of Ljubljana

To reach the effect of stabilizing the slope by roots as quickly, the damaged steep were planted and the less stable steep leaved it to its natural overgrowing.

The warning signs were during sanitation mostly poor considered by pedestrians. One of these kinds of signs is presented in the following figure.

Figure 22: The warning signs during sanitation

	Attention! Logging * Skidding The risk of falling trees

Source: City of Ljubljana

Figure 23: The reinforcing of slope in different time phases

Source: City of Ljubljana

3.3. Case Study: Municipality of Ajdovščina

The Ajdovščina area and its surroundings are mostly affected by high bora wind. The first noted wind damage was in 1988 when it was damaged 61.000 m3. In January 1993 it was damaged 26.000 m3, In July 2008 this number arise to 33.000 m3, in November 2013 11.000 m3 and in January 2015 around 17.000 m3.

Figure 24: The consequences of bora wind

Source: Forestry Service

Due to the high bora wind the direct and indirect costs occur.
DIRECT:

- damaged trees
- damaged infrastructure
- devaluation wood
- lower timber prices

INDIRECT:

- the multiplying of the pests
- reduction of forest stock
- long-term sanitation - forest grows more than 100 years,
- reduce the quality of the rest of the wood in the forest
- large number of injuries at work in the forest (an increase of serious injuries at work in the forest for almost 100%)
- the excessive volume of work in a short period of time

3.4. Recommendations for Forest Management in Slovenia

The direction of most frequent winds should be included by forestry management as:

- cutting down trees
- thinning of trees (the intensity of thinning)
- adaptation to the forest edge (avoiding sharp edges)
- reconstruction of stands (the reforestation start on the leeward side)
- priority should be given to trees that has stabilize stands (healthy, well-rooted, ...)

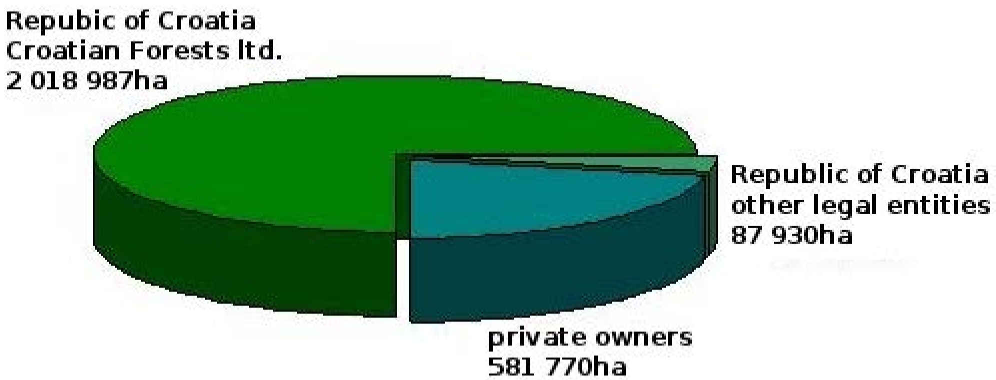
In Ljubljana, urban forest is affected by high gusty wind during storms with unknown main wind direction. Wind speed may be reduced by special tree species on proper places and placing the vegetation zones on edges. The critical slopes have to reinforced and planted with good rooted species.

4. Forest Management in Croatia

The basic principles of the Croatian forestry are the sustainable management, aiming to preserve the natural structure and biodiversity of forests, and the continuous rise of the stability and quality of the commercial and welfare functions of the forest. The Forest Act prescribes an integral forest-management area in the Republic of Croatia, which is further divided into management units. Forests and forest land in Croatia is managed in line with the Forest management plan, adopted for the period of 10 years.

The Forest management plan defines the ecological, commercial and social basis for the biological improvement of forests and the growth of forest production. The goal of the forest management in Croatia is a sustainable and harmonious usage of all the forest functions and the continuous improvement of their condition.
Total area of forests and forest land in Croatia amounts to 2 688 687ha which is 47% of its total land area. Out of that, 2 106 917ha is state-owned, whereas 581 770ha are privately owned. Vast majority of state-owned forests is managed by Croatian Forests Ltd. (2 018 987ha).

Figure 25: Ownership of forests in Croatia



Source: http://portal.hrsume.hr, Croatian Forests Ltd.

Except according to the ownership, forests are classified according to their purpose as well. The Forest Act states that according to their purpose, forests can be commercial, protective and those with a special purpose. Commercial forests are used for the production of forest products, next to the preservation and improvement of their welfare functions. Protective forests serve for the protection of soil, waters, settlements etc. Forests with special purpose are protected nature areas (reserves, national parks, nature parks, nature monuments, important landscapes, park forests)

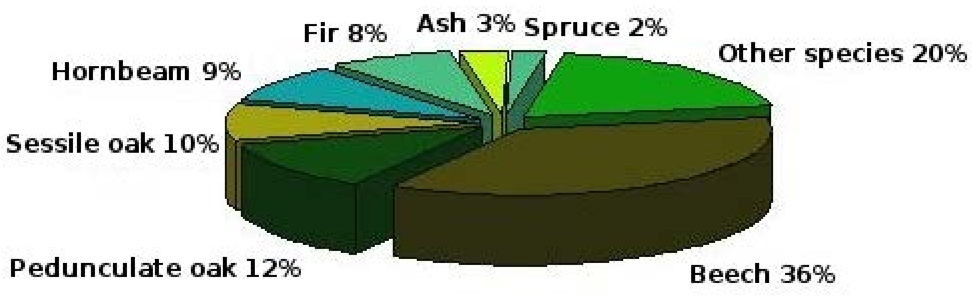
Table 8: Forests classification according to their purpose

OWNERSHIP	Commercial	Protective	Special purpose	TOTAL
Croatian Forsets Ltd.	1 8383 783ha	145 634ha	34 570ha	2 018 987ha
RH, other legal entities	492ha	4 883ha	82 555ha	87 930ha
Private owners	576 832ha	4 022ha	917ha	581 770ha
TOTAL	2 416 107ha	154 539ha	118 041ha	2 688 687ha

Source: http://portal.hrsume.hr, Croatian Forests Ltd.

All managed forests are divided into management units, which are further divided into compartments and sub compartments. Management plan for each management unit is adopted for a period of 10 years. All measurements and planning in forestry are being carried out every ten years, when all data are up-to-dated.

Figure 26: Growing stock by tree species



Source: http://portal.hrsume.hr, Croatian Forests Ltd.

The dominant tree species in the Croatian forests are shown on Illustration 2. However, coastal part of Croatia represents Mediterranean-littotal belt, which is part of Mediterranean region in the phytogeographical division of Croatia which includes large part of the islands, a narrow coastal strip, and Central and Southern Dalmatia. Different climatic conditions in this region have resulted in the development of specific vegetation, including different tree species and forest types.

This area is characterized by evergreen forests of Holm oak (Quercus ilex) and forests of Aleppo and Dalmatian black pine (Pinus halepensis and Pinus nigra subsp. Dalmatica). In the coastal zone in which can occur short-term frosts or is strongly affected by bora forests of Downey oak are developed.

A long history of human activity in Mediterranean region, which dates back to ancient Greece and Rome, has strongly affected vegetation. For centuries forests have been cleared to obtain arable land resulting in small forest areas surviving on limited and hard to reach areas. Changes in the economy in the second part of the twentieth century resulted in a reduction of agricultural efforts. The dominant species after the abandonment of agricultural land becomes Aleppo pine, while remains of vegetation were developed to maquis (dense and low coppice forests), rocky terrain and small fragmented arable land.

Figure 27: Marjan Hill (today park forest Marjan) at the end of XIX century with almost no trees

Source: Stabla na prostoru grada Splita.

Aleppo pine is a pioneering species of trees that can grow in soils with little water and only a few centimetres deep. Its seeds are very light, they have wings, and are easily blown by the wind. In this way, the Aleppo pine can easily occupy open spaces. The areas where growing often resemble the bare rocky desert. Small amounts of soil collected in crevices and under the rocky surface and they are sufficient to enable the development of Aleppo pine. Since the Aleppo pine has very modest requirements, it is often used for afforestation of bare land. The problem in such forested areas is frequent fires due to large quantities of flammable resin that contains the pine.

Figure 28: Black pine on the roof of a church in Nerežišća, island of Brač

Source: Slobodna Dalmacija (http://www.slobodnadalmacija.hr)

Black pine is endemic to islands and coastal areas of Croatia. This subspecies occurs on rocky coast and offshore islands in poor soil. It only attains modest stature not exceeding 15 m probably due to its poor environment and exposure to wind from the sea. It grows generally at higher altitude than Aleppo pine, which is more strictly coastal.
Holm oak forests have firmly leathery leaves that are often coated with a thin wax coating, has a multi-layered epidermis, small recessed stomata, and often hair that further slow evaporation of water. In the natural state such forests are very dense, dark, with a specific microclimate, which is wetter and cooler than the micro-climate of open space. Due to the darkness caused by the dense canopy assembly, which is durable because it is evergreen forest, the layer of ground vegetation is very poorly developed, and there are no spring flowers.

4.1. Legal Documents and Strategies Concerning Forest Management in Croatia

Nature Conservation Act (Zakon o zaštiti prirode)

National Conservation Act regulates environmental protection and sustainable development principles, protection of environmental components and protection against environmental burdening, actors in environmental protection, sustainable development and environmental protection documents, environmental protection instruments, environmental monitoring, information system, ensuring access to environmental information, public participation in environmental matters, access to justice, liability for damage, financing and instruments of general environmental policy, administrative and inspection system.

This law incorporates 92/42/EEC EU directive into the Croatian legislative. This directive ensures the conservation of a wide range of rare, threatened or endemic animal and plant species. Adopted in 1992, the Council Directive on the conservation of natural habitats and of wild fauna and flora aims to promote the maintenance of biodiversity, taking account of economic, social, cultural and regional requirements. The enlargement of the European Union with Croatia has brought the most recent amendments of the EU law for nature protection. Based on the political agreement enshrined in the Treaty of Accession of Croatia, the Council effected the necessary changes by adopting Directive 2013/17/EU of 13 May 2013 adapting certain directives in the field of environment, by reason of the accession of the Republic of Croatia.

According to the Article 5 of Nature Conservation Act, protection of the nature is an obligation of every person and legal subject. All persons and legal subject are required to cooperate in order to avoid and prevent hazardous activities and occurrence of damage, removal and remediation of the consequences of damages and restoration of natural conditions that existed before the damage occurred.

Protected natural areas defined by this Act, Article 111 are categorized as:

- strict reserve,
- national park,
- special reserve,

- nature park,
- regional park,
- natural monument,
- significant landscape,
- park forest,
- park architecture monument

Protected areas are divided into areas of national and local importance. Protected areas of national importance include strict reserve, national park, special reserve and park of nature, while protected areas of local importance include Regional Park, natural monument, significant landscape, forest park and park architecture monument.

Figure 29: Park forest Marjan, Split, Split - Dalmatia County

Source: http://www.marjan-parksuma.hr

Special attention is given to the protection of forests in Article 140. of the Nature Conservation Act:

1. For protected areas in categories strict natural reserve and national park, a program for conservation of forests is prepared containing measures for their protection.
2. The costs of producing programs for forest protection referred to in paragraph (1) of this Article shall be borne by the relevant public institution.
3. For protected areas in categories: special reserve of forest vegetation and forest park, a program for conservation of forests is prepared containing measures for their protection. This program is an integral part of the forest management plan which is developed and implemented as a part of the forest management plan.
4. The program of forest protection referred to in paragraph (1) of this Article shall be prepared and implemented pursuant to a special regulation governing the preparation of forest management plan with the prior approval of the Ministry.
5. Competent public institution may entrust the legal entity authorized to carry out the program of forest protection by signing a contract.

6. Draft program for forest protection shall be made publicly available by the competent public institution, in accordance with a special regulation governing the protection of the environment.

The provisions of this law do not apply in the case of deterring an immediate threat to life and health or property, rescuing people or property and the defense activities of the Republic of Croatia.

Law on Forests (Zakon o šumama)

Law on Forests regulates the growing, protection, use and management of forests as a natural resource, with the goal of preserving natural diversity and ensures management based on principles of economic sustainability, social responsibility and environmental friendliness.

This law proclaims forests and woodlands as goods of interest to the Republic of Croatia which enjoy its special protection. According to this law, forest is considered a land overgrown with forest trees on more than 10 acres (0.1 Ha).

Article (3) defines the beneficial functions of forests:

- protection of soil from erosion by wind and water,
- balancing water levels in the landscape and prevention of flood and high water waves,
- purification of water by filtrating through the forest floor and the supply of underground water flows and springs of drinking water,
- favorable impact on the climate and agricultural activity,
- purification of polluted air,
- impact on the beauty of the landscape,
- creation of favorable conditions for human health,
- ensuring space for recreation,
- facilitate the development of ecological, hunting and rural tourism,
- the preservation of the gene pool of forest trees and other types of forest biocenosis,
- conservation of biological diversity of the gene pool, species, ecosystems and landscapes,
- supporting the general and specific nature protection (national parks, etc.) of wooded landscape,
- mitigate the impact of "greenhouse effect" by binding carbon and oxygen enrichment of the environment,
- general protection and improvement of the human environment with the existence of forest ecosystems as biological capital of great value,
- important resource in the defense of the country and the development of local communities.

Forest management includes breeding, protection and use of forest land and the construction and maintenance of forest infrastructure, according to the Pan-European criteria for sustainable forest management.

Forest management is regulated by Article 17 of the Law on Forests:

1. Forests and forest land owned by the Republic of Croatia are managed by a Trading company.

1. Some of forests and forest lands referred to in paragraph (1) of this Article may use government bodies and legal persons established by the Republic of Croatia.
2. Notwithstanding paragraphs (1) and (2) of this Article, certain forests and forest land owned by the Republic of Croatia dedicated to scientific research and teaching can be managed only by a legal person with the status of a public institution founded by the Republic of Croatia and their scientific and educational components,
3. wood products from forests managed by the Public Institution are sold by public auction conducted by the Trading company, in the manner and under conditions specified by the regulations governing the sale of wood assortments. Proceeds of the sale belong to the Public institution.
4. Forests and forest lands owned by private forest owners are managed by forest owners.
5. Forest management under this Article shall be carried out in a manner and under conditions prescribed by this Act and special regulations.

Forests and forest land owned by the Republic of Croatia are managed by trading company **"Croatian forests Ltd." (Hrvatske šume d.o.o.)**.
Croatian Forests Ltd. and forest owners are required to manage forests maintaining and enhancing biological and landscape diversity and care of the protection of forest ecosystems. In forests that are vulnerable to drying and natural disasters owners are required to establish a comprehensive monitoring network in order to control and analyze negative processes.

Croatian Forests Ltd. and forest owners, as well as legal persons using forest and forest land shall afforest burnt area, the surface on which the rejuvenation failed and the surface on which occurred devastation, illegal clear-cut or contraction within the deadline set by the regional authority, if this deadline is not determined by forest management plan.

Croatian Forests Ltd. and forest owners are not required to take special precautions to visitors of forests and cannot be held liable for any damages or injuries suffered by such persons, unless they were inflicted deliberately or by gross negligence in the performance of regular activities of forest management. Visitors of the forest or forest land take all the risks to which they are exposed while they are in the forest or forest land.

For the improvement of forest management and management of forest land, Forestry Advisory Service is established. Forestry Advisory Service is a specialized public institution advisory service in forests owned by the Republic of Croatia and private forests.
Protection of the forest is prescribed by Articles 38, 39, and 40 of the Law on Forests. Croatian Forests Ltd. and legal persons using forests owned by the Republic of Croatia and forest owners are obliged to take measures to protect forests from fires and other natural disasters and harmful organisms. For the purpose of conducting intensive and continuous surveillance of forest ecological systems, due to the damage caused by atmospheric pollution and other factors influencing forest condition, the Ministry issues a program of measures for data collection and the establishment of Forest damage register. Special consideration is given to the forest fires. In order to improve control over forest fires and their causes, effects and prevention, the Ministry will establish and keep a unified information system and register on forest fires. Croatian Forests Ltd. and

Forestry Advisory Service are required to collect data on forest fires and no later than 8 days after the outbreak of fire and notify the Ministry.

The Ordinance on Forests Conservation (Pravilnik o čuvanju šuma)

This ordinance prescribes the tasks and duties of the forester. Forests and forest ecosystems conservation is organized for the protection of forests and forest land from the misappropriation of land, wood, non-timber forest products, wildlife, protected flora and fauna, the use of any forest resources and other illegal activities. Necessary measures are prescribed to protect forests from fire, pests, insects, livestock, wildlife and disease, prevent pollution of water, soil and air, and all other effects on the forest ecosystem. Protecting forests and forest ecosystems is an integral part of an integrated and indivisible process of forest management.

The Ordinance on Monitoring Damage of Forest Ecosystems (Pravilnik o načinu motrenja oštećenosti šumskih ekosustava)

This ordinance determines the competent authority and duties of the competent authority for the implementation of Commission Regulation (EC) No. 1737/2006 establishing detailed rules for the implementation of Regulation (EC) No. 2152/2003 of the European Parliament and of the Council concerning monitoring of forests and environmental interactions in the Community (OJ L 334, 30.11.2006.) in the part relating to monitoring damage of forest ecosystems, and provide the manner of data collection, keeping the register and conditions for using data on damage of forest ecosystems. The competent authority for the implementation of Regulation (EC) No. 1737/2006 in the part relating to the monitoring of damage to forest ecosystems is the Ministry responsible for the forestry.

Monitoring of damage to forest ecosystems in Croatia are part of the International Programme for the Assessment and Monitoring of Air Pollution Effects on Forests, according to the Convention on Long-range Transboundary Air pollution. Croatian Forest Research Institute is determined as national Coordination Centre for the Assessment and Monitoring of atmospheric pollution and other factors to forest ecosystems.
For the purposes of monitoring the damage of forest ecosystems, as well as for reporting of national and international bodies and institutions, the National Coordination Centre shall establish and maintain a unified Register of damage of forest ecosystems in electronic form, as well as archives of environment samples.

The Ordinance on the Method of Data Collection, Keeping the Register of Conditions for Using Data on Forest Fires (Pravilnik o načinu prikupljanja podataka, vođenju registra te uvjetima korištenja podataka o šumskim požarima)

This Ordinance determines the competent authority and duties of the competent authority for the implementation of Commission Regulation (EC) No. 1737/2006 establishing detailed rules for the implementation of Regulation (EC) No. 2152/2003 of the European Parliament and of the Council concerning monitoring of forests and environmental interactions in the Community (OJ L 334, 30. 11. 2006), in the part relating to forest Fire (Chapter III. and Annex II.), and provide the manner of data collection, keeping the register and conditions of using the data on forest fires.

The competent authority for the implementation of Regulation (EC) No. 1737/2006 in the part relating to forest fires is the Ministry responsible for forestry. The Ministry shall establish a register on forest fires in electronic form, based on the data held by Croatian Forests ltd.
Register on forest fires is a system of documentation, information and data on forest fires. Register consists of databases located in the Croatian Forests Ltd. with archived historical and current data, user applications, supporting documents, prescribed procedures and the procedures for its continued and proper operation.

Croatian Forests Ltd. undertakes the responsibility to maintain a Register and to provide the availability of data from the Registry to the Ministry at any time. Database storage, operation and maintenance of the Register are determined by agreement between te ministry and Croatian Forests Ltd.
The Register include data on the number of fires, origin of the fire, cause of the fire, mode of fire detection, intervention details, burnt areas, the size of fire-affected areas, spatial limits of fire-affected areas and resulting damage.

4.2. Case Study: Wind impact on forest vegetation in Dalmatia: Bora in March 2015

The following chapter gives overview of the events of strong bora that hit Croatian coast from 5th to 7th March 2015 and evaluation of impact and damages of strong wind to tree vegetation in Split region.

Before proceeding with the description of weather conditions on given dates at the area of Split, we will briefly return to the overview of types of forest trees in Dalmatia and consequences on the commercial and social value of forests in Mediterranean region of Croatia. As noted before, historically dominant tree species in Dalmatia was holm oak. However, deforestation of landscape for agriculture needs, followed by the abandonment of agricultural land resulted in spread of Allepo pine which has no significant commercial value. As Allepo pine is the dominant species nowadays, economical value of forests in Dalmatia is insignificant. However, social value of forest vegetation becomes significant, especially in highly urbanized area and areas whose economy strongly depends on tourism.

For the abovementioned reasons, the emphasis of this section will be on impact of wind and damage caused by the wind in urban areas and forests whose main purpose is improvement of the human environment, specifically on city trees in Split and Park Forest Marjan.

4.2.1. Forest vegetation in urban area of Split

Major urbanization plan of the city of Split prescribes general rules for the protection, development and expansion of green areas in the city of Split:

- Keeping historical heritage: all quality trees in the city must be preserved

- Protectiong areas of construction: at least 30% of the construction site must be a green area with both high and low greenery
- Minimum 50% of all roads in the city must be under the avenue

Following categories are defined by Major urbanization plan:

- Public green areas
    - Forest park Marjan
    - Public parks
    - Playgrounds
    - arranged green areas – landings
    - memorial park Sustipan
- Recreational areas
    - swimming places – obligatory planting of high vegetation
- Protective green areas and landscape areas
    - protective green areas and landscape areas
    - protective green areas and landscape areas with existing housing

Particularly valuable with full protection:

- Particularly valuable areas of nature (e.g. Forest park Marjan)
- Especially valuable urban areas with valuable landscape architecture (e.g. swimming place and city district Bačvice)

Figure 30: Limits of Park Forest Marjan

Source: http://www.marjan-parksuma.hr

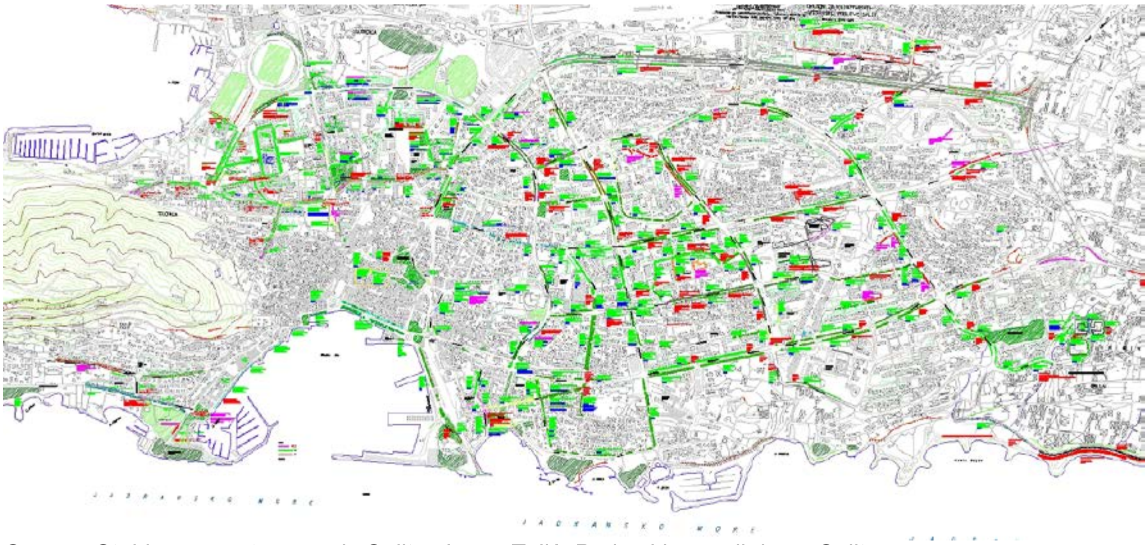
Figure 31: City district Bačvice

Source: http://www.istriasun.com/

Park Forest Marjan, area 300ha of which 196ha of vegetation is located on Marjan peninsula at western part of the Split peninsula. The climate of the Marjan peninsula is defined by its accommodation in the Mediterranean region and in Eumediterranenan zone, and area of evergreen vegetation. This zone has at least 50 weeks of the year with the temperature above 5° C. Geographical configuration and position of Marjan peninsula formed two distinct exposure, north and south, affection the development of vegetation types and layout of certain plant species.
Up until the 15th century Marjan peninsula was forested as high penalties were prescribed by town statute for logging and cattle grazing outside of the permitted period. In 13th century the hill of Marjan is encircled by a fence, and considered a municipal forest. However, the expansion of settlements on the slopes of Marjan, arson and logging devastated the Marjan so that in the 17th century became plain rugged hill. According to historical documents, it is assumed that the forest and underbrush of holm oak prevailed on Marja hill.
Reforestation of Marjan started in the late 19th century. On floral fundus of underbrush vegetation a forest of Aleppo pine sprouted, becoming the dominant monoculture of the nord side of Marjan. On the south side of the hill vegetation is formed of Allepo pine, cypress and Dalmatian black pine. In addition to these species, on limited areas and in smaller number other tree species can be found, including Maritime pine, Brutian pine, Himalayan cedar and Cedar of Lebanon.

In addition to Park Forest Marjan, most trees in Split are located in avenues, as Major urbanization plan of the city prescribes that minimum 50% of all roads in the city must be under the avenue.

Figure 32: Representation of avenues in the city of Split



Source: Stabla na prostoru grada Splita, Jasna Talić, Parkovi I nasadi d.o.o. Split

In the city of Split aproximately 65000 trees is planted in alley. Species used as city trees in Split are:

- Koštela (Celtis Australis – Mediterranea hackberry, honyberry), more than 2000 trees
- Tamaris (Tamarix – Tamarisk, Salt cedar), approximately 960 trees
- Sofora (Styphnolobium – Sophora), approximately 870 trees
- Hrast crnika (Quercus ilex – Holm oak), approximately 460 trees
- Pinjol (Pinus pinea), approximately 380 trees
- Divlji kesten (Aesculus hippocastanum – horse chestnut, conker tree), approximately 280 trees
- Platana (Platanus – Planes), approximately 250 trees
- Alepski bor (Pinus halepensis – Allepo pine), approximately 210 trees
- Palma (Palmae – Palm trees), approximately 180 trees
- Čempres (Cupressus sempervirens - Mediterranean cypress), approximately 110 trees, not counting avenue of cypress on cemetery Lovrinac
- Albicija (Albizia julibrissin – Persian silk tree), approximately 90 trees
- other species in smaller numbers

Figure 33: Avenue of old plane trees, Gupčeva ulica, Split

Source: Stabla na prostoru grada Splita, Jasna Talić, Parkovi I nasadi d.o.o. Split

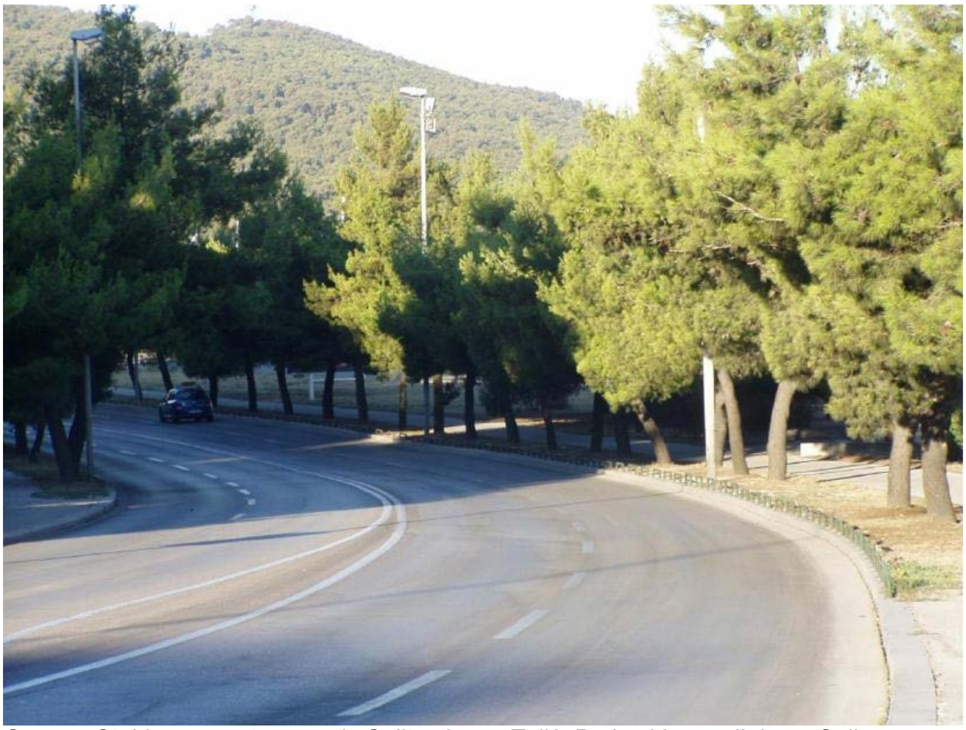
Figure 34: Chestnut avenue, Gundulićeva ulica

Source: Stabla na prostoru grada Splita, Jasna Talić, Parkovi I nasadi d.o.o. Split

Figure 35: Avenue of hol oak, Meštrovićevo šetalište, Split

Source: Stabla na prostoru grada Splita, Jasna Talić, Parkovi I nasadi d.o.o. Split

Figure 36: Avenue of Allepo pines, Ulica sedam Kaštela, city of Split

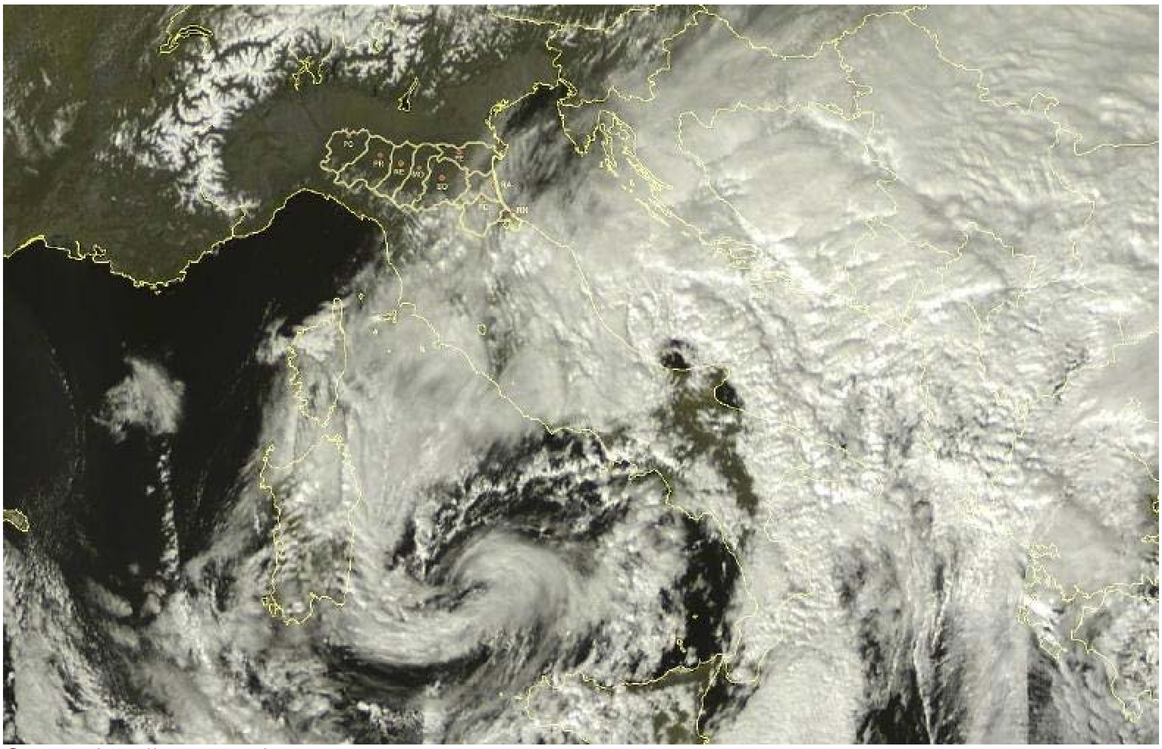


Source: Stabla na prostoru grada Splita, Jasna Talić, Parkovi I nasadi d.o.o. Split

4.2.2. Event Description

Strong gusts of Bora starting from 4th or 5th of March 2015. were announced by the DHMZ. Predicting the strong gusts red alert, which is the highest level of alert in Croatia, was stated on the 5th of March 2015. After 18 hours on the 5th of March the official weather station on the hill of Marjan recorded gust at speed of 165.7 km/h naming this storm the strongest in Split since November 2004. Previous strong gusts of Bora were recorded the month before, and the maximum speed of gust was 155km/h. Marine Metrological Center Split in its warning stated the wind on a part of the Adriatic above 100 knots, for the first time in its history. Predicted maximum was later 130 knots (more than 240 km/h).

Figure 37: Satelite image of the Rea cyclone taken on 5th March 2015



Source: http://crometeo.hr

On 5th March Split Public Fire Brigade already had about 20 interventions on removing fallen trees. Many of trees leaned on buildings, while others fell on the roads. Bora was the strongest during 6th March, when at the area of Split 142 trees have fallen, along with 110 traffic signs, 17 street lights, 6 traffic lights and 300 scattered and damaged garbage containers. In the area of Park Forest Marjan 10 trees have fallen, mostly on the road that goes around the peninsula, the complete data for the area within the forest have not been established.

Figure 38: Fallen tree, city of Split

Source: http://dnevnik.hr

Figure 39: Destroyed auto-camp in Stobreč near Split

Source: Slobodna Dalmacija (http://www.slobodnadalmacija.hr)

Figure 40: Cargo ship stranded on the north side of Marjan peninsula

Source: Slobodna Dalmacija (http://www.slobodnadalmacija.hr)

Figure 41: Truck overturned by bora, Podstrana near Split

Source: http://dnevnik.hr

Bora weakened on 8th March, after which the competent authorities started cataloging the damage. The greatest damage were recorded in the city of Split and the municipality of Podstrana. In the village Stobreč bora completely destroyed auto-camp where most of trees were crushed and demolished the infrastructure in the camp. Damages were also reported in whole Dalmatia, as well as in northern parts of Croatian coast.

Natural disaster was declared for the city of Split, municipality of Podstrana and municipality of Dugi Rat. Natural disaster was declared during the period of 5th to 7th of March 2015 when violent storm raged throughout the region and caused severe material damage. Commission for damage assessment collected the data on damages for city of Split are presented in following tables:

Table 9: City of Split, damage for legal entities

Damage for legal entities	
Type of damage	**Amount of damage in HRK**
Damage on buildings	7.364.036,67 HRK
Damage on forests	2.712.410,00 HRK
Damage on other goods	32.722,75 HRK
TOTAL	**10.109.169,42 HRK**

Source: Damir Gabrić, Split – dalmatian county

Table 10: City of Split, damage for natural persons

Damage for natural person	
Type of damage	**Amount of damage in HRK**
Damage on buildings	264.815,60 HRK
Damage on perennial crops	41.563,62 HRK
Damage on working capital	18.136,26 HRK
Damage on other goods	238.991,80 HRK
TOTAL	**563.507,28 HRK**

Source: Damir Gabrić, Split – dalmatian county

According to media reports, in 4 affected Counties there was over 1700 interventions during 3 day of strong Bora wind event, and some speculate that about 80% of interventions was because of fallen or damaged trees.

4.3. Recommendations for Forest Management in Croatia

- Nature Conservation Act prescribes obligation of Competent authorities to prepare a program for conservation of forests containing measures to their protection. According to this Act, this program shall be publicly available. However, it is not legally prescribed that the plan producer or other competent authority has the obligation to actively present the Plan to the general population, with the emphasis on parts of the community that may be particularly vulnerable in the possible accident caused by natural or other causes (fire, strong wind, etc.), or can provide a greater contribution to reducing the damage or actively contribute in repairing of consequences of the event.

- In addition to plans for forest protection, it is necessary to prepare plans for management of forest vegetation in urban areas, both from the aspect of protection of city trees and reducing the potential damage for residents and infrastructure. These plans should should contain guidelines and instructions for intervention by emergency services in case of natural disasters, plans for mitigate the damage and potential danger for the population, as well as guidelines and tips for civil population in accidental situations.

- As the biggest potential threat to forests in Croatia are forest fires, there is an obligation of he competent authorities concerning monitoring and data collection regarding forest fires. Register on forest fires is kept at the Croatian forests Ltd. The register has archived historical and current data on all relevant information on forest fires. This data can be used in forest management and preparation of plans and programs regarding forest fire protection. Based on this experience, similar registry can be created with information on accidents cause by other natural causes, like wind, rain or thunder storms which could improve planing, and action plan preparation in forest management. This could be particularly useful in urban areas where there is usually no systematic management of forest vegetation in the sense of safety and action plan preparation for response in case of natural disasters. Historical information from this register could also be used for a scientific analysis of forest vegetation in urban areas, as well as for the preparation of future document of urban planning for planning architecture and species of forest vegetation in urban areas.

5. Recommendations Concerning Forest Management and Storms in Europe

Several recommendations can be drawn from Wind Risk Prevention Project regarding forest management in Europe.

Global climate change is one of the most challenging factors for forest and city tree management, especially in densely populated urban areas. Typical storm phenomena, like bora and jugo, but also relatively new phenomena like summer storms are endangering trees. In general, Europe will have to face new types of storm events that need to be dealt with and adjusted to. It may therefore be demanded that a debate on the higher administrative levels (national level, EU) needs to take place and that forest management strategies should be expanded also to city tree strategies.

Additionally, good practice examples need to be established and further research has to be conducted on good forest and tree management.
A good practice example for Germany is the Forest Management Strategy of North-Rhine Westphalia. It explicitly addresses the challenges resulting from global climate change and gives various examples and strategies for adaptation measures. An advantage of such a forest management strategy on the regional level is that the authorities of the local level have an adequate framework and set of measures which they can adapt and enhance according to the local circumstances. Furthermore, it needs to be stressed as a good example that the Forest Management Strategy of North-Rhine Westphalia already identifies the most relevant stakeholders for the implementation process of forest management measures. This simplifies the question of responsibility on the local level.

Besides good practice examples, there is a need for a stronger awareness of potentially hazardous natural events. Sophisticated maintenance and usage concepts need to be derived for the different existing (and future) stocks, paying special attention to their varying level of susceptibility towards storms and other climate change stress factors.
This recommendation is further discussed in the Slovenian example. It can be recommended, that a stronger focus is put on the most frequent storms when cutting and thinning trees. Furthermore, there is a need for adjustments of forest edges, reconstructions of stands and wind resistant tree species.

Moreover, forest protection plans and forest management strategies need to be established and implemented in all EU countries, lacking these so far. These plans should contain guidelines and instructions for intervention by emergency services in case of natural disasters, plans for mitigate the damage and potential danger for the population, as well as guidelines and tips for civil population in accidental situations.
From the Croatian example it can be seen, that these planning and management activities should furthermore pay special attention to other threats like forest fires.

Concluding, the European Parliament states that “priority should be given to promoting the competitiveness and sustainability of the forest sector, supporting both rural and urban areas, expanding the knowledge base, protecting forests and preserving their ecosystems, improving coordination and communication and increasing the sustainable use of wood and non-wood forest products.“ (Website European Parliament 2016)

Although there is no common EU forestry policy, FOREST EUROPE functions as a coherent (but voluntary) framework with concrete criteria and indicators regarding forest management. FOREST EUROPE therefore is a suitable starting point for coherent future EU strategies. Nevertheless, strategies and measures constantly need to be assessed and (if necessary) adjusted to the latest knowledge on forest management, especially in climate change. If done so, FOREST EUROPE might become the most influencing and suitable instrument for a coherent approach for a sustainable forest management.

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Task D – Action plan

Action D.6: Comparing new measured data with data from existing measurement statins and systems

For the Wind Risk prevention project

University of Ljubljana
Technical University of Dortmund
University of Split
Municipality of Ajdovščina

Chapter D.6 – Comparing new measured data with data from existing measurement statins and systems

European Civil Protection Union

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1. Introduction

Wind is natural, highly spatial and temporal variable phenomenon, with occurrence almost everywhere on Earth on every day basis. Due to the difference in geomorphology, land use, position relative to equatorial plane and many other factors, some of the places around world are more susceptible to wind effects. The only way to truly study nature of the winds is to have extensive measurements of wind speed and direction. Wind data are 3D vector fields with profound dynamics, hence the high-resolution measurements – both spatial and temporal are needed. The most significant part of atmosphere for human acivities is atmospheric boundary level (ABL). It is up to 1km thick atmosphere layer form ground or sea level (Holmes 2007). The complex terrain geometry and texture affect the mean value and the fluctuations of the wind speed over height in ABL.

In the countries that are involved in this project quite different wind types were observed due to the vastly different geomorphological and land use properties. Nevertheless, one thing is common - extreme wind effects disabled power and communication sources, damaged buildings and endangered human life multiple times. In order to mitigate such problems generated by strong winds, an extensive research is needed.

Official wind speed measurements are always carried out by formal government body or national agency. Such institutions often have transboundary cooperation in order to create more accurate predictions. However, the measurement grids of official weather stations are sometimes not enough to address problem of strong winds. Some of the reasons we will try to clarify here. Often case is that the primary goal for those stations is delivering weather predictions where wind speed is just part of such product.

Wind effects are happening on very different scales – from annual repetitions to fluctuations with period less than one second. With current computational resources, it is impossible to cover all different time basis.
Without more wind measurements, some of the local phenomena in measured wind fields vanish, in favour of numerically smoothed solution. Also, wind speed measurements are highly expensive due to heavy maintenance of mechanical cup anemometers, which are still in common usage. This is somewhat relieved by usage of ultrasonic anemometers, which do not have mechanically moving parts subjected to wear and tear.

One of the potential solutions is using the data obtained by meteorological enthusiasts to enrich the official data. Enticing scientific projects with goals of collecting more data on wind and merging unofficial and official data is highly recommended.

The focus of this report is an evaluation of the data obtained from new measurement site and existing sites in order to enhance public knowledge on local winds in countries where project was implemented.

Such enhancement and raised awareness will, hopefully, facilitate the necessary change in regulations and engineering practice which will at the end be beneficial to public.

2. Wind speed measurement

2.1 Wind speed measurement in Slovenia

Slovenian official wind speed measurements are carried out by national agency ARSO. The Environment Agency is a body of the Ministry of the Environment and Spatial Planning. Its mission is to monitor, analyse and forecast natural phenomena and processes in the environment, and to reduce natural threats to people and property. The following tasks are performed by the national services for meteorology, hydrology and seismology:

- preserving natural resources, biodiversity and sustainable development;
- observing, analysing and forecasting natural phenomena and processes in the environment;
- reducing impact of natural hazards;
- ensuring legal protection and professional assistance to participants in environmental encroachment procedures;
- guiding change of national and personal values system in relation to the environment as well as influencing the value criteria for environmental encroachments;
- ensuring high-quality environmental data for all target groups;
- raising the awareness of people and institutions about the environment and environmental issues.

2.2 Wind speed measurement in Croatia

National services

In Croatia, national body for official wind speed measurements is Croatian National Hydrometorological Service (DHMZ). Network of manned and automated measurement stations cover the Croatia. Stations are positioned in accordance with WMO recommendations on open spaces; oh height 10m above ground level. On automated stations, data is collecting at rate of 1Hz with automatic averaging on 10-minute span. Total count of stations is 25. Their position is given in Figure 1.

Figure 1: The positions of automatic stations.

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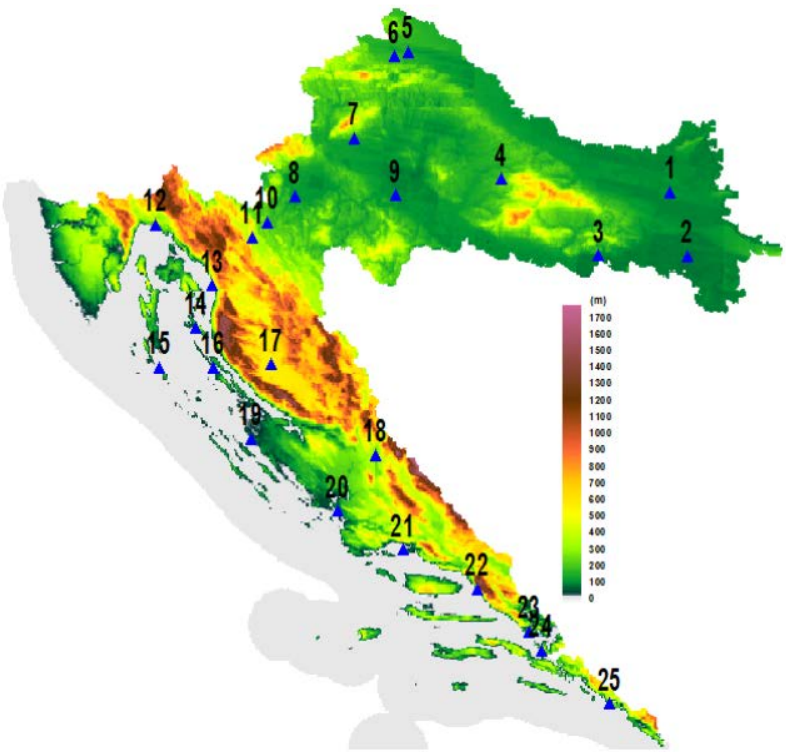


Source: Hydrometorological Service

Along, with official grid, DHMZ is partner to several privately funded wind speed measuring stations, which include Croatian Freeways, National company for power and distribution and several companies in field of windpower. DHMZ is performing data integration and verification for them, as well as mounting and servicing measuring equipment.

Other wind measurement

Unofficial measurements are conducted by groups of enthusiast meteorologist. They are not recognized as meteotological authorities and cannot issue weather warnings. Nevertheless, they form a dense grid of measurement station dispersed over Croatian territory. Their data is available online, as current values or historical values. Two groups are prominent in Croatia:

- Pljusak (http://pljusak.com)
- CroMeteo (http://crometeo.hr)

Main dispute over correctness of data they push online is undefined calibration status of measuring equipment and micrometeorological inhomogeneity due to changes in close environment of measuring stations.

Field measurements in scope of the project

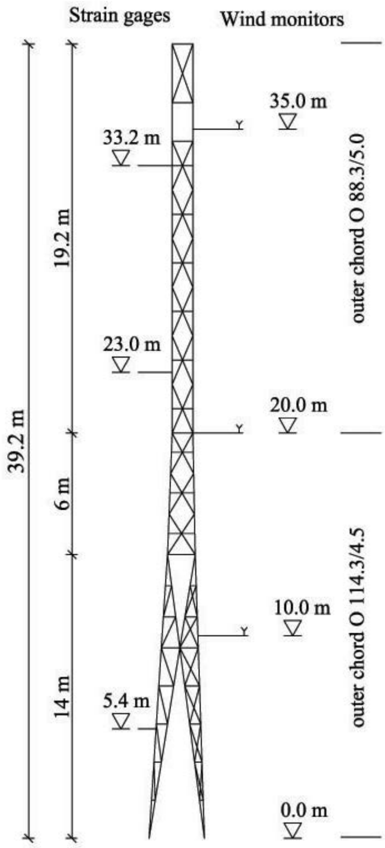
Data used for needs of project Windrisk is collected by University of Split, Faculty of Civil engineering, architecture and geodesy at their test site Bobani near Split. The measurement setup consists of rented mobile operator antenna mast fitted with meteorological and construction monitoring equipment and improvised field laboratory for logging and analysing data. Collected data is complete for period of 2008-2012 and intermitted from 2012, onward. That setup is used for gathering wind loading data on steel trusses, usually used as antenna towers or power transmission towers for several doctoral researches.

Figure 2: Location of measurement site

Source: GoogleMaps

Wind speed measurement is preformed using cup anemometers at height of 10m, 20m and 35m above ground level. Wind direction is obtained using electronic wind vane at every height. Temporal resolution of acquired wind data is 1 s. From 2012. onward, ultrasonic 3D wind speed sensor is intermittently used. Along with wind speed and direction, measurements of air relative humidity, pressure and temperature were performed. Simultaneous logging of wind speed at three different levels enables determination of wind vertical profile. Detailed specification of used equipment is given in table 1.

Figure 3: Antenna tower



Source: Private photo / V. Divić "Simulacije krajnjih graničnih stanja pod djelovanjem vjetra metodom konačno-diskretnih elemenata – Doctoral thesis 2014.

Figure 4: Field laboratory

Source: V. Divić "Simulacije krajnjih graničnih stanja pod djelovanjem vjetra metodom *konačno-diskretnih elemenata – Doctoral thesis 2014.*

Measuring equipment used for these measurements are calibrated with DHMZ and verified by their nearest official measurement station, which is located in Split.

Table 1: Specification of the equipment

	Brzina vjetra	**Smjer vjetra**	**Temperatura**	**Vlažnost zraka**	**Atmosferski tlak**
Vrsta	umSP 2.2	umDR 2.2	HIGROCLIP S,C,S3,C3	HIGROCLIP S,C,S3,C3	Vaisala PTB 220
Osjetnik	Polulopte	Vjetrulja	PT100	ROTRONIC HYGROMER - C94	BAROCAP kapacitivni senzor
Točnost	0.2 m/s	5°	0.1°C	1%	0.1 hPa
Opseg mjerenja	0.2 … 75 m/s	0°…360°	-40°C…+85°C	0…100%	500…1100hPa
Uzorkovanje	1 s	2.3 s	0.7s	0.7s	1s
Radna temperatura	-40°C … +85°C	-40°C … +85°C	-40°C…+85°C	-40°C…+85°C	-40°C…+60°C

Source: V. Divić "Simulacije krajnjih graničnih stanja pod djelovanjem vjetra metodom konačno-diskretnih elemenata – Doctoral thesis 2014.

2.3 Wind speed measurement in Germany

The national service is the German Meteorological Service (Deutscher Wetterdienst). The duties of the Deutscher Wetterdienst are

- the provision of meteorological services for the general public or for individual customers and users, especially in the fields of traffic, trade and industry, agriculture and forestry, the building industry, public health, water management including preventive flood control, environmental protection, nature conservation and science,
- the meteorological safeguarding of aviation and shipping,
- the issuance of official warnings of weather occurrences that could become a danger for public safety and order, especially concerning the impending danger of floods,
- the short- and long-term registration, monitoring and evaluation of meteorological processes, structure and composition of the atmosphere,
- the registration of the meteorological interaction between the atmosphere and other areas of the environment,
- the forecasting of the meteorological processes,
- the monitoring of the atmosphere for radioactive trace substances and the forecast of their transport,
- the operation of the necessary measuring and observation systems for fulfilling the duties listed in items 1 to 7, and
- the holding in readiness, archiving and documentation of meteorological data and products.

Online they provide a list on all measurement stations, which is available at link https://www.dwd.de/DE/leistungen/klimadatendeutschland/stationsuebersicht.html?lsbId=526270 . All data regarding wind climate is available online over Climate Data Center website and dedicated FTP server (ftp://ftp-cdc.dwd.de/pub/CDC/).

3. Wind data format specifications

When storing wind measurement data archive one must have in mind that the wind measurement data is not a single scalar value, but structured data consisting of several values that describe a single moment in time reading. Wind measurement reading format depends on type of the instrumentation used, while value depends on wind conditions at the time of reading and place of measurement.

If we want to compare wind data measurements from different locations or with different instrumentations used, we must first consolidate data. Data consolidation [https://www.techopedia.com/definition/28034/data-consolidation] refers to the collection and integration of data from multiple sources into a single destination. During this process, different data sources are put together, or consolidated, into a single data store.
Wind data from cup anemometer is proportional to number of rounds cup anemometer makes because of the wind and position of the wind direction needle. Ultrasonic anemometer data comes from measuring the effect of wind between two points.

NMEA is standard format for delivering measurement data. NMEA 0183 is a combined electrical and data specification for communication between marine electronics such as echo sounder, sonars, anemometer, gyrocompass, autopilot, GPS receivers and many other types of instruments. It has been defined by, and is controlled by, the National Marine Electronics Association. [http://www.nmea.org/]. The NEMA data format consists of sentences of data with checksum, each sentence having record for one measurement.
Since wind data consists of more than one value, this format of data is convenient for storing data, but one must know semantic of sentence when extracting meaningful values.

Another standard in measurement data delivery is Observation and Measurement. Observations and Measurements (O&M) is an International Standard which defines a conceptual schema encoding for observations, and for features involved in sampling when making observations. It was developed in the context of Geographical Information System by Open Geospatial Consortium (OGC) as a part ov the Sensor Web Enablement initiative.

The O&M standard defines an abstract model and XML schema for observations, supports the common strategy of sampling and provides general framework for systems dealing with technical measurements in science and engineering.

XML is a standard format for data exchange on Internet. XML format is simple textual format that enables interoperability between various environments (operating systems, hardware and software). XML data caries its own description in the form of XML tags. An example of XML data is shown in figure 5.

Figure 5: Observation And Measurement XML example.


```xml
<om:OM_Observation
gml:id="obsTest1"
xmlns:om="http://www.opengis.net/om/2.0"
xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance"
xmlns:xlink="http://www.w3.org/1999/xlink"
xmlns:gml="http://www.opengis.net/gml/3.2"
xsi:schemaLocation="http://www.opengis.net/om/2.0 http://schemas.opengis.net/om/2.0/observation.xsd">
<gml:description>Observation test instance: fruit mass</gml:description>
<gml:name>Observation test 1</gml:name>
<om:type xlink:href="http://www.opengis.net/def/observationType/OGC-OM/2.0/OM_Measurement"/>
<om:phenomenonTime>
<gml:TimeInstant
gml:id="ot1t">
<gml:timePosition>2005-01-11T16:22:25.00</gml:timePosition>
</gml:TimeInstant>
</om:phenomenonTime>
<om:resultTime xlink:href="#ot1t"/>
<!-- a notional URL identifying a procedure ... -->
<om:procedure
xlink:href="http://www.example.org/register/process/scales34.xml"/>
<!-- environmental conditions during measurement -->
<om:parameter>
<om:NamedValue>
<om:name xlink:href="http://sweet.jpl.nasa.gov/ontology/property.owl#Temperature"/>
<om:value xsi:type="gml:MeasureType" uom="Cel">22.3</om:value>
</om:NamedValue>
</om:parameter>
<!-- a notional URN identifying the observed property -->
<om:observedProperty
xlink:href="http://sweet.jpl.nasa.gov/2.0/phys.owl#Mass"/>
<!-- a notional WFS call identifying the object regarding which the observation was made -->
<om:featureOfInterest
xlink:href="http://wfs.example.org?request=getFeature&amp;featureid=fruit37f "/>
<om:result
xsi:type="gml:MeasureType"
uom="kg">0.28</om:result>
<!-- The XML Schema type of the result is indicated using the value of the xsi:type attribute -->
</om:OM_Observation>
```


Source: Observations and Measurements - XML Implementation, obtained from http://www.opengeospatial.org/standards/om

Although it is standard and lightweight, many programmers avoid use of XML format, due to the problem with parsers. However, another format, is gradually replacing XML format for exchange of data. JavaScript Object Notation (JSON) format provides the same benefits of interoperability and openness, but without the disadvantages of XML. JSON is a useful data serialization and messaging format.

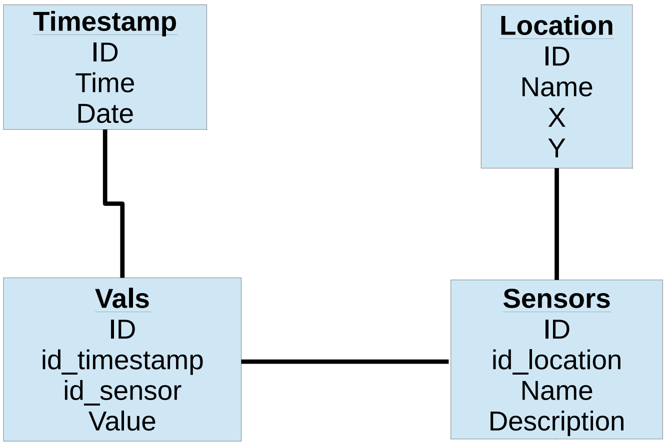
Figure 6: Example of JSON Observations and Measurement file.


```
{
"metadata": {
"intendedObservationSpacing": "P1D",
"status": {
"term": "checked",
"vocabulary": "http://www.example.org/vocabs"
}
},
"defaultPointMetadata": {
"interpolationType": {
"term": "Continuous",
"vocabulary": "http://www.opengis.net/def/waterml/2.0/interpolationType"
},
"quality": {
"term": "good",
"vocabulary": "http://www.opengis.net/def/waterml/2.0/quality"
},
"uom": "http://www.qudt.org/qudt/owl/1.0.0/unit/Instances.html#Meter"
},
"points": [
{
"time": {
"instant": "2010-01-01T00:00:00"
},
"value": 3.2
},
{
"time": {
"instant": "2010-01-02T00:00:00"
},
"value": 3.6}
]
}
```


Source: Observations and Measurements - JSON Implementation, obtained from http://www.opengeospatial.org/standards/om

In the scope of this work we developed our own model of data. The data is stored in database and pre-processed for online presentation. The model of data has been designed having in mind scalability of the system for data storing and presentation. The model of data is shown in figure 7.

Figure 7: Data model for storing wind measurement data.



The model is implemented in mySql database and web service for data logging is enabled. Also a service for data retrieval is implemented.
Data is retrieved in JSON format, such that each dimension is enabled separately. An example of data is shown in figure 8.

Figure 8: Data model for storing wind measurement data.


```
[
{"ID":"1336840",
"time":"14:51:00",
"date":"2016-12-19",
"name":"dir_v_3",
"value":"1.3433"},
{"ID":"1336840",
"time":"14:51:00",
"date":"2016-12-19",
"name":"dir_u_3",
"value":"-2.30371"},
{"ID":"1336840",
"time":"14:51:00",
"date":"2016-12-19",
"name":"v_max_0",
"value":"2.94534"},
{"ID":"1336840",
"time":"14:51:00",
"date":"2016-12-19",
"name":"v_max_1",
"value":"4.7567"},
```


We propose format for wind data archive exchange, suitable for both cup anemometer and ultrasonic two or three dimensional anemometer. Proposed format is based on JSON syntax making it suitable for cross platform interoperation.
The JSON scheme for wind data used in this report is shown in Figure 9.

Figure 9: JSON scheme of the measurement data.

```
{
    "$schema": "http://json-schema.org/draft-04/schema#",
    "title": "wind data scheme",
    "type": "array",
    "items": {
        "title": "Measurement value",
        "type": "object",
        "properties": {
            "id": {
                "description": "The identifier of the timestamp  of the measurement ",
                "type": "number"
            },

            "date": {
             "description": "The date of measurement",
                "type": "date",

            },
            "time": {
                "description": "The time of measurement",
                "type": "time",

            },
            "name": {
                "description": "The name of the value, such as dir_u, dir_v, max_speed ..",
                "type": "string",


            },
            "value": {
             "type": "number",

            }
        }
    }
}
```

The model of data is based on readings from 3D ultrasonic anemometer that measures 3 components of the wind speed separately. Three wind components are often referred as *u*, *v* and *w*.

- Along wind component *u* is the component of the wind towards east, zonal velocity.
- Across wind component *v*, the component of the horizontal wind towards north or meridional velocity.
- Vertical wind component *w* is upward velocity.

Having this in mind, wind speed measured by 3D anemometer is calculated using equation:

$$W_{Speed} = \sqrt{diru^2 + dirv^2 + dirw^2}$$

Cup anemometer measures wind speed and wind direction as separate values. Having as a goal unification of data so we can compare values, we will transform the data from cup anemometer to two horizontal wind components, omitting the vertical component which is not measured by this kind of instrument.
Horizontal component of wind speed are calculated using the equations

$$diru = -w_{speed}\sin(wind_{dir})$$

$$dirv = -w_{speed} \cos(wind_{dir})$$

Where w_speed is value of wind speed measured by anemometer, and wind_dir is wind direction having in mind meteorological standard measured by anemometer expressed in radians.

Series of wind data measurements measured by two dimensional anemometer can now be expressed as shown in figure 10.

Figure 10: JSON scheme of the measurement data.


```
[
{"ID":"1336838","time":"14:50:54","date":"2016-12-19","name":"dir_v","value":"-0.93969"},
{"ID":"1336838","time":"14:50:54","date":"2016-12-19","name":"dir_u","value":"-0.02184"},
{"ID":"1336837","time":"14:50:51","date":"2016-12-19","name":"dir_v","value":"-0.17021"},
{"ID":"1336837","time":"14:50:51","date":"2016-12-19","name":"dir_u","value":"-2.82907"},
{"ID":"1336836","time":"14:50:42","date":"2016-12-19","name":"dir_v","value":"1.15856"},
{"ID":"1336836","time":"14:50:42","date":"2016-12-19","name":"dir_u","value":"-5.2634"},
{"ID":"1336835","time":"14:50:39","date":"2016-12-19","name":"dir_v","value":"0.26612"},
{"ID":"1336835","time":"14:50:39","date":"2016-12-19","name":"dir_u","value":"0.17827"}
....

]
```

4. Wind data analysis

4.1 Wind data

Prior to wind speed analysis, loading sessions are subdivided into non-overlapping 10-minutes intervals of data. Every dataset was classified with mean direction of wind speed, height of measurement and mean wind speed. Every set of data was decomposed on mean wind speed and fluctuation.

Global overview of the wind flow at the site "Bobani" can be seen from the wind rose at measuring stations (Figure 5.9). It can be seen that the predominant directions of wind flow are northeast, which corresponds to the local wind *bura*, and southeast, which corresponds to the local wind *jugo*. Furthermore, it is evident that *jugo* is somewhat more frequent than *bura*, but that *bura* has a somewhat greater intensity.

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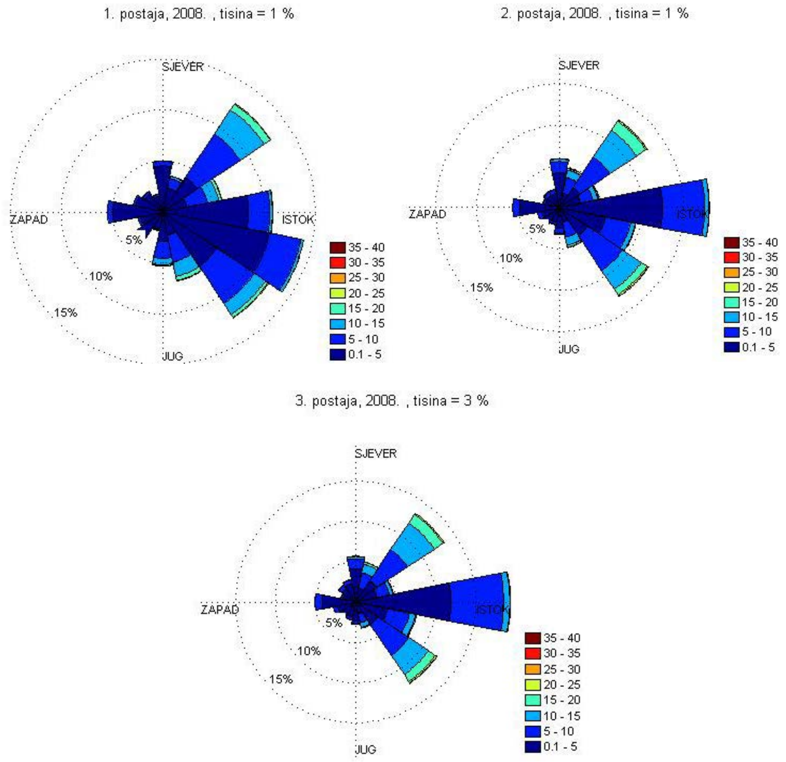
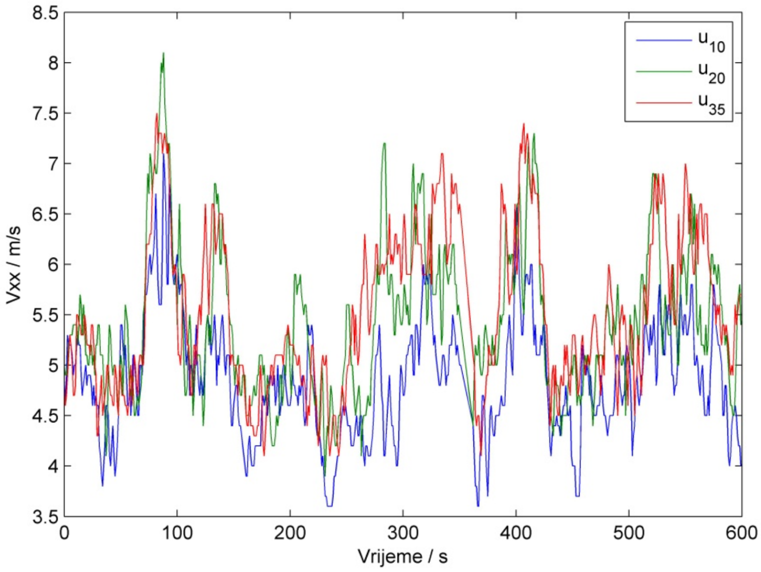
Figure 9: Wind roses at measuring stations.



Source: V. Divić "Simulacije krajnjih graničnih stanja pod djelovanjem vjetra metodom konačno-diskretnih elemenata – Doctoral thesis 2014.

The analysis of the wind flow was carried out on a series of second records, each lasting ten minutes. In each array there is a profile record (Figure 5.10.). The criteria for separating the array from a set of all second records is a constant direction for the duration of that array, measured at a height of 10 m, and no overlapping of each successive arrays. Arrays are grouped by direction into two groups: *jugo* and *bura*. Group *bura* has 1248 arrays, and group *jugo* has 1053 arrays. The mean value, fluctuating wind component, standard deviation, turbulence intensity, gust factor, and wind power range are calculated for each array. Groups are further divided by mean velocity measured at the height of 10 m. Limits of the subgroups are 2,4,6,8,10,12,14,16,18 and 20 m/s.

Figure 10: An example of one data array.



Source: V. Divić "Simulacije krajnjih graničnih stanja pod djelovanjem vjetra metodom konačno-diskretnih elemenata – Doctoral thesis 2014.

Average wind speed is a central 10-minute record of second values. Vertical profile of mean wind speed is obtained from the relationship of the speed record by height. Engineering practical approach is through logarithmic law that states:

$$U_h = U_{10}\left(\frac{h}{10}\right)^{\alpha}$$

where v_h is the mean wind speed at the height *h*, and α is a coefficient of speed change by height. From mean speed records and by using a method of minimum square distance, it is possible to define α according to the following expression:

$$\alpha = \frac{\sum_i \left[\log\left(\frac{U_i}{U_{10}}\right)\cdot\log\left(\frac{h_i}{h_{10}}\right)\right]}{\sum_i \left[\log\left(\frac{h_i}{h_{10}}\right)\right]^2}$$

By grouping the records about wind directions and taking their mean, coefficients α are obtained for each direction. Coefficients shown in Table 5.2. provide the first insight into the diversity of behaviour of local winds *bura* and *jugo*.

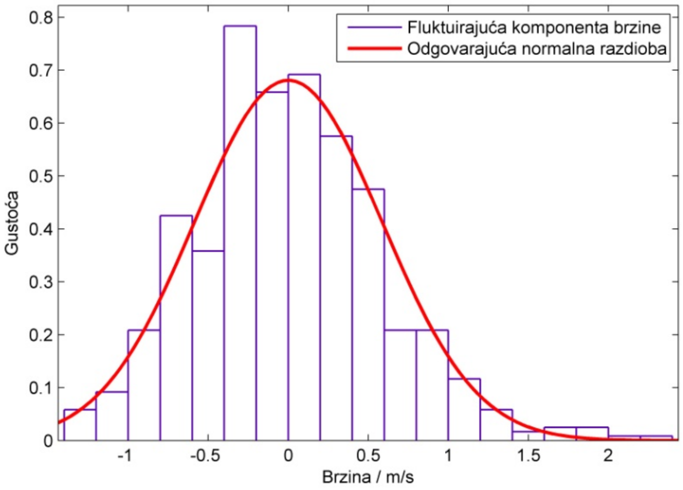
Table 2: Coefficient α with regard to the wind speed

Direction	α
N	0.102
NNE	0.071
NE	0.062
ENE	0.083
E	0.054
ESE	0.105
SE	0.143
SSE	0.218
S	0.264
SSW	0.243
SW	0.185
WSW	0.117
W	0.095
WNW	0.109
NW	0.075
NNW	0.084
SVI	0.107

Source: V. Divić "Simulacije krajnjih graničnih stanja pod djelovanjem vjetra metodom konačno-diskretnih elemenata – Doctoral thesis 2014.

Fluctuating component of wind speed is obtained by Reynolds decomposition, by subtracting the mean value from wind speed second records. Fluctuating components are well described by a normal distribution (Figure 13) which is verified by standard statistical tests and is in agreement with theoretical settings described in chapter three.

Figure 11: Histogram of the fluctuating component and the associated normal distribution



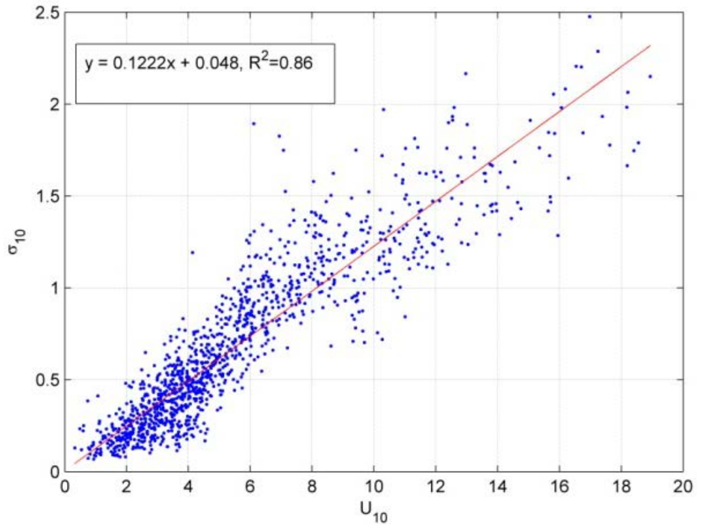
Source: V. Divić "Simulacije krajnjih graničnih stanja pod djelovanjem vjetra metodom konačno-diskretnih elemenata – Doctoral thesis 2014.

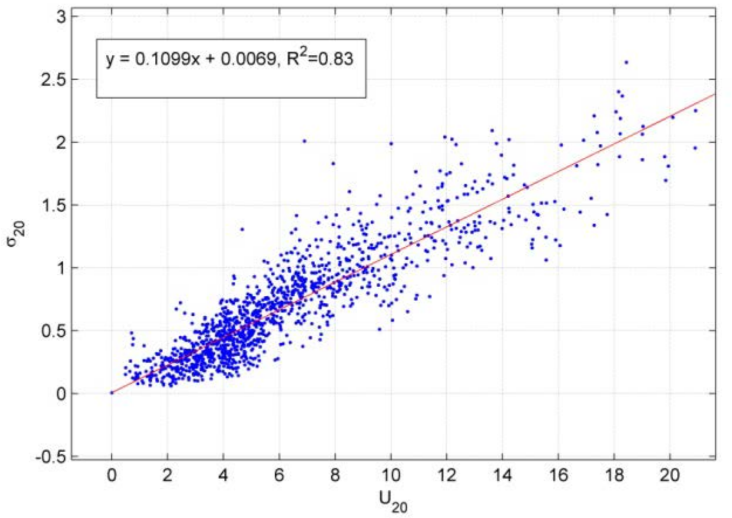
Mean value of the fluctuating component is zero, and the only parameter that is required to describe the distribution is the standard deviation. The relationship between the mean velocity and the standard deviation is the turbulence intensity. The intensity of turbulence is a standard measure of wind gusts and is defined as

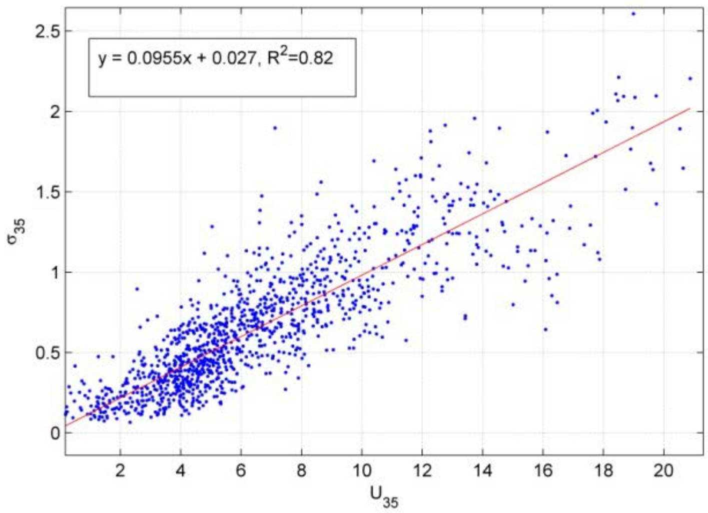
$$Iv = \frac{\sigma}{V_{10}}$$

where σ is the wind speed standard deviation, and V10 is the mean wind speed, averaged at 10-minute interval. For information on mean speed and standard deviation a regression line is calculated on the basis of which the intensity of turbulence is obtained.

Figure 12: a) Mean speed correlation and the standard deviation for *jugo*

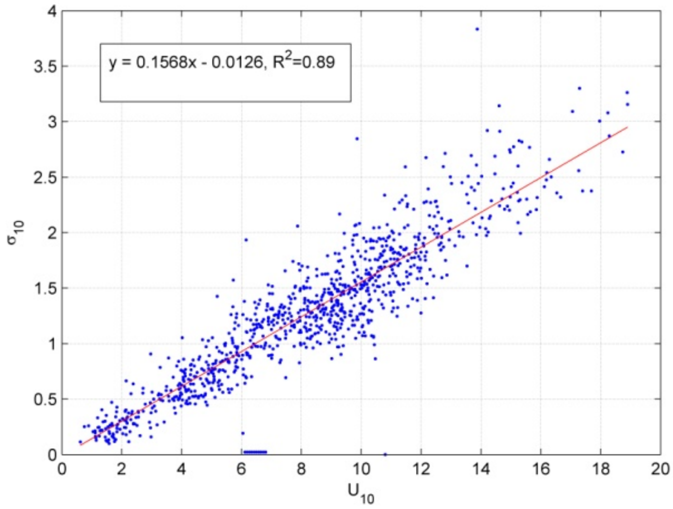


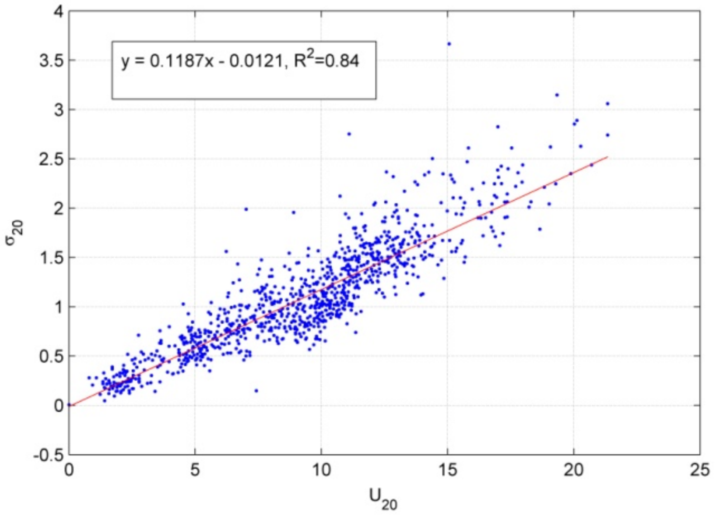


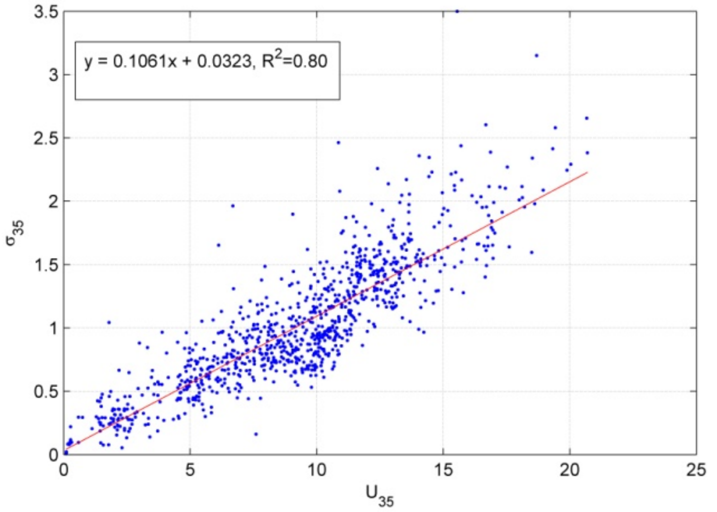


Source: V. Divić "Simulacije krajnjih graničnih stanja pod djelovanjem vjetra metodom konačno-diskretnih elemenata – Doctoral thesis 2014.

Figure 13: b) Mean speed correlation and the standard deviation for bura





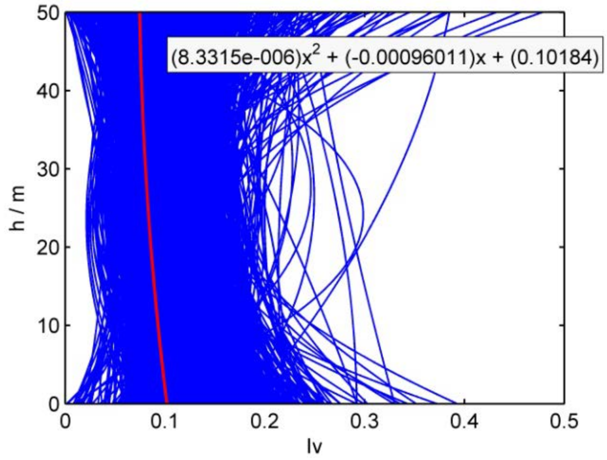


Source: V. Divić "Simulacije krajnjih graničnih stanja pod djelovanjem vjetra metodom konačno-diskretnih elemenata – Doctoral thesis 2014.

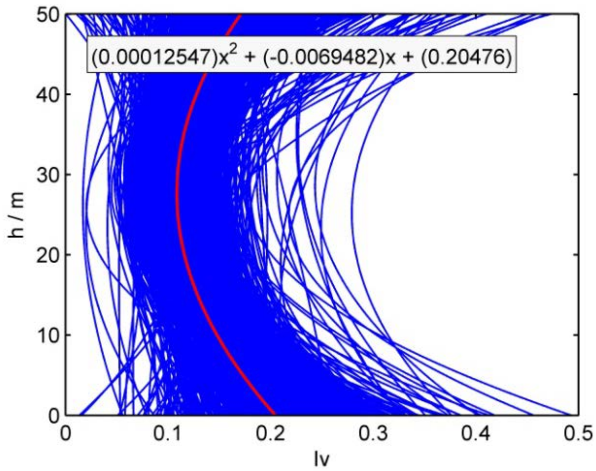
The slope of the regression line is equal to the intensity of turbulence. By comparing the intensity of the turbulence for *bura* and *jugo* it is evident that *bura* has a greater intensity for each of the listed heights. This agrees with previous research which emphasizes greater gustiness of *bura* when compared to *jugo*. The turbulence intensity can be functionally described by a second order polynomial. The coefficients of the polynomial are obtained by adjusting the polynomial to the data (*curve fitting*).

Figure 14: Changes in turbulence intensity by height for a) jugo, b) bura

a)



b)



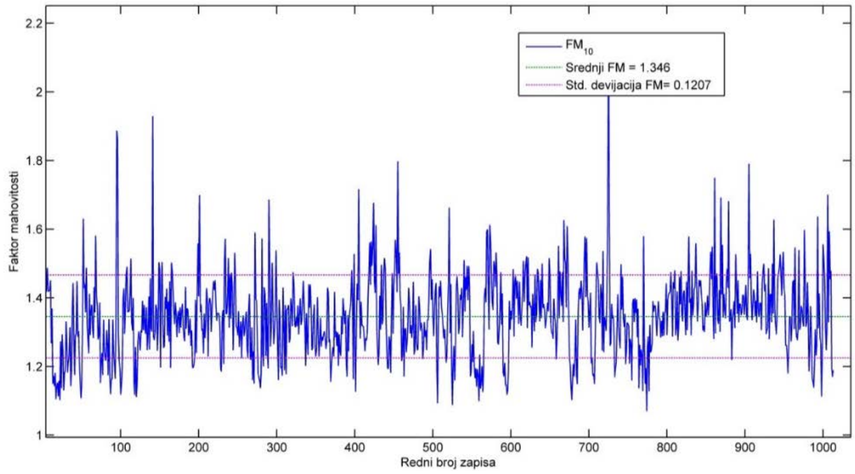
Source: V. Divić "Simulacije krajnjih graničnih stanja pod djelovanjem vjetra metodom konačno-diskretnih elemenata – Doctoral thesis 2014.

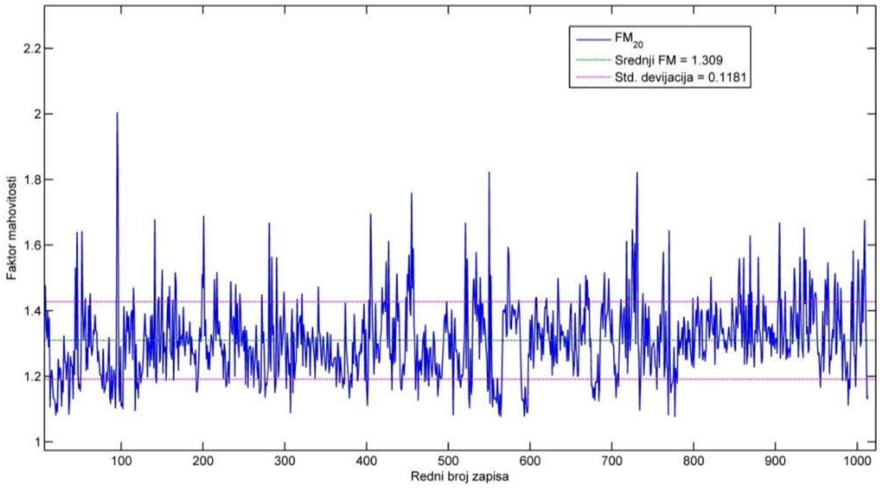
Figure 5.13. shows the results of adjustment of polynomial to the data. The mean values are shown as red lines and the corresponding analytical expressions are inscribed next to them.

In addition to the intensity of turbulence, another measure of wind gustiness is a factor of wind gust which is described as the ratio of the maximum second wind speed and the mean 10-minute wind velocity.

$$FM = \frac{V_{xx}}{V_{10}}$$

Figure 15: Gustiness factor for *jugo*


FM10
Srednji FM = 1.346
Std. devijacija FM= 0.1207
Faktor mahovitosti
Redni broj zapisa
1
1.2
1.4
1.6
1.8
2
2.2
100
200
300
400
500
600
700
800
900
1000


FM20
Srednji FM = 1.309
Std. devijacija = 0.1181
Faktor mahovitosti
Redni broj zapisa
1
1.2
1.4
1.6
1.8
2
2.2
100
200
300
400
500
600
700
800
900
1000

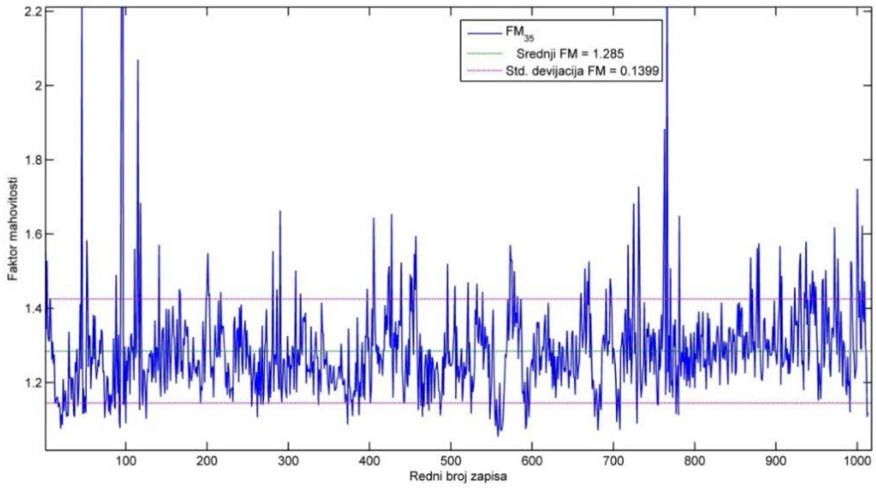

FM35
Srednji FM = 1.285
Std. devijacija FM = 0.1399
Faktor mahovitosti
Redni broj zapisa
1.2
1.4
1.6
1.8
2
2.2
100
200
300
400
500
600
700
800
900
1000

Figure 16: Gustiness factor for *bura*

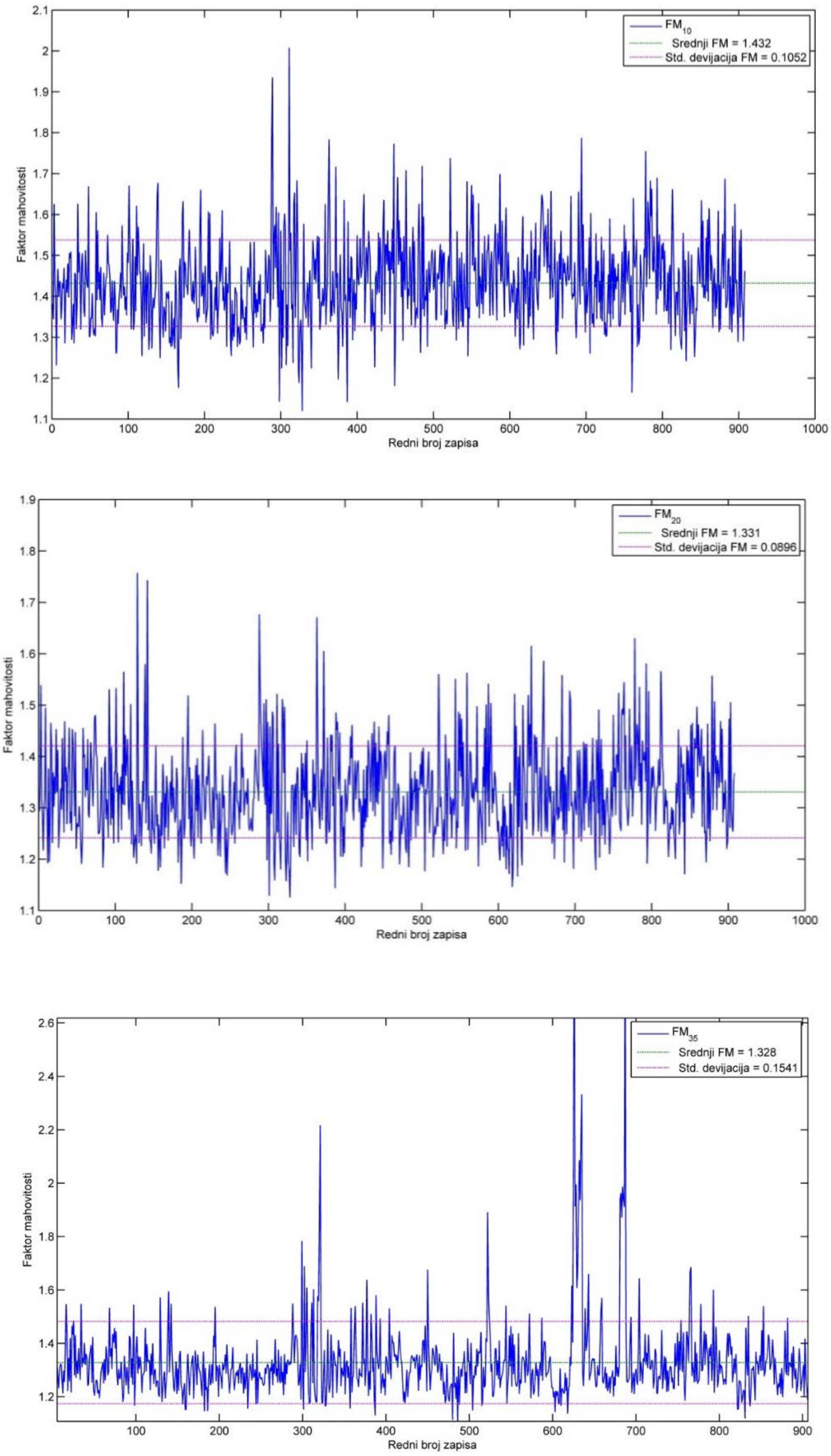
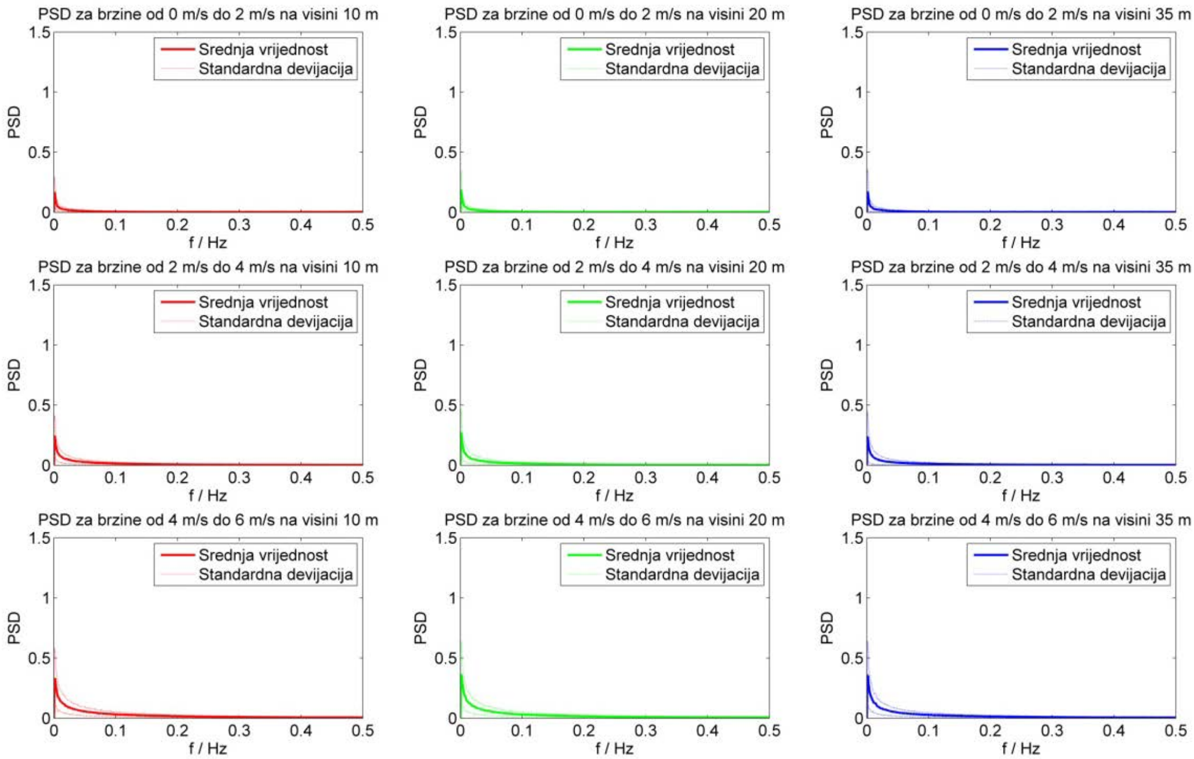
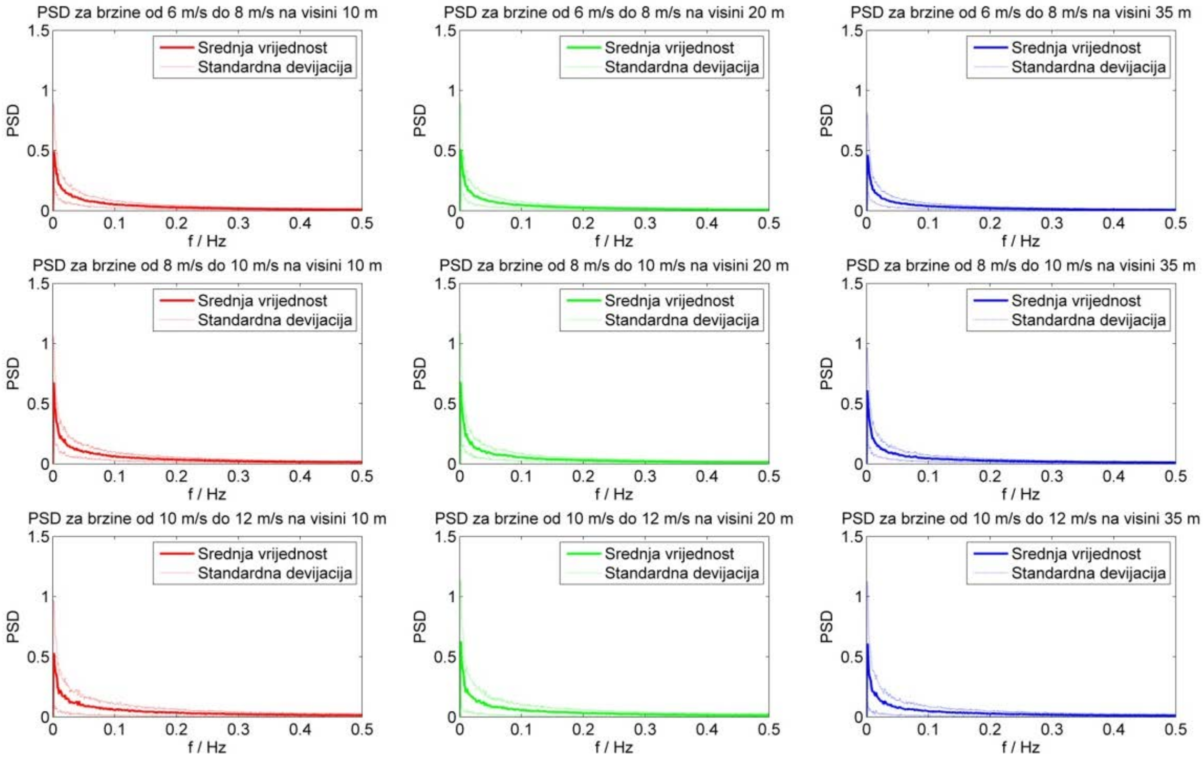


Figure 17a: PSD for sirocco wind for different speeds and heights



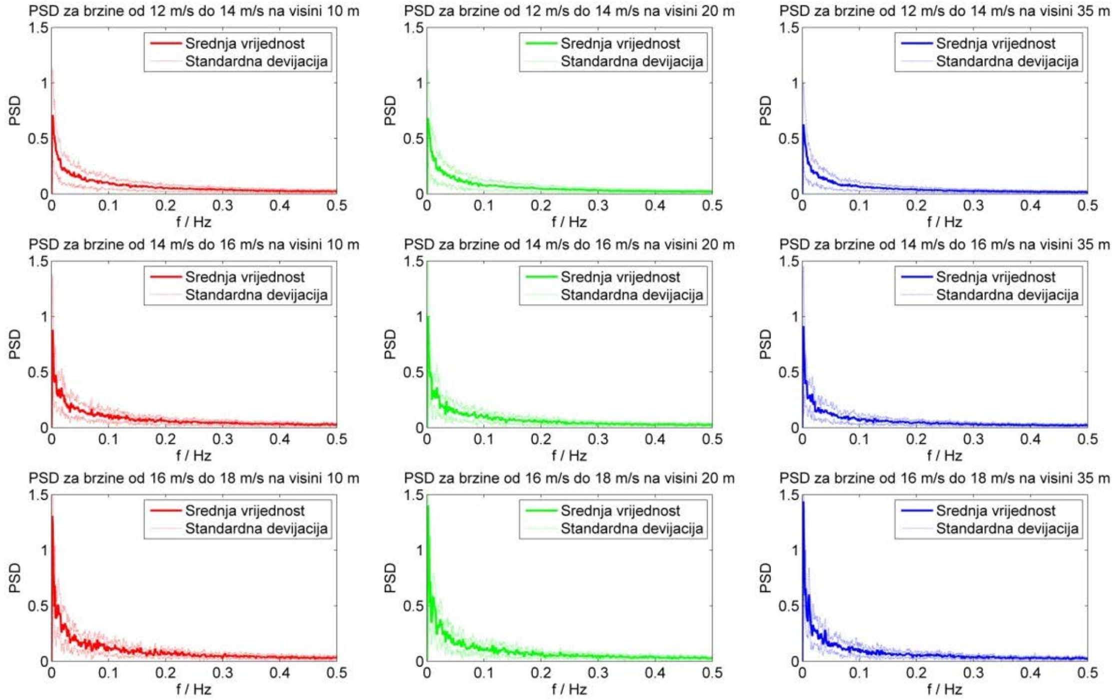
Source: V. Divić "Simulacije krajnjih graničnih stanja pod djelovanjem vjetra metodom konačno-diskretnih elemenata – Doctoral thesis 2014.

Figure 19b: PSD for sirocco wind for different speeds and heights



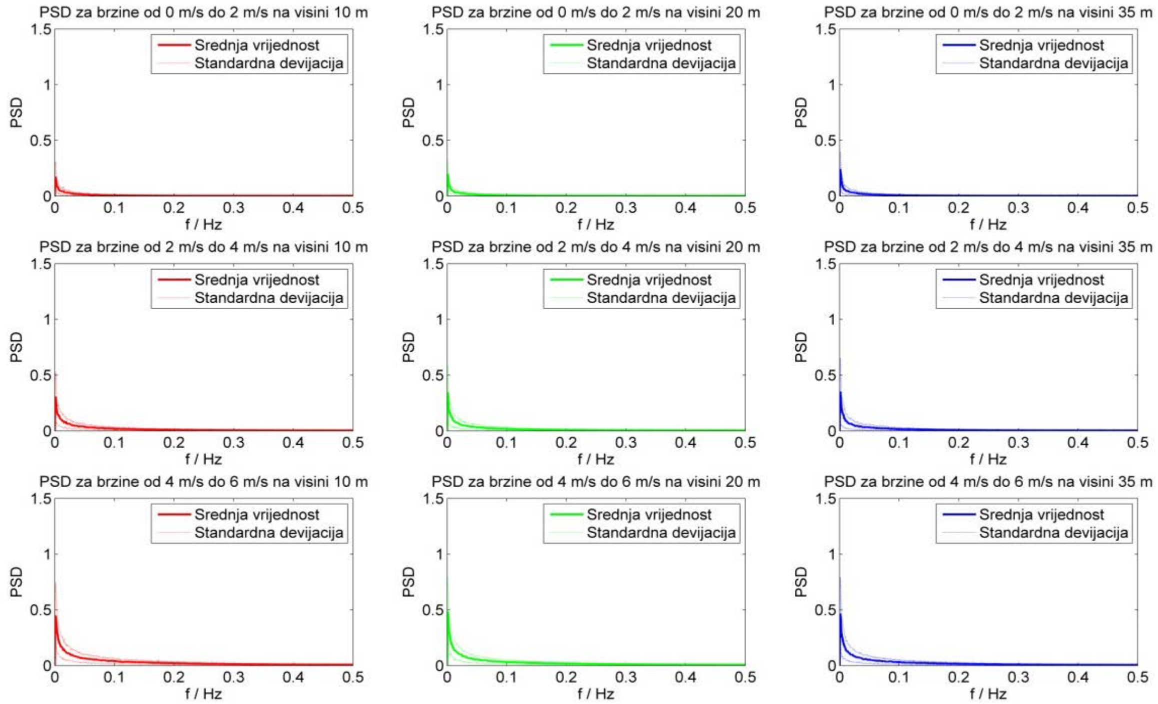
Source: V. Divić "Simulacije krajnjih graničnih stanja pod djelovanjem vjetra metodom konačno-diskretnih elemenata – Doctoral thesis 2014.

Figure 19c: PSD for sirocco wind for different speeds and heights



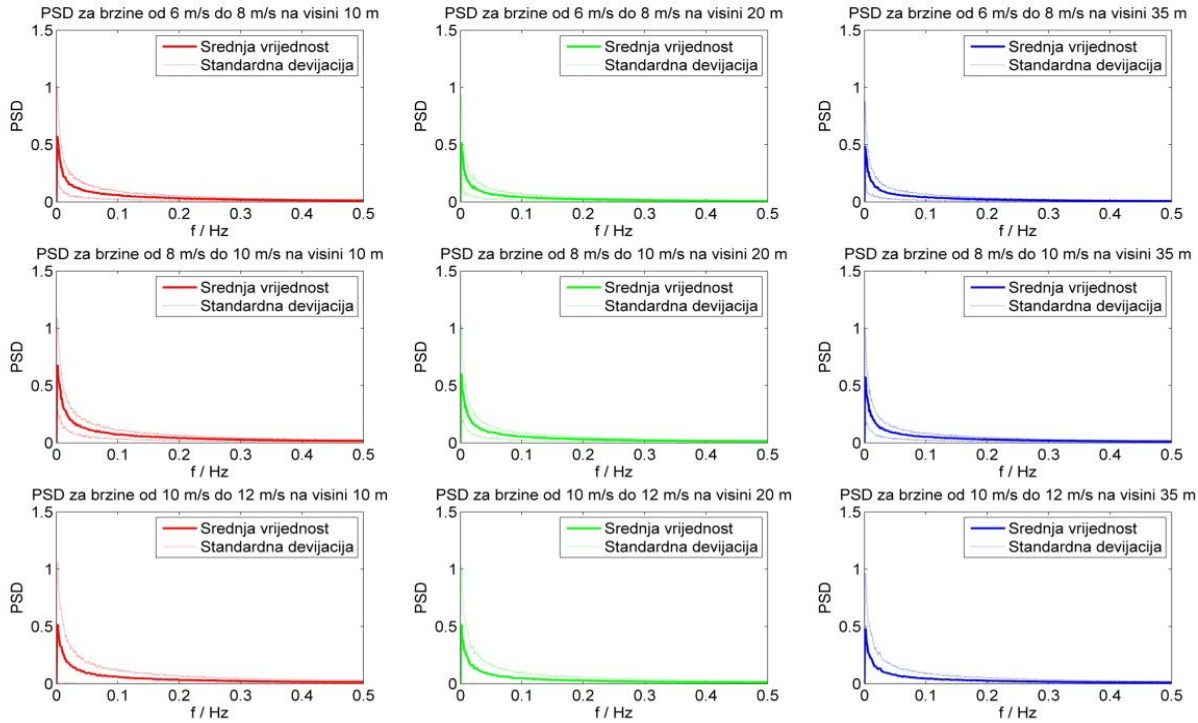
Source: V. Divić "Simulacije krajnjih graničnih stanja pod djelovanjem vjetra metodom konačno-diskretnih elemenata – Doctoral thesis 2014.

Figure 2018a: PSD for bora wind for different speeds and heights



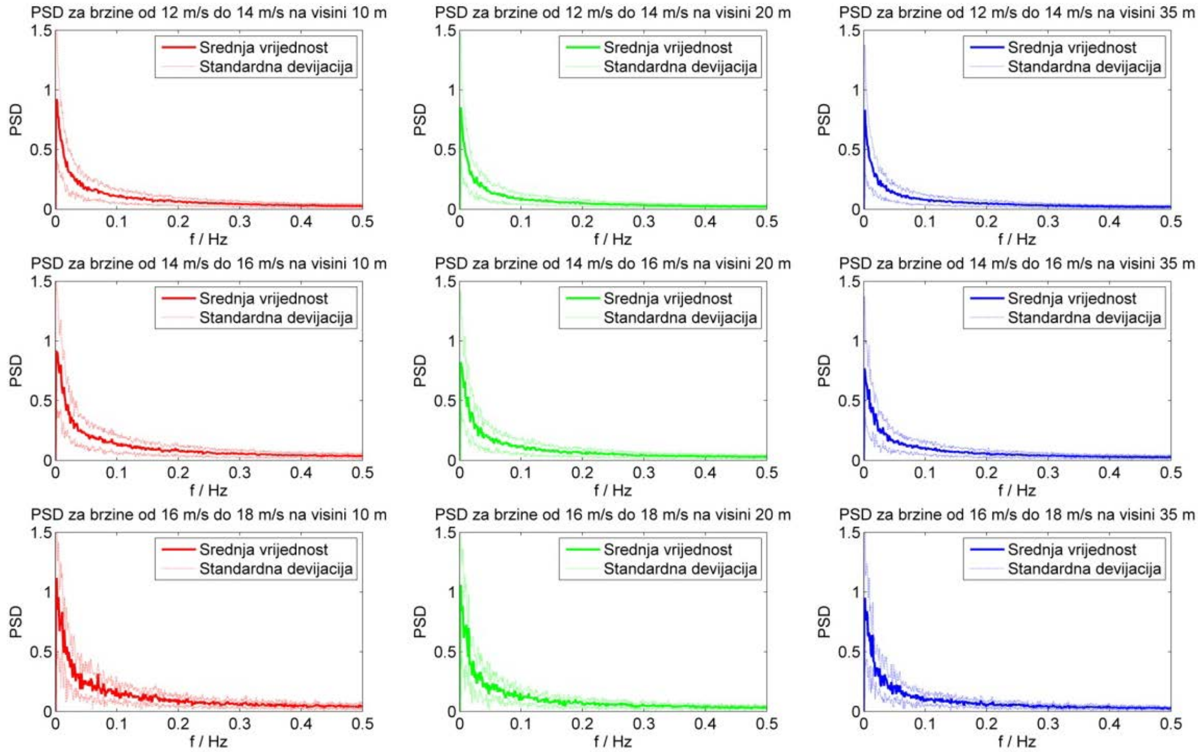
Source: V. Divić “Simulacije krajnjih graničnih stanja pod djelovanjem vjetra metodom konačno-diskretnih elemenata – Doctoral thesis 2014.

Figure 20b: PSD for bora wind for different speeds and heights



Source: V. Divić "Simulacije krajnjih graničnih stanja pod djelovanjem vjetra metodom konačno-diskretnih elemenata – Doctoral thesis 2014.

Figure 20c: PSD for bora wind for different speeds and heights



Source: V. Divić "Simulacije krajnjih graničnih stanja pod djelovanjem vjetra metodom konačno-diskretnih elemenata – Doctoral thesis 2014.

The spectra shown in Figures 19 and 20 provide insight into the **distribution of energy at frequencies of the fluctuating component for local winds *bura* and *jugo*, grouped by speed which completes the picture of the dynamic effects of wind on construction.**

The impact of atmospheric parameters

In addition to wind speed, which is the most influential factor for determining the impact on the construction, the second atmospheric parameter is the air density. Air density is a function of atmospheric pressure, temperature and air humidity. By using the equation for ideal gas, the density of dry air can be expressed as:

$$\rho_d = \frac{p}{R_d T}$$

where ρ_d is air denisty, p absolute pressure, R_d gas constant for dry air that equals 287.058 $Jkg^{-1}K^{-1}$. For humid air the density is calculated as the density of the mixture of two gases: dry air and water vapor. The density of moist air is then expressed as:

$$\rho_a = \frac{p_d}{R_d T} + \frac{p_v}{R_v T}$$

where p_d partial pressure of dry air, p_v partial pressure of water vapor, and R_v gas constant for water vapor 461.495 $Jkg^{-1}K^{-1}$. The partial pressure of water vapor is calculated from the saturation pressure of water vapor and relative humidity.

$$p_v = \phi p_{sat}$$

where ϕ is relative humidity, p_{sat} is the saturation pressure of water vapor given in relation to the temperature.

$$p_{sat} = 610.78 \cdot 10^{\frac{7.5T - 2048.625}{T - 35.85}}$$

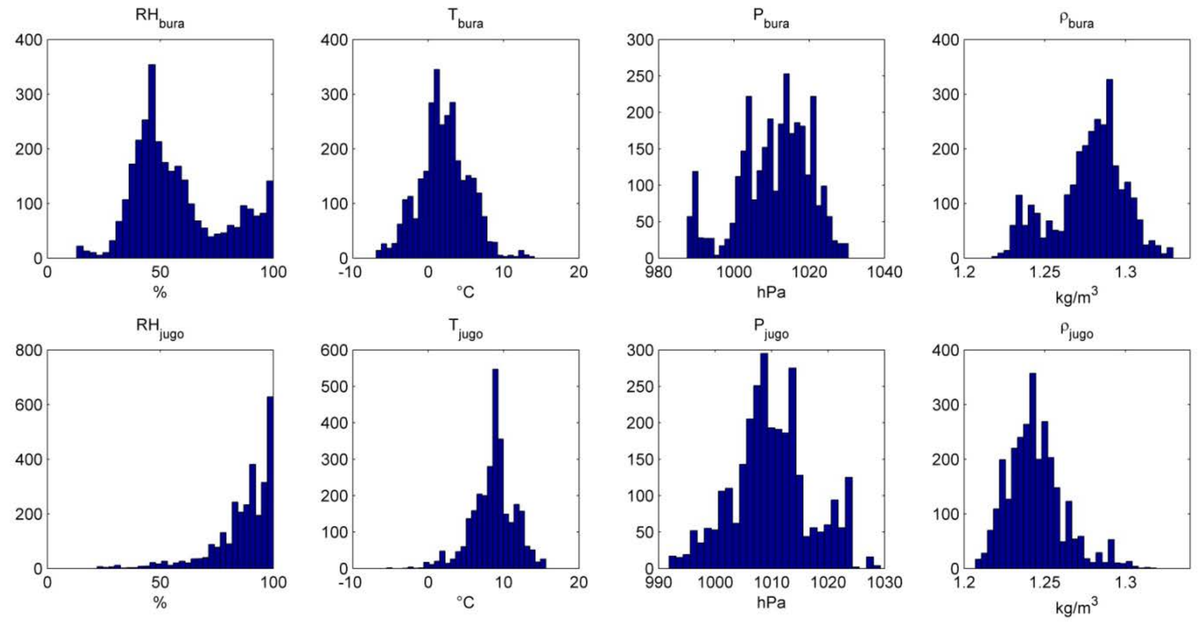
The partial pressure of the dry air is the difference in atmospheric pressure and partial pressure of water vapor.

$$p_d = p - p_v$$

In situations with no measurements of atmospheric parameters, the value of 1.25 kgm^{-3} is taken for air density.

Within a field experiment, continuous measurement of atmospheric pressure, humidity and relative humidity was conducted in order to compare the density of air in the *bura* and *jugo* regime. It was expected that during *jugo*, which is associated with low atmospheric pressure and increased air humidity, the air density would be lower. Figure 21. shows the histograms of atmospheric parameters for *bura* and *jugo*. The presented data is related to the winter period when the differences are the greatest.

Figure 21: The distribution of atmospheric parameters for *bura* and *jugo*



Source: V. Divić "Simulacije krajnjih graničnih stanja pod djelovanjem vjetra metodom konačno-diskretnih elemenata – Doctoral thesis 2014.

The average value of air density for *bura* equals 1.28 kg/m^3, while for *jugo* 1.24 kg/m^3. Although the difference between said values is only 3%, it is important to mention because its influence runs through the total budget burden on the construction of the wind. **Furthermore, the average value of the air density during the *bura* exceeds the average value of 1.25 kg/m^3 in 85% measured values, and *jugo* exceeds that value by 32%.**

Assessment of expected extreme wind speeds

According to the recommendations of the European normative documents, basic wind parameter that is used when calculating the effect of wind on constructions is the referent wind speed V_{ref}, defined as a maximum 10-minute average speed at a height of 10 m above flat ground, with roughness category II, that can be expected once in 50 years (design life of the construction). So, the more accurate and representative assessment V_{ref} is of an utmost importance for the assessment of wind loads, and thus for safety and durability of the built construction. For construction security brief gusts of wind (1-3 seconds) are significant.

Table 3: Maximum measured 10-minut (V10 in m/s) and second (Vx in m/s) wind speeds at the heights of 10 m, 20 m and 35 m above ground level, at the location MS Bobani in the year of 2008.

	10 m		20 m		35 m	
smjer	V10	Vx	V10	Vx	V10	Vx
N	16.4	28.0	18.6	29.1	19.0	28.5
NNE	20.7	29.2	22.8	30.9	23.3	31.0
NE	24.0	29.7	25.7	32.2	25.5	32.2
ENE	20.5	29.5	22.3	36.2	22.9	36.0
E	16.0	21.8	17.8	23.9	18.5	24.3
ESE	18.0	28.2	19.5	29.0	20.0	27.9
SE	19.3	30.5	21.7	32.1	21.1	30.1
SSE	18.5	29.4	20.8	32.3	20.4	28.5
S	13.7	30.4	16.5	27.4	15.5	28.0
SSW	11.3	22.1	15.3	23.7	11.3	21.6
SW	13.2	23.0	15.4	26.4	15.4	26.1
WSW	12.8	20.9	14.3	24.8	14.1	22.9
W	8.0	11.6	9.4	12.5	9.8	12.4
WNW	8.0	11.3	9.4	12.7	9.4	11.7
NW	7.9	10.2	8.7	11.6	8.7	11.0
NNW	17.0	27.6	19.4	30.0	19.4	29.0
SVI	24.0	30.5	25.7	36.2	25.5	36.0

Source: V. Divić "Simulacije krajnjih graničnih stanja pod djelovanjem vjetra metodom konačno-diskretnih elemenata – Doctoral thesis 2014.

In assessing the maximum speed the maximum 10-minute wind speed at 10 m above ground level is used, at the location of GMP Split Marjan, which can be expected not to be exceeded more than once in 50 years and is 34.9 m/s [11]. This value is obtained using the general distribution of extremes over many years of records. Using the equation of correlation of wind speed at 10 m above the ground, at locations MS Bobani and GMP Split Marjan (Table 3), the value of the **maximum expected 10-minute wind speed at 10 m above the ground is obtained for a return period of 50 years at the site of MS Bobani and it equals 35.2 m/s.** Maximum expected second value, relevant to wind load, equals 48.6 m/s.

6. Conclusions

This report focused on recommendations from a spatial planning perspective on how to reduce vulnerabilities. As stated in the introduction, the aims were to investigate on whether spatial planning is capable of systematically addressing vulnerabilities, although these are location-based and differ according to the location.
For comparison of the wind data measurements from different locations or with different instrumentations used, we must first consolidate data. We proposed format for wind data archive exchange, suitable for both cup anemometer and ultrasonic two or three dimensional anemometer. Proposed format is based on JSON syntax making it suitable for cross platform interoperation.

Since the wind effects are very local the measurements should be made on more locations to capture the whole phenomena and to get a good view of the critical areas. The weather agencies are yearly upgrading their monitoring systems with new weather stations and the grid is getting denser, but the cost is not cheap. It should be the focus of local authorities to help in this matter with their own measuring stations in critical points.

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WIND RISK

Task D – Action plan

Action D.7: Guidelines for local economical endorsements for construction of buildings

For the Wind Risk prevention project

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Chapter D.7 - Guidelines for local economical endorsements for construction of buildings

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1. Introduction

In Action D.7 the guidelines for local economical endorsements for adaptation of old and construction of new buildings is provided.

The focus of Action D.7 lies on the development of recommendations from an economical point of view, concentrating on endorsements for adaptations of old and construction of new buildings in the three partner countries Slovenia, Germany and Croatia. The basis for developing guidelines for local endorsements for construction of building is provided by the results of task C. The basic idea is for the local community to rather give an endorsement to the owner to design or redesign the building to withstand high wind, rather than to help financially in the aftermath as the costs are much higher.

At the initial stage of the project action D.7 report the different expenses caused by high wind are presented. They can be divided in expenses due to direct damage to buildings, expenses caused during interventions of firefighters and civil protection groups and, the last, expenses due to indirect damage of windstorms, which affects mostly local economy. The amount of indirect costs can be very difficult to evaluate, but nevertheless they are divided in three main costs which are presented in detail. For example, the first group of costs comes from temporally loss of working force, due to closed roads. The second group of costs comes from downtime of the firms due to electrical power failure and damages which reduce the production of company. The third group of costs comes from transport companies due to road closure and consequently the delays of deliverables. All available data that we obtain in this report presents the base for discussion and implementation of recommendations in practice.

The aim of this report is therefore developing efficient guidelines for financially supporting engineering projects in order to enhance the quality of roof constructions and therefore to avoid greater expenses due to wind damage in the three partner countries Slovenia, Germany and Croatia.

2. Expenses during windstorm

Expenses produced by the devastating effect of windstorms can be categorized into:

- expenses due to direct damage to buildings and other objects,
- expenses that occur during the interventions of firefighters (professionals and volunteers) and the Civil Protection group,
- expenses that occur as indirect damage of windstorms and affects mostly local economy.

2.1. Direct damage to buildings

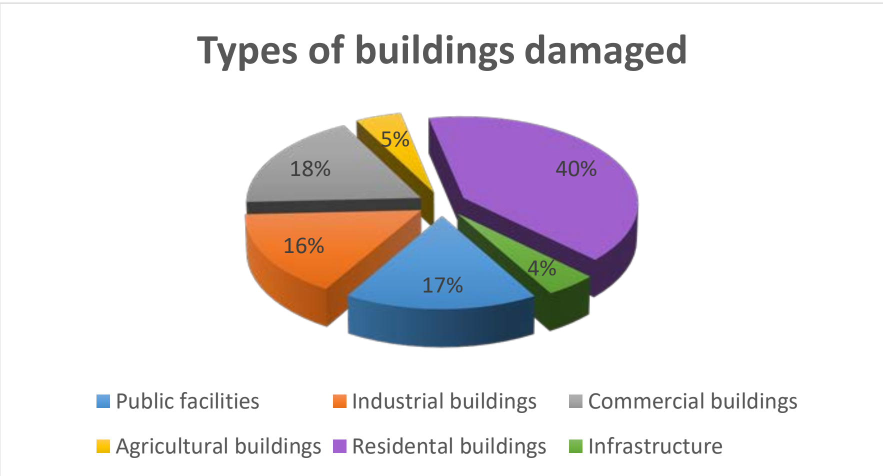
In this chapter the damage done to the buildings by strong winds and their effect will be presented.

2.1.1. Damage to buildings in Slovenia

With the data provided by the Municipality of Ajdovščina about the interventions in the time of wind storm in Ajdovščina, dated between the 31st of January 2012 and the 11th of February 2012, the analysis of type of buildings and part of buildings that were damaged during the storm, is presented.

The chart in Figure 1 shows the types of buildings that were damaged. In 21% those buildings (public and infrastructure) belong to the Municipality of Ajdovščina and the Slovenia Republic. Therefore, the damage of those buildings affect the local budget directly as the meanings for refurbishment of the buildings as well as indirectly as decreased functionality of those buildings.

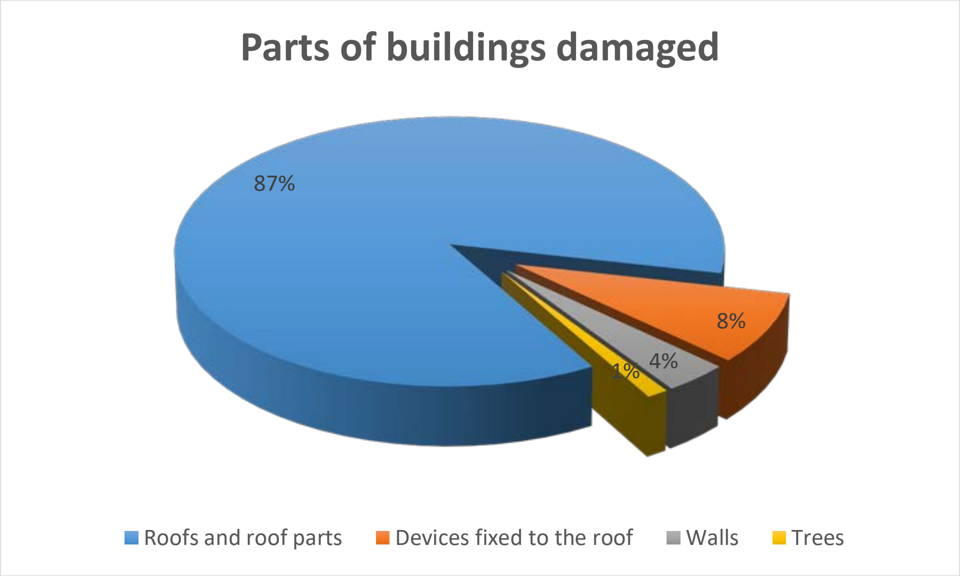
Figure 1: Damage to buildings



Source: Černigoj, 2012

Parts of buildings that were damage during the storm are represented in Figure 2. The majority is represented by the roof damage.

Figure 2: Internal and external pressure in buildings



Source: Černigoj, 2012

As already mentioned in task D.4, most of this damage could be avoided by correct dimensioning of all of the roof parts and also with changing the national building regulations. As work of construction engineer is believed only the calculation of main roof frame system which consists of dimensioning wooden columns, beams and rafters. There are no calculations of horizontal roofing battens or metal fasteners (such as screws, nails, etc.). As shown in Figure 3, especially in the case of metal roofing, the roofing gets torn off along with the wooden substructure. This could be avoided with carefully planning the wooden substructure and calculation of type and quantity of fasteners.

Figure 3: Torn off roof

Source: Photo archive GRC Ajdovščina, 2012

Also devices fixed to the roof (such as AC condenser units, solar panels, etc.) seem to be problematic since the bearing construction of such parts is not especially designed for areas with strong winds.

Though most of the property that suffered damage was insured and therefore does not present a direct cost to the municipality or the owner, some of the damage could still be avoided.

2.1.2. Damage to buildings in Croatia

Damages on buildings due to high winds happen often in Dalmatia. Both major wind directions can cause roofs or facade damage on old houses as well as on newly built houses if proper building measures were not applied.

It is not uncommon for local news to report warnings on locations where buildings are damaged because of the wind or are dangerous due to possibility of damage. One such warning on local web site can be seen on figure 4

Figure 4: News from local news web site

Foto: Zvonimir Barišin / CROPIX

Prijeti raspadanje pregradnih zidova zgrade: Zatvorena ulica u Splitu!

Zatvoren je sjeverni kolnički trak ulice Domovinskog rata, od Solinske do Dubrovačke

16.01.2016. u 19:50h
MARIO MATANA

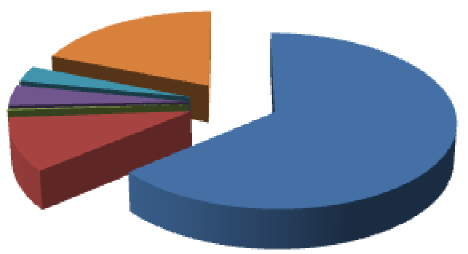
Source: Local News Mario Matana

Official number of total costs of damages on buildings due to the high wind for a period is not assessable, because damages are not always reported. There is no central repository of damages due to natural hazards so the exact amount of costs can only be speculated about. That is why we will focus only on costs of damages produced during one event for which we have official data.

In cases when natural disaster event is proclaimed there is opportunity of damage refund if damages are reported to local government bodies. In these cases official data can be assessed and can further be analyzed. Such event was already analyzed in C5 report of the wind risk project, when we analyzed social and economic impacts of wind risk related events. The event of natural disaster that we have data for was Bora in March 2015.

Based on reported damages for 3 municipalities (Split, Podstrana and Dugi Rat) that were majorly affected by the Bora wind we show the structure of reported damages in Figure 5. As can be seen from the chart, the majority of the damages were damages reported under category “damage on buildings”.

Figure 5: Structure of documented damages of Bora in March 2015



Source: Municipalities Split, Podstrana and Dugi Rat

Damages on buildings were reported both by natural persons and legal entities. Amount of reported damages of both natural and legal persons for these three municipalities are shown in table.

Table 1: Damage on buildings – Bora in March 2015

Damage on buildings for Bora in March 2015.	
	Amount of damage in HRK
Damage on buildings for natural person	1.214.178,50 HRK
Damage on buildings for legal entities	7.863.335,07 HRK

Source: Natural persons and legal entities

An event that was reported by all national media and was often discussed in social medias, was the damage of the facade of the building in Split in February 2015. This event happened prior to Bora in March. The damage happened when billboard attached to facade made of Styrofoam detached and took part of the façade with while falling.

Figure 6: Facade break during the Bora event in 2015

Source *http://www.slobodnadalmacija.hr/dalmacija/split/clanak/id/262921/pogledajte-kako-je-bura-odnijela-fasadu-u-splitu-zabiljezeni-udari-i-do-160-kilometara-na-sat*

2.1.3. Damage to buildings in Germany

When summer storm *Ela* occurred in June 2014 in North-Rhine Westphalia and especially the City of Essen, it was a so far unknown storm phenomenon for Germany. Insurance companies published that *Ela* was the second costliest storm event (both summer storms and winter storms) in Germany within the last 15 years (cf. Deutsche Rückversicherung 2015: 21).

In comparison to the Slovenian and Croatian example, damages to buildings that resulted from summer storm *Ela* were rather indirect because city trees fell into the roofs. Nonetheless, in order to provide for comparability between the three Wind Risk partner countries, damage costs to buildings from summer storm *Ela* are presented in the following. Beforehand it needs to be stated though, that the evaluation of socio-economic costs from *Ela* is still not completed and that all numbers presented might by adjusted by the insurance companies.

Summer storm *Ela* led to losses of € 400 million regarding private property in Germany. On top of that there were € 250 million to vehicle insurances, summing up to € 650 million recorded insured losses, according to the German Insurance Association (*Gesamtverband der Deutschen Versicherungswirtschaft e.V.; GDV).* The total damages in Middle Europe by *Ela* were estimated € 2.1 billion. (Cf. Deutsche Rückversicherung 2015: 23; GDV 2015: 3.)

The following table gives an overview of the estimated costs of damages to public buildings in the City of Essen. These damages arose due to uprooted trees and falling branches that damaged roofs, fences, windows etc.
The administration of the City of Essen estimated the total "amount of public damages" to more than € 61 million in July 2014. The "amount of damages" was generated by considering all expenses that would be necessary in order to restore the original state as before the storm event (so called restoration costs). (Cf. Stadt Essen 2014: 11f.)

Table 2: Estimated socio-economic costs of damages to public buildings

Damage inventory	Estimated amount of losses due to summer storm *Ela*	Loss is insured	Loss is public/private
Public buildings and outdoor facilities	€ 110,000.00	no	public
Total	**€ 110,000.00**	**no**	**public**

Source: Stadt Essen 2014: 14 and Annex.

Furthermore, there are preliminary estimated costs of damages related to educational and other public spaces like sorts grounds which can be seen in the following table.

Table 3: Other estimated socio-economic costs of damages related to public services

Damage inventory	Estimated amount of losses due to summer storm *Ela*	loss is insured	loss is public/private
Restoration of buildings, fences, sports grounds, etc.	€ 1,000,000.00	no	public
Expenses for pruning, felling and reports in areas for sports	€ 1,000,000.00	no	public
Educational buildings	€ 680,000.00	no	public
Total	**€ 2,680,000.00**	**no**	**public**

Source: Stadt Essen 2014: 14 and Annex

2.2. Costs of interventions

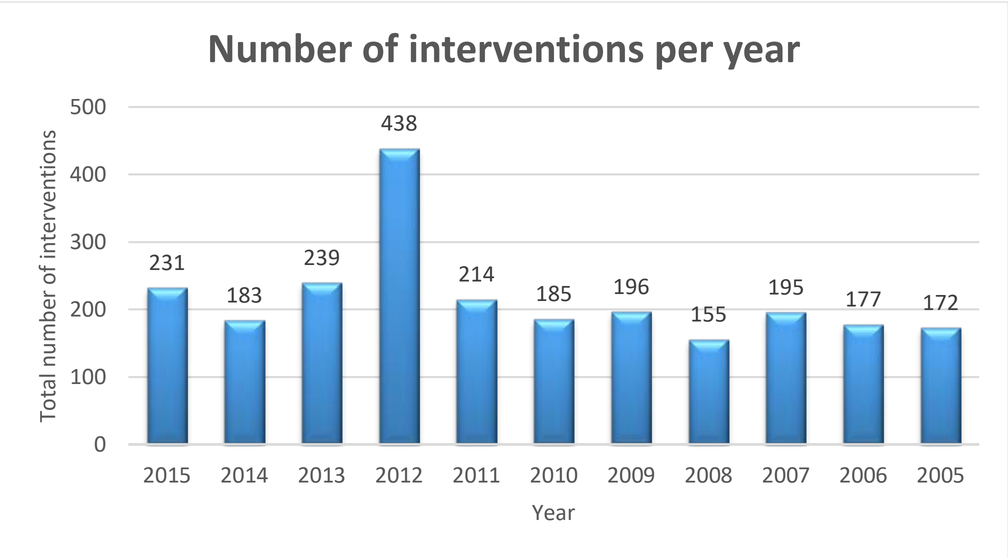
2.2.1. Intervention costs in Slovenia

During the intervention different costs occur. Some of (smaller) interventions are covered by the professional firefighters which are located in bigger cities. In that case the amount of costs can be neglected due to the fact that the firefighters concerned were already on duty when called. If there is no professional firefighters in the surrounding area, or if the extents of intervention are greater and therefore cannot be solved using only the firefighters on duty, additional professional firefighters and volunteer firefighters are called in to help in the intervention. In that case none of the additional costs are predicted in local budget and therefore should be taken into consideration while trying to find some guidelines that would decrease the amount of damage in natural disasters such as windstorms.

2.2.1.1. Costs of professional firefighting group during windstorms

The firefighting squads act on different types of interventions. Due to the data of the GRC Ajdovščina (Firefighting and Rescue Center of Ajdovščina) the percentage of interventions of which the cause is the Bora wind is to be between 10 % and 25 % of all the interventions that are carried out every year. The Figure 7 chart presents the total number of interventions that the Firefighting and Rescue Center of Ajdovščina carried out each year. The total number of windstorms can therefore be estimated to be between 20 and 50 each year, with exception of the year 2012 where there were 249 interventions in between the 31st of January and the 12th of February making that over 56 % of all interventions in the year.

Figure 7: Number of interventions per year



Source: GRC Ajdovščina, 2012

During the windstorm of 2012, there was over 10.000 € of non-predicted costs for the professional firefighting team, which consisted of additional fuel usage, water transport (in some parts of Ajdovščina, there was no drinking water due to electrical power failure) and over 430 additional working hours of the firefighters that were not supposed to be on duty in those days. In Firefighting and Rescue Center of Ajdovščina only two firefighters are on active duty at once but during windstorm event of 2012 there was 12 firefighters on active duty during all the time (except nighttime, when the bora wind calmed down).

2.2.1.2. Costs of volunteer firefighters during windstorms

Although the volunteer firefighters are supposed to be free, there can be great expenses connected to calling in volunteer firefighters. If the volunteer firefighter is or should be on his usual working place, the municipality should compensate the expenses of firefighter's salary to his employer. Therefore, expenses are made not only for municipality but also to the economy due to the fact that employees do not only make the profit in the amount of their salaries but they also make profit for the company they work in, providing chances for the development of the company.

2.2.1.3. Total cost of interventions during 2012 windstorm in Ajdovščina

Because of the difference of Bora windstorms in their duration and strength, as well as for the fact that there is no official data for smaller windstorm events, the average annual costs can hardly be estimated. The estimation of resources used only for interventions of 2012 Bora windstorm event that dates between January 30th and February 11th sum up to about 40.000 €. This amount though, does not cover the expenses that were issued by the volunteers' firefighter's employees for the reduced progress of their companies. The amount of those kind of costs are not possible to estimate due to the lack of data.

2.2.2. Intervention costs in Croatia

Organization of intervention forces is not uniform among counties in Croatia. According to document: “Report on status of protection and rescue in Split and Dalmatia County” published in 2007, civil protection is in transition from time when it was under jurisdiction of Ministry of interior affairs to new organization. That is the reason why interventions during events of natural hazards are not centrally coordinated and records on number of interventions by cause is hard to speculate about.

Forces of Civil protection and Firefighting forces are both responsible for protection and rescue operations during severe weather conditions in Croatia. In case of injuries first aid teams from clinical hospital and health centers intervene, besides them, public companies are responsible for their managing domain:

- Croatian forests for interventions in forests
- Transport: Road managing companies, Croatian highways, Airports, Harbors
- Medias: TV, Radio, Press report about severe weather

Number of civil protection headquarters active in Split and Dalmatia County is given in table 3.

Table 4. Number of civil protection forces in Split and Dalmatia County

	Civil Protection Headquarters	Delegates	Shelter leaders	General purpose troops	Civil protection special troops
Cities	150	979	124	1.018	315
Municipalities	167	428	2	784	-
TOTAL:	317	1.461	126	1.802	315

Source: Report on status of protection and rescue in Split and Dalmatia County”)

Firefighting forces that can carry out intervention in case of severe weather conditions are organized either as city/municipality firefighting department or volunteer fire department. In the area of Split and Dalmatia County we have registered:

- 5 fire associations of cities or regions (Firefighting association of Split-Dalmatia County and the cities of Split, Solin, Kaštela and Omiš) and therein no one behaves as a professional commander,

- 49 Volunteer Fire Departments

- 2 Fire Department.

There are 13 fire operational areas, namely: Trogir, Kaštela, Solin, Split, Omiš, Makarska, Sinj, Imotski, Vrgorac, Šolta, Brač, Hvar and Vis.

During severe weather conditions majority of interventions are removal of fallen tree, broken roofs or thins. It is not uncommon to have fire during strong bora wind, since this kind of wind is associated with dry weather conditions. Fire during bora wind are especially dangerous since dry weather and strong wind enables fire to spread fast.

Costs of interventions during the Bora in March 2015 can be estimated from number of interventions. Number of interventions is assessed from media reports and interviews with commanding officers. It is said that over 1500 interventions were performed during the 3-day period. The number and major cause of interventions by County is given in table 4.

Table 5. Number of interventions during Bora in March 2015

County	Interventions
Primorje-Gorski Kotar County	120 interventions during first day. Mostly removal of trees from roads, billboards and thins
Zadar County	180 interventions, 80 during the first day. 10 fires of chimneys
Split and Dalmatia County	Over 700 interventions of firefighting and civil protection forces. One truck, one evacuation from shopping mall because of facade damage, several small fires
Dubrovnik-Neretva County	Over 100 interventions, mostly trees, thins and chimneys removal. After the strong rain 27 deflatation intervention
Šibenik-Knin county	Besides intervention because of strong Bora, 5 wildfires interventions 70 Ha of underbush burned

Source: http://www.24sata.hr/news/pune-ruke-posla-vatrogasci-imali-cak-1500-intervencija-409456

It can be observed that weather conditions were not uniform in all areas affected with severe weather of Croatia. Dubrovnik–Neretva County had problem because of rain, while Šibenik-Knin County was affected with forest fires besides strong wind.

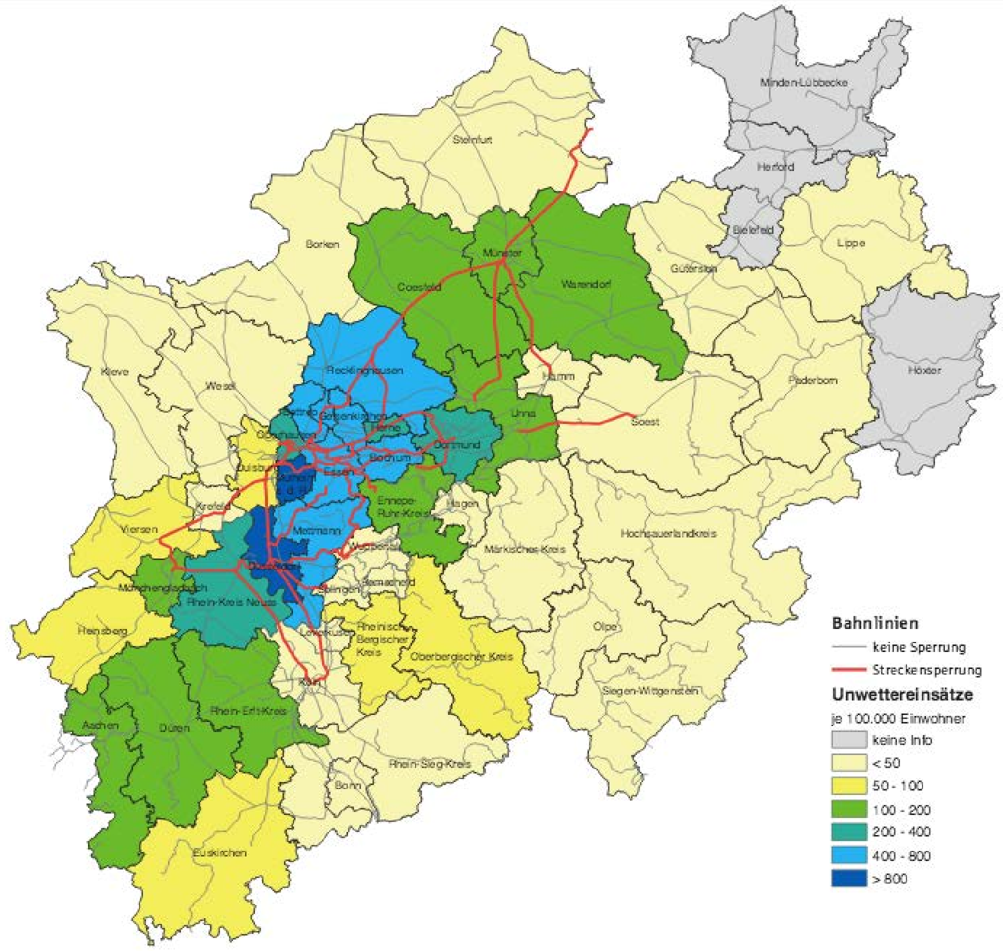
2.2.3. Intervention costs in Germany

During summer storm *Ela* the emergency call numbers of the fire brigade and the police Essen were overloaded during the night of the event because so many people called to record damages. Already until midnight the fire brigade hat 850 emergency operations to process, throughout the whole night they added up to 5,000. Problematic was, that especially during the first hours, emergency units were not able to reach their operating place due to fallen trees and branches blocking the roads. (Cf. Stadt Essen 2014: 1)

Overall the costs for interventions by the fire fighters amounted € 1,927,835.00 of which € 1,408,673.00 arose solely for personnel. These damage costs include actions for prevention of acute hazards like loose roof tiles, hazardous trees, local floods and securing of building facades. (Cf. Stadt Essen 2014: 2)

The following figure shows that in the central Ruhr Area and the City of Essen more than 400 and up to 800 emergency operations were conducted per 100,000 inhabitants (cf. Deutsche Rückversicherung 2015: 23).

Figure 8: Closure of rail tracks and operations of emergency units in North-Rhine Westphalia



Source: Deutsche Rückversicherung 2015: 23

Furthermore, the City of Essen estimated the socio-economic costs for purging activities and other hazard prevention measures, which can be taken from the following table.

It is relevant to note that the listed costs are mainly associated with public money and that all of the listed costs have not been insured, meaning the costs came on top of the City's budget.

Table 6: Estimated socio-economic costs for purging and hazard prevention

Inventory	**Estimated losses due to summer storm *Ela***	**Loss is insured**	**Loss is public/private**
Securing, felling, clearance, disposal of damaged trees on public green spaces, roads, educational establishments, cemeteries, playgrounds as measures of acute hazard prevention	€ 23,166,060.00	no	public
Securing, felling, clearance, disposal of damaged trees in forests as measures of acute hazard prevention	€ 3,285,000.00	no	public
Gathering, storing and removal of damaged trees and windthrow	€ 1,036,800.00	no	n/a
Acute hazard prevention measures of the fire brigade Essen	€ 1,927,835.00	no	public
Purging of water bodies and riversides (incl. restoration of fences etc.)	€ 350,000.00	no	public
Traffic control measures	€ 30,700.00	n/a	n/a
Total	**€ 29,796,395.00**	**no**	**public**

Source: Stadt Essen 2014: Annex.

2.3. Indirect costs

Indirect costs produced by natural disasters can difficult to evaluate, but the extents of indirect costs can be even greater than of the direct costs. Indirect costs can be divided into:

- costs concerning local economy regarding the temporally loss of working force, due to closed roads preventing people to come to work or due to closed schools, kindergartens, etc. forcing the parents of children to take days off to take care of their children who cannot stay at home alone,
- costs concerning local economy regarding downtime of the firms due to electrical power failure and due to the damage on parts of buildings which can reduce the production of the company,
- costs concerning transport companies due to road closure that results in expired fresh goods because delayed deliveries and costs for extending deadlines for other deliveries.

2.3.1. Indirect costs in Slovenia

Indirect costs in Vipava valley are especially hard on smaller businesses as for larger companies were forced to adapt to harsh weather conditions to minimize the downtime of company due to the damage from the high winds.

By the data provided by the director of the smaller firm that provides customers (stores) with supplies. While the H4 highway is closed, the transportation of the goods from the company warehouse, that is located near to Ajdovščina, to the customers, that are located all over Primorska region, is mostly completely disabled. Taking into account that the customers should be provided with fresh goods every day which are then offered to the final customer, the importance of unblocked transport is crucial for the company and the stores, the company is providing the goods to. In this kind of business, there are two types of economic damage that can be caused with the stopping of the transport. The first type of damage occurs during the time of the event of Bora, providing obstacles for the transport in and out of the storage units, which results in the financial loss due to the unfinished busyness connected with the transport. The data provided by a smaller local company, the expenses during the 2012 windstorm event were calculated to over 50.000€, which was almost fatal for the existence of the company. The other type of damage is much more devastating and it is not revealed straight away. While the transport is disabled, the customers depending on free goods are forced to look for supplies elsewhere and therefore may change the permanent supplier resulting in loss of busyness for suppliers that are forced to use the Vipava valley roads, which can be also fatal for small businesses in Vipava valley.

Also the municipality of Ajdovščina has to deal with some indirect costs. One of those costs is related with school and kindergarten closure during the Bora windstorms. The municipality has a contract with a local bus company that is worth about 500€ per day (for the transport to one school) which is lost due to closure of that particular school as for the children staying at home.

2.3.2. Indirect costs in Croatia

Total number of indirect costs of wind damages in Croatia is not easy to speculate. The official data of damage reports for Bora in March 2015 collects over 14 000 000,00 HRK of damage costs, while total number is estimated by media to be 30 million of HRK.

Total amount of collected costs reported for refunding in three majorly affected municipalities in Dalmatia (Municipalities Split, Podstrana and Dugi Rat) after the event of natural disaster in March 2015 is shown in Table 7.

Table 7: Damages for Bora in March 2015

Damages for Bora in March 2015.	
Type of damage	**Amount of damage in HRK**
Damage on buildings	9.170.541,17 HRK
Damage on equipment	1.436.910,00 HRK
Damage on perennial crops	47.924,46 HRK
Damage on agriculture	556.524,94 HRK
Damage on other goods	427.400,97 HRK

Source: Municipalities Split, Podstrana and Dugi Rat

Among indirect costs, in Croatia most obvious costs are costs regarding closure of highway.

Figure 9: Closing the part of the road due to the high wind conditions

Source: *http://www.novilist.hr/Info-fun/HAK/Stiglo-nevrijeme-Olujna-bura-otezava-promet-u-prekidu-trajektne-linije*

The most critical part of the highway is a part from Sveti rok to Maslenica where Bridge Maslenica is located. The location of the bridge was selected from political reasons, not taking into account wind load. Acording to data provided by Croatian Highways (Hrvatske autoceste – HAC) between 2008 and 2013 this part of the road was closed 862 hours. During 2012 the road was closed for 260 hours (source: http://www.jutarnji.hr/vijesti/hrvatska/zasto-je-tako-cesto-zatvoren-maslenicki-most/919295). This causes many losses to road managing companies but indirectly causes losses to all companies depending on transport since journey by alternative route lasts 1 hour longer.

2.3.3. Indirect costs in Germany

Regarding indirect costs resulting from summer storm *Ela*, the breakdowns of local transport networks due to blockages of road and rail network were of special importance.

All federal roads (*Bundesstraßen*) and an unknown number of municipal roads were blocked by trees due to storm *Ela*, as the following pictures depict.

Figure 10: Damages to roads, rail network and train stations

Source: Website Stadt Essen 2016; Photographs by Peter Prengel ©

Furthermore all of the rail network of the *Deutsche Bahn* and the above-ground tram network of the local transport company EVAG (*Essener Verkehrs-AG*) were not passable due to trees damaging the overhead lines. The losses due to damages to the rail network of the *Deutsche Bahn* are estimated € 20 million direct costs due to trees damaging the overhead lines and € 36 million indirect costs due to shortfall in receipts. (Cf. Bundestag 2014 ;Stadt Essen 2014: 1)

In the damage inventory the City of Essen set up, there is a positions relating to indirect costs that arose due to shortfall in receipts of the local transport company EVAG. These losses are reported to be private losses but as the EVAG is a subsidiary company of the City of Essen, the costs of € 65,000.00 needed to be covered by the city.

Table 8: Estimated socio-economic costs of damages to infrastructure facilities and transport

Damage inventory	Estimated amount of losses due to summer storm *Ela*	Loss is insured	Loss is public/private
Shortfall in receipts	€ 65,000.00	no	private*

Source: Stadt Essen 2014: 12f. and Annex

Further indirect damages resulted from the fact that thousands of inhabitants were not able to reach their work places due to the blockage of roads and rail. Also, due to safety regulations, all 250 schools and kindergartens in Essen remained closed for three days after the event. This circumstance led to additional indirect costs as kids and teenagers could not be educated during this time and parents needed to stay at home to take care of them. Unfortunately, these indirect costs cannot be underlined by monetary numbers.

Regarding other infrastructures there were no reported losses, i.e. infrastructure facilities of energy supply, water supply, wastewater treatment and telecommunication remained undamaged (cf. Stadt Essen 2014: Annex).

3. Guidelines for local endorsements

3.1. Co-financing the design phase of buildings

In this final chapter, the guidelines for the local endorsements are given to the local authorities of municipalities or other administrative divisions that are in areas exposed to high wind storms. Assuming the costs of windstorm damages as well as the number of building permits issues increases proportionally with the size of populated areas, some guidelines proposing the co-financing of construction of the newly built buildings and the reconstruction of old ones.

As mentioned in the D.4 task, the safety of the structure should be greatly increased by making the wind calculation (that includes the design of building parts that are the most exposed to the wind) mandatory as a part of the building permit issue. Due to the fact that all the wind storm events present possible expenses for the municipalities, some of the resources should be invested in the designing phase of the building and therefore provide wind resistant construction with greater chance of surviving the wind storm events with little or no damage.

The propositions will be given by the example of Municipality of Ajdovščina in Slovenia. Municipality of Ajdovščina has about 19.000 inhabitants. According to the data given by the authorities and the Rescue and Fire department of Ajdovščina, the average amount of only intervention costs sum up to about 5.000 € per year concerning only the Bora wind events. Taking into account the data obtained by the Statistical office of Slovenia shown in Table 9 the average number of building permits issued is about 62 per year (for the last 8 years).

Table 9: Issued building permits in municipality of Ajdovščina

Year	Issued building permits
2008	65
2009	69
2010	48
2011	80
2012	52
2013	52
2014	42
2015	88

Source: Statistical office of Slovenia

Due to the fact that only 80 % of the permits are issued for buildings new buildings, the average can be calculated as about 50 permits per year. Taking those numbers into consideration, the municipality could co-finance the designing phase of the construction in the average amount of 100 € which would partly cover the expenses of wind calculation report and therefore greatly increase the safety of buildings in areas exposed to wind. Later on a study should be made to calculate the highest percentage of co-financing the design plans that would not yet exceed the municipality budget.

Although the data is concerning only municipality of Ajdovščina, all other municipalities that are exposed to high winds or other weather phenomena should also consider same steps in providing safety for inhabitants.

3.2. Supervision

As bora is repetitive phenomena, parts of roofs should be regularly examined. As shown in Figure 11, due to the forces that occur during windstorm events, the fasteners can be partly or fully pulled out of the wooden substructure of the roof. Providing space between roofing and fastener leads to water leakage which ensures reduction of wooden substructure durability and bearing capacity. It also results in greater forces applied to the fastener during the next windstorm event, which ensures further displacement of the fastener.

Figure 11: Fastener pulled partly out as a result of Bora windstorm

Source: ZAG

It is known that the durability of metal roofing is halved in the area of high winds due to described fact. The lifespan of metal roofing should be around 30 years but (due to the data of local roofers) most of this kind of roofing is replaced with a new one in about 15 years of installing the roof. Also the wooden substructure of the roof should be replaced partially.

Providing supervision after the windstorm events (as an endorsement of the municipality) would help preventing the unnecessary damage and risk for the need of interventions. The supervisor should prescribe fixing or changing the fasteners and/or the roof tiles.

Also the supervisions' task should be to make sure, that the roof is getting built properly and accordingly to wind calculation elaborate the building phase of the structure. Unfortunately the common practice is that the construction companies try to cut down time and money for the construction of a building. For that purpose the number of fasteners may be reduced or the prescribed type of fasteners may be changed. Such mistakes are usually overseen by supervision, since that kind of a detail is regarded as not relevant for everyday construction stability. Supervisions' attention on areas with high wind speeds should be concentrated to the overall construction of exposed structural elements.

4. References

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