CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

FACULTY OF ENVIRONMENTAL SCIENCES

DEPARTMENT OF LAND USE AND IMPROVEMENT

POTENTIAL DEVELOPMENT OF WIND POWER IN LOCAL ACTION GROUP MORAVIAN KARST

Diploma Thesis

DIPLOMA THESIS SUPERVISOR: Ing. Kateřina Černý Pixová, Ph. D.

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DIPLOMA THESIS ASSIGNMENT

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Thesis title

Potential development of wind power in Local Action Group Moravian Karst

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Objectives of thesis

The aim of thesis is to analyse factors which affect the building process of wind power station. The thesis should focused the reasons for increasing of using wind power in the industry fo energy and together concentrate on evaluation of all factors which can influenced the possibilities of the constructions. Mainly the suitable placement of the wind power station will be tested in view of higher acceptability from local inhabitants. Also all steps in planning and building process will be mapped in order to optimize placement selection and further possibilities of using this kind of buildings e.g for next area protection.

Methodology

Bibliographic search is focused on present state of knowledge in wind power. Main part should compare the situation and practical impacts of wind power buildings in the Czech republic and abroad. The model area will be evaluated from maps and other results based on outputs from specialized software (e.g. WindPro). The suitable placement for building the wind power station will be set. All analyses and presentation will be made in GIS environment. Subsequently all the decision making process about building placement in context of landscape protection will be commented.

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40-60 pgs

Keywords

renewable resorces, energy, wind power, wind power station, Kladno, Prague west

Recommended information sources

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Prague February 21. 2013

Hereby I declare that I wrote and developed this thesis by myself and independently, with the help of my supervisor Ing. Kateřina Černý Pixová, Ph.D. The references of this thesis are published in separate chapter as well as all cited authors.

In Prague, 2013/04/22

Bc. Michaela Dudáčková

Abstrakt

Obsahem diplomové práce je stanovení větrného potenciálu na vymezeném území Místní akční skupiny Moravský Kras. Toto vyhodnocení bude dále použito jako dílčí výstup části projektu EnergyRegion, jehož je tato skupina partnerem.

Zjišťování větrného potenciálu předchází teoretická část, která rozebírá jednotlivé aspekty větrné energetiky v České Republice, částečně i v zahraničí. Tyto kapitoly slouží čtenáři pro zorientování se v oboru obnovitelných zdrojů, zaměřené vždy na odvětví větrné energetiky. K bližšímu seznámení s větrnými turbínami dojde později při popisu jednotlivých problematik vlivu těchto energetických staveb na jednotlivé složky svého okolí, krajinu, zastavěné území a tamní obyvatelstvo, flóru a faunu. Pro ucelený pohled na celou problematiku je však nutné uvést i kontroverzní otázky, které čím dál tím častěji vyvstávají, pokud se téma výstavby větrných elektráren otevře.

Dle stanovené metodiky bude v analytické části stanoven klimatický, technický a reálný potenciál dané oblasti vyjádřený v procentech, na bázi poměru celkové plochy území MAS Moravského Krasu a příslušného potenciálu, a metrech čtverečních. V závěrečné diskusi je naznačena možná budoucí debata o výstavbě větrných turbín v oblasti na základě zjištěných výsledků.

Klíčová slova: obnovitelné zdroje, energie, větrná energie, potenciál, větrná turbína, Místní akční skupina Moravský Kras.

Abstract

This master thesis contains analysis of wind power potential in within a territory of Local action group Moravian Karst. The analysis will be further used as a partial output of EnergyRegion project which the LAG Moravian Karst has a partnership with.

Theoretical part preceding the analysis describes various aspects of wind power industry in the Czech Republic**,** partly abroad as well. These chapters should bring understandable facts to readers which help to understand the field of wind power energy. Wind turbines are further introduced later while describing all issues of their influence towards close surroundings, landscape, urban areas and their citizens, flora and fauna. However, also controversial issues have to be debated in order to get the comprehensive view concerning topics of the wind power development.

Climatic, technical and realizable potentials are in the next part analysed according to established methodology and expressed as a percentage of the total area of the LAG Moravian Karst and the set potential, or as a value in square meters. Possible future debate that can , based on observed results, arise about building wind turbines in the surroundings is indicated at the final discussion.

Key words: renewable sources, energy, wind power, potential, wind turbine, Local Action Group Moravian Karst.

Obsah

Introduction

This thesis is based on the international project called EnergyRegion observing possible ways of independent energy production from renewable sources and options for energy savings. The project is situated in two territories of Local Action Groups (LAG): Moravian Karst and Opavsko, from which the territory of LAG Moravian Karst was chosen for deeper observation. Reason why this master thesis is focused on wind power development arises from fact that the topic is very controversial and we shall investigate to understand both opinions; opinion supporting the development and, vice versa, opinion that fights against the development.

The EnergyRegion has got observing of renewable energy sources as one of the main aim. The purpose of the thesis corresponds to aim already set up and determines general questions of how big is the wind power potential within the territory of LAG Moravian Karst and which obstacles could threaten the future wind power project? And also, can wind power be a way of energy independency for local municipalities?

Answer to the first question comes out from analyses of climatological, technical and realizable potential within the territory of LAG Moravian Karst. Assessment of technical potential is based on gap analysis whereas the climatological potential rises mainly from wind conditions. Estimation of realizable potential is made according to predicting of Hanslian methods.

Before the elaboration of wind power topic begins, reasons leading to usage of renewable sources are described: climate change, peak oil, pollution and energy demand. These topics are also reason why the EnergyRegion project was run. Especially the issue of energy dependency and rising emissions of CO_2 are the engine of each project activity.

Further text introduces wind power in a way that determines and explains terms important for background analysis. The theoretical part has a goal to depict the positive as well as negative face of wind power industry. The issues debated are important for following evaluations of potentials because all restrictions and limitations used during the analysing process are based on them. The legislation, acts and decrees are also concisely described.

In the second half of the theoretical part a background for second answer can be found. Three main obstacles of wind power implementation are highlighted: legislation framework of landscape character protection, conditions for the protection of specially protected animals and wind power plant connection in to distribution network. These topics are also important background for third question about evaluation of realizable potential.

New technologies and materials used for constructions of turbines or new locations which overcome old taboo by forest development close the theoretical part of the thesis and move it into the analytics.

The processes and methods of all analyses are systematically described in chapter methodology. Used limits and restrictions are linked by reference and thus are possible to verify evaluated values. For all landscape analyses were used GIS software ArcGIS under student licence developed by Esri Company. The final evaluation of the wind power potentials show maps located in the results chapter. The climatological and technical potentials are depicted by maps whereas the realizable potential is estimated throughout series of individual sub-analyses and evaluation of limited factors.

Results of each potential conclude importance of environment protection and awareness against energy dependency. Especially the realizable potential, its complicated calculation and unstable meaningful value are discussed. Moreover, a possible way of future wind power development is presented even with alert to possible obstacles with project implementation.

Aims of the thesis

The reason of this thesis elaboration is cooperation with LAG Moravian Karst on analysing the wind potential as a part of work for EnergyRegion project. The results thus have a real utilization. Moreover, these results are going to be used as materials for future development of the territory in a field of energy independency. This effort of local municipalities is confirmed by the actual accession into EnergyRegion project.

Although already three wind turbines are erected in the territory, municipalities' knowledge about wind power potential into the future is very low as they are fully dependent on investors. It is happening despite the fact that examples from abroad show how convenient could be the participation with the investors on the wind power project. Therefore, the main aim of the thesis is to analyse the potentials of wind power.

Climatological potential is basic information about possibility of wind power development. The most important fact is the economy which is closely connected to wind speed. Second important factor for wind power development is knowledge of the territorial limits. Based on technical potential map master plan could be developed with defined area for wind energy.

The last aim of the thesis is to identify possible obstacles of future wind power projects. This task can be partly answered by analysing the realizable potential. This potential works with factors which cannot be predicted by any calculation so the value can be only estimated. Therefore, factors which are used in the process of estimation are actually the obstacles that can threaten the future wind turbine installation.

Theoretical background

Reasons of renewable sources

Czech citizens sometimes do not believe in global problem, even do not believe they are part of the problem or think the aftermath can not threat them. Unfortunately, the Czech citizens are part of the global problems as well and all issues happening out there will have influence on their daily life. The position of the Czech Republic towards global problems is a result government discussion nevertheless each citizen is responsible for own behaviour. The recapitulation of global problems with conventional sources of energy is described below. It is important to argue why the potential of renewable sources could be observed.

Climate Change

The biggest expert of climate change issue is the Intergovernmental Panel on Climate Change (IPCC) which has been established under the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) in 1988. Since that time IPPC have produced plenty of studies, reports and papers about causes and consequences of the climate change. The main documents are called Assessment Reports (AR) and next year, on October 2014, the Firth Assessment Report is supposed to be formed. (IPCC, 2013)

According to the last Assessment Report the global climate change has become a reality as well as the significant impact of human activities on them. The average global temperature of atmosphere has been increased about 0, 74°C in last century when the highest increase is reflected especially in higher latitude, the report claims. Furthermore, the crucial impact of CO_2 emissions is enhanced as the report presents a fact the concentration of CO_2 emissions in atmosphere is currently higher than has ever been over 650 000 years. The report continues with predictions of conditioned economy development and production of CO_2 emissions and consequences of the climate change. For basic information about the future forecasts and possible circumstances that will probably coming read report of Ministry of Environment (IPCC, 2013): *Climate change is evident and will continue. The question is how quickly and how to prepare them*.

Nevertheless there exists other site of coin - climate-sceptics. In general, sceptics claim there is no problem that would be so significant to reorganise human behaviour or economic system, however they do not contradict .the fact of global warming. The core of the dispute lies between politicization of the topic and notion about the degree change and following circumstances. The most famous Czech climate-sceptic is Czech ex-president Václav Klaus. Some of his claims were debated across the whole world among the political as well as scientific field. Another representative is Luboš Motl, scientist working as a theoretical physicist who gets Weblog Awards for his blog “The Reference Frame” in 2008. His work argues that prediction of temperature increase according to IPCC which is calculated on wrong models and thus the forecasts are not realistic and accurate. Furthermore, he speculates about the relationship of human production of CO_2 emissions and temperature increasing when he refers to the natural processes and temperature fluctuations. (Ekolist, 2011)

Global warming is therefore a disputable topic which nevertheless should not be underestimated. Political attitude against this issue is thus rather prudent, especially in the

Czech Republic. Although the Czech Republic is a signatory of Kyoto Protocol[1] and thus supposed to deal with reducing greenhouse-gas (GHG) emissions, the attitude of the Government and citizens is lukewarm. The issue of global warming, concretely a reduction of GHG emission, is discussed mainly in connection to mining limits or completion of nuclear power plant Temelín where the energy sources issue is argued. In legislation point of view the rules of Kyoto Protocol are established, unfortunately the reality needs more effort to get this issue into citizens' mind.

IPCC, besides its Assessment Reports, produced also publications offering adaptation and mitigation methods, named Special Reports. *Renewable Energy Sources and Climate Change Mitigation* (IPCC, 2013) report from 2011 describes relationships among climate change issue, GHG emissions production and sustainable development. The report contains facts about renewable sources of energy and recommends them as one of the mitigation measure.

Peak oil

This notion has been used by Shell geologist Dr. Hubbert for marking the peak of domestic (U.S.) production of oil in 1970. He also predicted global production peak that should have occurred between 1995 and 2000. According to Pahl (2007) the issue of peak oil is viewed by a growing number of observers as a greater threat than global warming. The danger he apprehends in the obtaining the oil from the second half of the world oil reserves, when highlighting the mining methods which should be constantly more effective presents the fact that globally oil industry invested $8 billion into exploration of oil but only found $4 billion of oil in 2003, and last but not least alerts to issue of new mining resorts such like the Arctic. Furthermore, he also points out we have lived in times of very cheap oil (and natural gas) which ensures food for 6.6 billion people. While the market collapsed after oil production problems, serious disruption in food production will be held. Similar opinion has Čermák; Czech stock analyst at brokerage company Colosseum. He also sees a very big problem in fact the resources of oil are getting shrink. He even provides estimate that resources extractable in a way of current technologies are sufficient for next 42-46 years. (Alena Adámková, 2011)

Oil dependence is thus a big global issue that will have incalculable aftermaths. The date of peak oil has been predicted by several observers; Campbell estimated the global extraction of oil to happen around 2010, Deffeyes estimated even year of 2005 and the most optimistic in estimation was the U.S. Department of Energy claiming the peak oil will occur by the year of 2037. Unfortunately, the date is not as important as a fact the oil dependence is increasing every year. Therefore, with increasing chance of peak oil the position of Oil Producers intensifies. More complicated technologies and a risk of extraordinary natural pollutions caused by extraction or transportation drive up the price of oil. Therefore all goods made from oil and related services have become extremely expensive. Based on these facts the human effort should be focused on changing the oil-based economy, Pahl (2007) recommends further in his book.

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[1] Kyoto Protocol is an international agreement on emission reduction target claiming developed countries are mainly responsible for current high level of greenhouse-gases in the atmosphere, adopted in Kyoto, Japan on December 1997. The signatories of the Protocol have obligated to reduce the greenhouse-gas emissions to an average of 5% against 1990 level s.

The situation of the Czech Republic would be very difficult during the peak oil times. In fact, domestic extraction of oil oscillates between 2-3% so the oil industry is thus dependent just on import from foreign countries; even thou the quality of the South Moravian oil is high and therefore used for pharmaceuticals purposes. (Ing. Jan Zaplatílek, 2007) For oil import are used two pipeline systems - Družba importing oil from Russian Federation and IKL importing oil mainly from area of Caspian Sea, North Africa of Arabian Peninsula. Even though the final price of oil is influenced not only by market factors but also by administrative effects such as retail trade (including distribution) and taxes. However, the most important role still has mining companies. At first, they have to include the extraction costs into the oil price which is in case of Canadian oil sands at least $100 per barrel. According to Čermák most likely the price will never come lower than $80 per barrel as in case of crisis 2008[2]. (Alena Adámková, 2011) Therefore price of secondary products should rise as well. Important role will thus have the Government attitude towards the promotion of these products such as gasoline or diesel. The only way how to keep the products accessible for citizen is implementing low taxes. Naturally, that will be a difficult undertaking.

Pollution

Despite the fact first two issues (climate change and peak oil) are not very discussed topics in the Czech Republic, pollution of the environment has been focused since the communist period ended. Traditional coal participates on gross electricity generation by 55, 7% (MPO, 2013) and thus the issue of air pollution and impact of the coal mining on environment is substantial which is moreover confirmed by European Environmental Agency (EEA) in report *Revealing the costs of removing the damage caused by air pollution from European industry* (2011). The report presents energy industry as a sector with the highest share on total costs used for damage removing according to the pollutant register. Total amount of costs is estimated between €66-112 millions, though the actual costs of disposing damages caused by CO_2 from energy industry are estimated between €26-71 millions.

Energy industry is according to facts the biggest pollutant of environment, however the problem is not only in coal burning but also in the mining process as well. This process has enormous impact on landscape character, local ecosystems and landscape processes, mainly in case of surface mines.

Debate about breaking the mining limits and its calculated costs is summarized in the document *Opinion of the Commission for the Environment of Sciences Academy on the issue "territorial-ecological mining limits" in North Bohemian brown coal field* (2010). At first, the undeniable impact of coal industry in North Bohemian brown coal field (NBbcf) is presented. It concretely publishes proven fact: pollution of air, water and soil, disruption of social structure, changed lifestyle and lack of opportunities for regeneration have caused distinctly higher morbidity, higher mortality, decrease of life expectancy, slowdown of children development and other negative consequences. Moreover, this impact has influenced genetics of local citizens and thus children of these citizens, so consequently next generations are negatively influenced as well. Therefore recommendation for keeping the territorial-ecological mining limits can be found in conclusion of this document.

[2] During the crisis 2008 the prices of oil were extremely low due to problems of all risky assets. It was time of economic downturn and global depression. The situation was stabilized by interventions of states and their central banks.

The issue has been calculated economically as well. The study calculates only with damage caused by emissions, precisely by impact of certain volume of burning brown coal at Mostecko district. Estimation of this volume corresponds to 873 million of tons of brown coal. Total amount of costs needed for elimination of the damage caused by 873 million tons brown coal is approximately 1,334 trillion CZK.[3] (Ekolist, 2012)

Energy demand

Welfare of current society is based on energy and the prosperity is derived by energy consumption. Social and economic well-being thus could be gauged by the Human Development Index (HDI) established under the United Nations Development Programme (UNDP). Basically, it has been founded that developed countries have HDI very high while their energy consumption per capita is fluctuated between 4000 to 9000 kilograms of oil equitant (kgoe) per year. Contrary on that, developing countries' HDI exceeds the boundary of 0, 5 rarely when they have low energy use. Most of the countries have energy use below 500 kgoe. For achieving the HDI 0, 8 their energy consumption should increase into a level of 1000 kgoe. (Mathew, 2006)

As a part of this issue the population growth is supposed to be implemented because global population is increasing day by day. In this case developing countries have more rapid trend than the developed countries. Still, with more people around the world the energy demand increase as well. Since historical data about energy demand are used, focusing on developed countries, its energy demand has increased 1, 5% per year during decade, and corresponding change in developing countries was around 3, 2% per year during decade. Based on these facts it is clear the world can expect very disturbing future. The Total Primary Energy Supply (TPES) should likely increase to 16, 300 Mtoe by 2030. (Mathew, 2006)

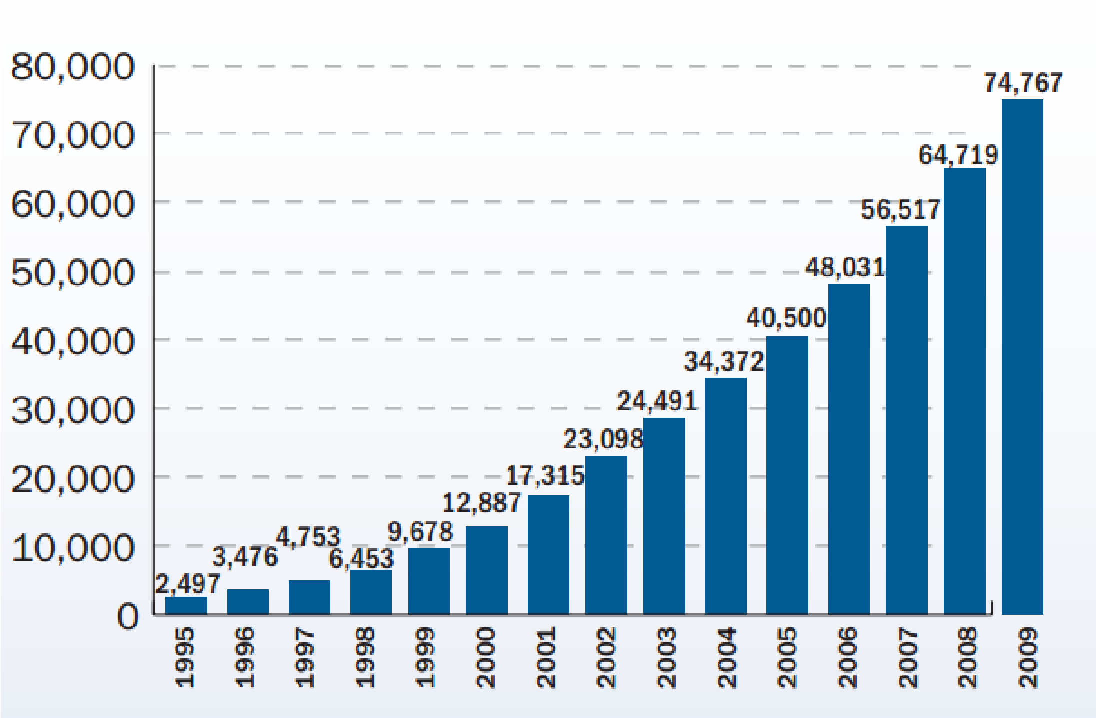
As an example of decreasing air pollution in the Czech Republic territory could be presented a potential development of wind turbines array in the North Bohemia. If this array about 300 MW is erected instead of brown coal-fired power plants; the air pollution could be reduced by 750 thousand tons of CO_2, 3600 tons NO_x, 420 thousand tons of dust and 420 thousand tons of ash and cinder annually. (Cetkovský, S., & Coll., 2010) On the other hand, this 300 MW wind turbine array represented by one hundred of wind turbines is supposed to be erected within the area of the North Bohemia.

Introduction of wind power

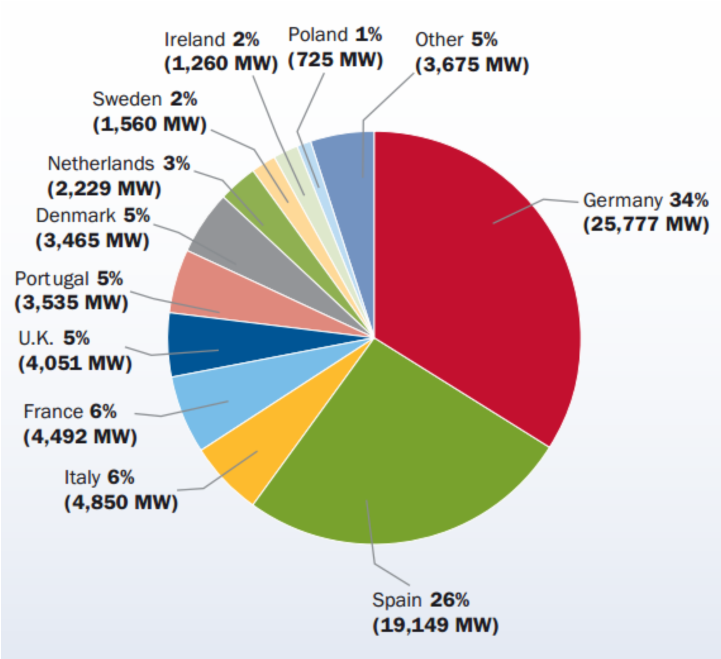
One possible way how to change fossil fuel dependency and other issues presented above is to change the mode of energy production. Trend of renewable energy sources comes from first energy crisis due to embargo of OPEC in 1973. Thus European developed countries started to search new ways of safe energy and therefore the renewable sources of energy have been developed. However, options of wind power described below, hiding indisputable competitive advantage and completely fulfil the meanings of renewability or inexhaustibility.

[3] The study also contains further examples of impacts caused by burning 873 million tons brown coal such as loss of 228 000 years of European citizens, formation of 8820 new cases of chronic bronchitis, the fact that the amount of hospitalization increases about 2 064 in case of heart disease and in case of respiratory disease even about 4 417 cases.

After that experience several states of Europe, mainly Denmark and Germany, started to develop their renewable energy programmes and thus observation of using wind power. For example, Germany uses wind power by 7, 2% for covering total electricity consumption. Moreover, federal state of Germany Schleswig-Holstein and Mecklenburg-Vorpommern cover from wind energy 36, respectively 35% of its consumption. (ČEZ, 2013) The picture n.1 and n.2 depict the situation of wind power in the European Union.



Picture No. 1: Cumulative wind power installation MW in the European Union (EWEA, 2010)



Picture No. 2: EU member state market share for total installed capacity (2009) (EWEA, 2010)

Same trend has occurred in the United States. Unfortunately, here the wind power industry collapsed after Reagan' administration by pulling the plug on the energy tax credits and incentives. (Greg Pahl, 2007) However, new renewable energy strategy published on July 2008 called Contribution to U.S. Electricity Supply confirms the usefulness but also the commercial maturity of wind energy. The main goal is achieving 20% of total electricity production by wind power by 2030. The first step, determined by year 2018, is to reach the capacity around 16 thousand MW. Expected costs are supposed to be higher only about 2% than costs of similar energy sources with the same amount of energy generation. Moreover, the impact of this act is supposed to have the same effect as removing 140 million cars from U.S. roads. (ČEZ, 2013)

In current world, indispensable role has China which Central Government want to significantly reduce greenhouse gas emissions polluting the air. According to International Energy Agency (IEA) China is currently one of the largest emitters. Therefore China has established a commitment of the reduction CO_2 emissions when the goal is to reach at 2020 between 40-45% compared to 2003. One of the measures is intensive development of wind turbines. (ČSVE, 2012c)

Wind power in the Czech Republic

Power of wind has been used by Czech citizens for different purposes more or less within whole country. This fact is confirmed by study of Pokorný and Vařeka (1975) mapping history of wind mills in Bohemia, Moravia and Silesia. The study confirms wind mill using, mainly situated in east of Moravia and Silesia with 681 wind mills.

As first period of wind power development is counted first half of the 90's when 24 wind turbines were erected (with nominal output 8, 22 MW). This period has been influenced mainly by the spirit of the initial inspiration from abroad, especially from Denmark or North Germany. Unfortunately, the development has not got very good direction. Czech made turbines showed very high failure; moreover the technical background was on the beginning level when plenty of installations were built at sites with an inappropriate wind condition. Furthermore, the economic advantage of this kind of renewable energy source was very unprofitable; the purchase price was between 0, 9 and 1, 13 CZK/kWh. (Cetkovský, S., & Coll., 2010)

The era of second period of wind power development has been started by pricing decision of the Energy Regulatory Office when the minimum feed-in tariff was determined. More specifically, the feed-in tariff of energy from wind was 3000 CZK/MWh in 2002 and 2003. Later on, the tariff has started decreasing even up to 2 340 CZK/MWh in 2009. (Cetkovský, S., & Coll., 2010) This decreasing tendency has continued as the actual feed-in tariff for 2013 is set to 2 120 CZK/MWh. (ČSVE, 2012a) The realization of wind turbines projects is nevertheless still cost-effective and therefore plenty of investors are interested in this field. (Cetkovský, S., & Coll., 2010)

Instaled capacity and energy production in each year									
Year	2004	2005	2006	2007	2008	2009	2010	2011	2012
Capacity (MW)	17	28	54	116	148	192	215	217	260
Production (GWh)	8,3	21,3	49,4	125	245	290	336	397	416

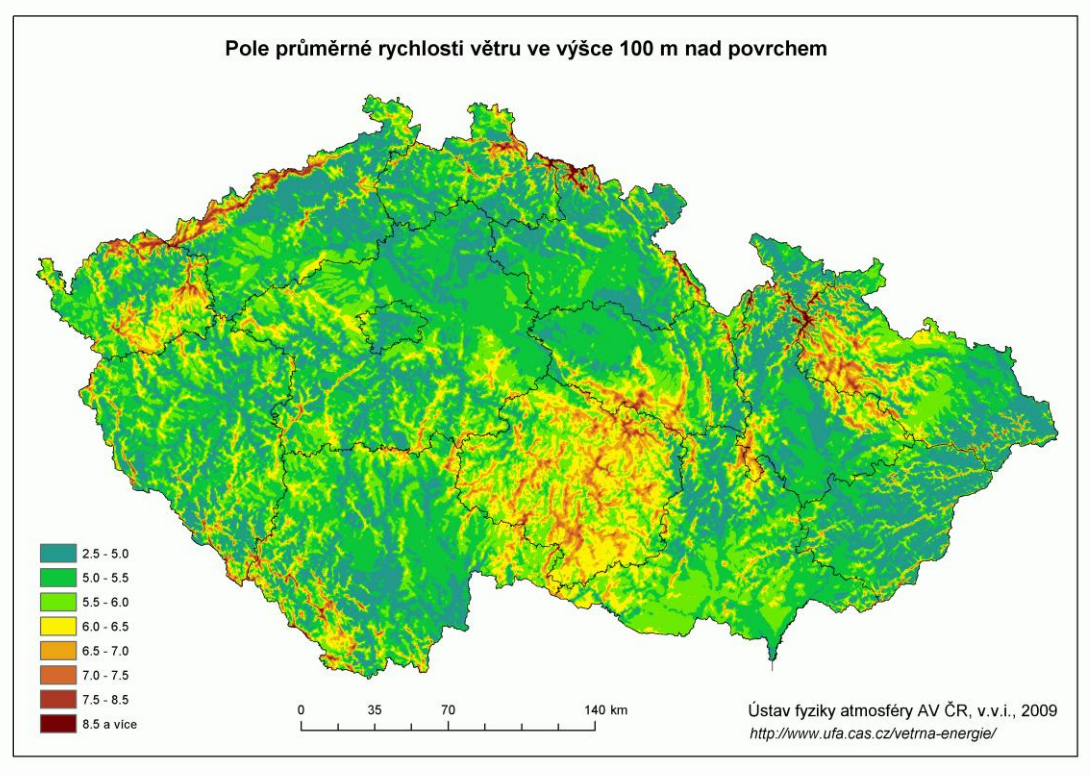
Chart.No. 1: Wind power development in the Czech Republic between years 2004 and 2012 (ČSVE , 2012b)

The chart above depicts the claim about cost-effectiveness throughout the recent years. The installed capacity has been fifteen times multiplied since the year 2004; the biggest growth occurred between years 2007 and 2008.

Regionally, the development is not diversified evenly. The highest capacity is installed in Usti Region with 87 MW and Carlsbad Region with 50 MW. Conversely, the Zlín Region has got only 0, 23 MW. Sites of interest have the following capacity: Olomouc Region has the capacity around 39, 2 MW and South Moravian Region has the capacity only 8, 25 MW. (ČSVE, 2012b)

Wind condition

The main requirement for wind power development is wind conditions of chosen locality. The actual wind map of the Czech Republic describing field of average wind speed in 100 meters above the surface has been formulated by Institute of Atmospheric Physics, Academy of Sciences of the Czech Republic in 2007. The map has been developed according to three mathematical methods: statistical method VAS, wind power model WAsP and dynamic model PIAP. (Cetkovský, S., & Coll., 2010)



Picture No. 3: Field average wind speed at 100 meters above ground (Ústav fyziky atmosféry AV ČR, 2008)

Wind power potential

Wind power potential represents quantity and capacity of wind turbines that are supposed to be erected within some territory. This wind power potential needs to be divided into three categories: climatological, technical and realizable potential. Climatological potential is defined as a total amount of energy obtained from wind under a specific condition. These values are entirely theoretical neither including real technical possibilities nor the legislation limitations. These factors are taken into account in the technical potential describing utmost possible development of wind energy if all current technical options are used. Also this value is nevertheless theoretical because the full usage of technical potential is absolutely unrealistic in actual fact. Therefore, the realizable potential has to be determined. Only this case represents potential which implementation is a realistic under the current conditions. On the other hand, the estimation of this potential is fundamentally affected by subjective approach of concrete expert, his/her experiences, attitudes and expectance. (Cetkovský, S., & Coll., 2010)

Climatological and technical potential

In general, the technical potential of the Czech Republic have been performed by the Institute of Atmospheric Physics. As the first criteria was used the wind speed in altitude 100m above ground; break-even point was determined as 6m/s that is actually in accordance to assumption of the Energy Regulatory Authority No. 475/ 2005.[4] Moreover, this value works as limits for typical locality located in an open field at medium altitudes (500 m.s.l.) and thus was modified according to concrete conditions of sites. Therefore, the differences in specific altitudes and types of landscapes were taken into consideration. The second step was confrontation with restriction areas consequential from the Czech legislation such as territory of urban settlement and surrounding (500 meters), Large-scale and Small-scale Protected Areas, Specially Protected Areas, military districts, surroundings of airports, roads and energy infrastructure protecting zones. Furthermore, conditionally suitable areas were taken into opposition although the development could not be completely excluded, e.g, areas of Natural Parks or Nature 2000. The issue of connection into energy grid was not taken into account, despite the fact it could represent unbearable financial costs. The final step, placement of the turbines, was performed individually within the defined territory. The aim was to get the total amount of erected turbines within the territory, preferably on the best position. Characteristics of turbine are: height of the rotor axis 100 meters and rotor diameter 90 meters, wind turbine capacity 2 MW/3MW for position with wind speed around 7 m/s. Minimal area between turbines depends on predominant wind direction and correspond to a range 270 – 540 meters. This placement enabled to erect 22 098 of wind turbines. Subsequently, the value was reduced by calculation of redundant “shaded” turbines. Therefore, the amount of turbines was decreased on 12 922 which is actually the technical potential of the Czech Republic. (Cetkovský, S., & Coll., 2010)

[4] Decree No. 475/2005 Coll. and its amendments No. 364/2007 Coll. adjusting a certain provision of the Act on the promotion of renewable resources. 1) Intended lifetime of new source is 20 years; 2) Efficiency requirement: presumed wind speed is supposed to be 6m/s at the height of the wind turbine rotor; 3) Total specific investment costs must be less than 38 500 CZK/kWe and the annual utilization of installed capacity is supposed to be higher than 1 900 kWh/kWe. (Acts Collection of the Czech Republic, 2005b)

Realizable potential

Unpredictable political and sociological circumstances have to be taken into consideration if we want to estimate realizable potential factors. Result of the analysis is thus non-objective and unclear solution. (Hanslian, D. & coll., 2008) (Cetkovský, S., & Coll., 2010) The principle of estimation consists of reduction of technical potential. That reduction can arise from derivation of density development of wind turbines in neighbouring countries or is based on assessing factors limiting the implementation of the technical potential.

The first method of derivation of realizable potential takes over the density of wind turbines in neighbouring countries. The density is expressed by proportion of number of turbines per square kilometres. Subsequently, the area of adjacent territory in the Czech Republic is recalculated by this value. Each part of the republic is recalculated by value from the closest foreign region that corresponds to request on similar condition of both places. In case of South Moravian region, where the majority of LAG Moravian Karst territory is situated, the density value is set on 0, 0214 wind turbines per square kilometres. As place for comparison, the State of Lower Austria was used. The value corresponds to expected development of 151 turbines within whole South Moravian region.

The second method works with deductive assessment of factors limiting the implementation of turbines which construction is based on results of technical potential. These factors are parameterised and transferred into series of reductions. Such reductions basically represent attitude towards the turbines implementation. As the future attitude cannot be estimated, three scenarios are established: low, middle and high scenario corresponding to intensity of support to wind power. The result of realizable potential is equal to the sum of reduced factors in all three scenarios. Used reductions have however subjective character, nevertheless this type of potential cannot be analysed without this subjectivity which is confirmed by Cetkovský. (Cetkovský, S., & Coll., 2010).

Limitations of wind power development

Regardless the fact that wind power is a significant renewable source of energy having relatively convenient conditions within the Czech territory, there is no official prescription determining process and development of wind power. Inconsistencies in the methodology for wind power development are thus replaced by various regulations and decrees determined by legislation. The current permitting process of location and operation of economic establishment is considerably complicated. It is basically consisted of Strategic Environmental Assessment, Planning Documentation, Environmental Impact Assessment, Territorial Decision, Integrated Prevention and Pollution Control, Planning/Building Permission and Certificate of Occupancy. (Petržílek, P., 2007) Moreover, the proposal of wind power project is linked to other restrictions within the permitting process such as statement of the Czech Ornithology Society and the Czech Union of bats protection. (Kočvara, 2008)

It is, however, crucial to distinguish promotion of renewable sources of energy throughout strategic documents of the Czech Republic and legislative framework of electricity production from wind power plants and its support.

Strategic documents promoting electricity production from RES

Sustainable development strategy of the Czech Republic

This document represents a framework for further materials with conceptual character such as sectorial policies; and serves as a strategic document for decision making processes within individual ministries as well as inter-ministries cooperation and cooperation together with stakeholders. (Ministry of Industry and Trade, 2010)

The aim of the document is to establish a balance among social, economic and environmental pillars of sustainable development. Basic strategic time-horizon is year 2014, even though several targets are embedded in more distant future, precisely in year 2030. Furthermore, the strategy is not a static document; contrary on that it is historically contingent document and therefore it has supposed to be developed and changed under the changing conditions. (Ministry of Industry and Trade, 2010)

The document highlights preference of renewables sources of energy ahead of conventional sources of energy as the main principle of sustainable development. This principle basically means using RES in any cases of materials and energy needs wherever it is economically and technically possible. Such principle is based on European trend suggesting increase of RES on primary energy sources. The topic "energy" prescribes to ensure support of energy efficiency, using all of energy savings forms and increases the share of RES in the energy balance. (Ministry of Industry and Trade, 2010)

State environmental policy

The current document circumscribed on term 2012-2020 has been submitted to the Government for discussion on January 2013. According to the minister of the Environment, this key document is supposed to ensure healthy and quality environment for citizens of the Czech Republic significantly contributes on effective usage of all resources and minimalizes impacts on environment within as well as beyond the borders of the Czech Republic. (Ministry of the Environment, 2013)

Utilization of RES is estimated for purpose of maximal possible replacement of the conventional energy sources by renewables. Furthermore, the Policy clearly claims about the importance of wind power under the condition of the Czech Republic and even determines tasks that should lead to simplification of authorization procedure. (Cetkovský, S., & Coll., 2010)

State energy policy

It is a strategic document for 30 years period representing targets of the state in a field of energy management in accordance with needs of economic and social development including environment protection and also as a background for Territorial energy policies. Moreover, in this document concrete tools and measures to achieve determined objectives are described. The policy declares a fact that the Czech Republic will support all kinds of resources which can be reproduced in a long term and simultaneously their use will contribute to strengthen the state independency on foreign energy sources as well as on environment protection. (Cetkovský, S., & Coll., 2010)

Current State Energy Policy was accepted on November 2012 and the main priorities presented in a field of energy industry are:

- To reinforce the position of nuclear power for electricity production as well as to support maximal usage of waste heat from nuclear power plants. Moreover, as a crucial act is highlighted a completion of nuclear power plant Temelín, concretely two unfinished blocks and start a development of fifth block of nuclear power plant Dukovany. Simultaneously, there is supposed to be a start of observation of potential location for a new nuclear power plant.
- To develop economically effective renewable sources with gradual elimination of financial subsidies for new sources. All this is supposed to happen with an effective state support in a field of grid connection, permitting processes, support in technical development, development of pilot projects, and afterwards achieving the determined target of 15% share on electricity production.
- To keep the decreasing tendency of electricity production from coal although the coal resources are supposed to be partly recovered.

(Ministry of Industry and Trade, 2013)

Strategy for regional development of the Czech Republic

The Strategy for regional development is a basic conceptual document which according to Act no. 248/2000 Coll. about support of regional development formulates state approach towards support of regional development, establishes objectives and principles for elaboration of regional development programmes. (Methodological support of regional development, 2012)

The document determines prior areas of regional strategies that predetermine character and intensity of the future development. One of the priority areas is called "Nature, landscape and environment" where the priority is marked as "economical management of material and energy resources". (Cetkovský, S., & Coll., 2010)

Legislative framework of electricity production from wind power plants and its support

Treaty of Accession of the Czech Republic to the European Union

After 1st of May 2004, after joining the Czech Republic to the EU, the Directive of the European Parliament and the Council of Europe has become obligatory. More precisely, it is a directive 2001/77/ES on the promotion of electricity production from renewable sources of energy in conditions of domestic electricity market. (Cetkovský, S., & Coll., 2010)

According to the directive, all members of EU are obliged to take appropriate measures and programmes of support which will lead to an increase of electricity production from RES. Concrete forms of measures are supposed to be chosen individually according to rules of domestics' electricity market of each member, however still with a consideration of indicative objections. In case of the Czech Republic, the indicative objective was set as 8% share of electricity produced from RES on gross electricity consumption in the Czech Republic by 2010. (Official Journal of the European Union, 2001)

Substitution for Directive 2001/77/ES occurred in 2009 by Directive 2009/28/ES on the promotion of energy from renewable sources and amending and subsequently repealing of Directives 2001/77/ES and 2003/30/ES. This directive adjusts the objectives on the promotion of the renewable sources of energy by 20% share of electricity produced from

RES on gross electricity consumption by 2020, also share of the biofuels on total consumption of petrol and diesel in traffic sector by 10% with the same time-horizon 2020. But the full objective on the promotion of the renewable sources of energy due to different starting position, possibilities of energy from RES and energy mix of each member state is modified. Therefore, correct indicative objective on the promotion of the renewable sources of energy for the Czech Republic is set up to 13% by 2020. (Official Journal of the European Union, 2009)

Act on Energy Economy

This act adjusts energy politics mainly by setting rules for State Energy Policy, Territorial Energy Policy and State Programme for promotion of energy savings and utilization of renewable sources of energy. (Tzb-info, 2012a)

Energy Act

In general, the act adjusts business conditions in accordance with Community law, state administration, and non-discriminatory regulation in the energy sector. (Cetkovský, S., & Coll., 2010)

Business in energy sector is conditioned by providing grant of state permission. After getting permission, the business has to be licensed by the Energy Regulation Office, but with duration of 25 years only. In case of total installation exceeding 30MW, development of direct grid is possible only after getting State Authorization which is granted based on the decision of the Ministry of Industry and Trade. Administration in the energy sector belongs to the Ministry of Industry and Trade, Energy Regulation Office and State Energy Inspection. (Tzb-info, 2012b)

Energy Regulation Office is an Administrative authority for regulation in the energy sector. Its actions are supposed to promote the economy competition, promotion of RES utilization as well as secondary energy sources and protection of consumers interests in a field of energy sector where is no competition. Furthermore, this office sets the conditions of grid connection as well as a methodology for calculation the share of costs of grid connection and required power supply via implementing legislation. Another important action of the Energy Regulation Office is an annual determination of pricing decision of electricity produced from RES. (Tzb-info, 2012b)

Act on promotion of Renewable Energy Sources

The act adjusts the manner of support energy production from RES in accordance with community legislation, state administration, and rights and obligations of natural and legal persons. This document further contains indicative objective of 8% share of electricity produced from RES on total gross electricity consumption of the Czech Republic by 2010. (Acts Collection of the Czech Republic, 2005a)

Decrees on conditions for connection to the electricity grid

The decree of Energy Regulation Office No. 51/2006 Coll. sets the conditions for connection of electricity generating plant, distribution systems, and supply points of consumers to electricity grid. (Tzb-info, 2011)

Important tools for promotion of electricity production from wind power plants

The support for electricity production from wind power plants is subordinated to act which eliminates the support for utilization situated on area of size at least on 1 kilometre square and total installed capacity in excess of 20 MWe. The tools of support are precisely represented in following list:

- Entitlement to prior connection to the transmission or distribution system
- Obligation of operator to purchase all the generated electricity
- Direct financial support. Producer of electricity from wind power plant has the right to choose a way of the subsidy. One way is called compulsory purchase at a fixed price when all the electricity is sold to operator of transmission or distribution system. Second way is a Green Bonus - amount of money increasing the market price of the electricity reflecting smaller damages of the environment during the electricity generation.
- Guaranty of returning the investments. Implementing legislation of Energy Regulation Office (Acts Collection of the Czech Republic, 2005b) adjusts conditions that guarantee return of investments till 15 years.

(Cetkovský, S., & Coll., 2010)

Economical evaluation

Current situation of economic balance of the wind power industry is very good, in terms of production costs there have occurred a big decrease when the production costs worldwide were around 57 €¢/kWh in 1980 and today it is only 4 €¢/kWh, precisely 2,8-3,2 €¢/kWh in conditions with high wind speed and good grid connection. These costs differ regarding the country as they depend mainly on investment costs. For example, the investments costs in USA are calculated as 2, 5 €¢/kWh, in Denmark as 3, 5 €¢/kWh, in Germany as 5, 0 €¢/kWh and for the Czech Republic even as 7, 4 €¢/kWh. (Cetkovský, S., & Coll., 2010)

Based on facts written above, in some cases the competitiveness of wind power towards conventional sources of energy is already high. In any cases, the wind power is more profitable than coal plants, according to analysis of Bloomberg New Energy Finance in Australia. Their calculations present that the production costs of one MW from new wind power plant is approximately 1 570 CZK while the production costs for new conventional gas power plant are approximately 2 270 CZK or even for new conventional coal power plant are approximately 2 800 CZK. This fact is due to two reasons: carbon emission taxes and reluctance of banks to invest onto projects of emission-intensive technologies. But this fact is valid only for new coal power plant, not the old coal power plants which construction is already repaid. (BIOM, 2013a)

Same situation is confirmed for South African Republic (SAR) by Roger Price from Windlab Company investing into the wind development in SAR. Their calculation of production costs of wind power plants is around 1, 98 CZK whereas the production costs of old coal power plant is approximately 2, 16 CZK. Their calculations follow local current development of new coal power plants with total investments costs around 220 billion CZK. However, the construction is getting more expensive. Even the company developing these plants (half is owned by state) has already asked to increase the investments by 16%. (BIOM, 2012a)

Case study of financial costs

One part of paper of Beranovský and Srdečný (2007) presented in appendix shows real financial costs for better understanding of financial aspect of the wind power project. The paper presents a calculation of wind power plant development in south Moravia, concretely Vranov platform. The development calculated with one turbine of capacity 2MW with the high of rotor about 75 meters above the ground. Three variants were established according to these requirements while their disparity is only in used technology and rotor diameter.

The economic evaluation of real project shows possible economy of investments and future incomes. Moreover, the results show importance of turbine type choice, more specifically the crucial importance of rotor diameter parameter. The 10 meters difference in rotor diameter may be even as significant as the project can be announced to be unrealizable.

Externalities

Petržílek (2007) describes cause of negative externalities as a market failure occurring if expenditure is spreading to other persons without any financial compensation. The study of Cetkovský, & Coll. (2010) even complements the fact by important criteria; differentiation between external effect and impact. The external effect occurs when benefit of an individual or company profit is influenced by the specific change. Contrary on that, it is not an externality if the specific change does not have any financial impact. Moreover, the negative externalities are supposed to be divided into private and social costs of specific economic activity. Private costs are determinate by the market price of sources, on the other hand, social costs are formed by private and external costs. Therefore, if the market fails in terms of externalities, producer maximizing profit does not have any reasons to repay the external costs. Private costs for specific activity are thus lower than the social costs.

ExternE

This is the current most respected and complex methodology for impact assessment and quantification of external costs. General approach of this methodology is based on fuel cycle analysis which is very similar to Life-cycle –analysis. All processes of energy transformation are analysed from mining process throughout treatment, transport and production of electricity to an issue of waste disposal. At the same time, the methodology follows an analysis of impact pathway approach (IPA) which means the analysis of externalities are made by approach called bottom-up. That basically allows considering the specific conditions of the locality. (Cetkovský, S., & Coll., 2010)

Basic phases of the ExternE analysis are:

- Emissions: assessment of analysed technologies and determination of each pollutant and its amounts.
- Dispersion: determination of pollutant increase in all influenced regions.
- Impacts: determination of dependence between specific pollutant concentration and its impact on chosen receptor.
- Costs: expression of the impacts in monetary unit according to market prices when it is possible or quasi market price (public expenditure on treatment). Plenty of estates and services are not really tradable such as human health, forests and other kinds of ecosystems. Therefore, their evaluation is made by an alternative technique; non-market valuation methods.

The lowest producers of environmental externalities are wind power energy and nuclear power energy. In case of wind power, the main CO_2 emission impact comes from the production of wind turbine component. This fact can be quantified by analysis of ExternE, precisely by the IPA. Thus quantified costs are specific for each technology but they are identical for all countries where these technologies are used. (Cetkovský, S., & Coll., 2010)

Category of impact	nuclear power plant	heavy oil power plant	black coal power plant	brown coal power plant	natural gas power plant	hydro-power plant	wind power plant on shore	solar power plant on roofs	biomass
human health	0,21	2,55	1,21	1,38	0,63	0,07	0,10	0,86	2,53
Environment	0,03	0,35	0,20	0,22	0,13	0,01	0,01	0,09	0,58
Radionuclides	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
climate change	0,05	0,47	1,90	2,10	0,97	0,02	0,20	0,20	0,16
Total	**0,28**	**3,37**	**3,31**	**3,69**	**1,74**	**0,10**	**0,13**	**1,15**	**3,26**

Chart No. 2: External costs of energy technologies (€¢/kWh) in 2008. (Cetkovský, S., & Coll., 2010)

Impacts of wind power

Wind power influences the environment due to operation of wind turbines which differs according to their position. These impacts include noise emissions, landscape character issue, increase of disturbance and mortality of wildlife, shadow flicker effect, price drop of property and tourism threat, and load transmission grid issue.

Noise emissions

The noise from wind turbines is mostly described as "swishing" or "thumping", however it arises due to amplitude modulation. The swish sound is a function of the observers` position relative to turbine. The thumb sound is caused by uneven air passing through the turbine blades as they rotate. These two mechanisms are entirely separate, nevertheless it is possible that they interact. (Bowdler, D., 2008)

Moorhouse & Coll. (2007) used another division for noise coming from turbines but basically confirmed previous study. The noise sources fall into two categories: mechanical and aerodynamic. Mechanical sound source is, in general, connected with the electrical generation part of the turbine, the gear box and the generator. The character of noise is described as a "whine" or "hum" and it is almost identical to noise from other types of rotating machinery. The second category, aerodynamic source of sound, is generated by pressure variations within the air that fluctuates at acoustic frequencies.

Due to distinction of harmfulness, each state has established hygiene limits of noise (measured as equivalent of acoustic pressure levels $L_{Aeq,T}$). These limits are set up for critical period: night time between 10 PM and 6 AM. Similar noise limits have the Czech Republic as well. According to Decree No.523/2006 Coll. (Acts Collection of the Czech Republic, 2006) all day limits and night limits are set:

» $L_{all\ day} = 50$ dB

» L_{night} = 40 dB

Hygiene limit is healthy and economic compromise as there is not a strict boarder of a hearing damage. These limits could be exceeded from time to time. Healthy limits are set for defined majority of population; therefore more sensitive people can perceived the noise more. (Cetkovský, S., & Coll., 2010)

Consequences of noise on human health are delineated in study of Hanning. (2012). The study describes associations with inadequate sleep at the beginning such as fatigue, sleepiness and cognitive impairment, obesity, risk of diabetes, high blood pressure, heart disease, cancer, depression and impaired immunity. Study further contains a deal with ways of noise annoyance and sleeping damage. Hanning (2012) here also recommends to set a setback distance 1, 5 km from an erected turbine in order to prevent a significant risk of disturbance from noise.

The last but not least division of noise is according to frequency. Normal frequency scale heard by humans is between 20 to 20 000 Hz. Low frequency sound is recognized around the bottom of human perception (10 to 200 Hz) whilst infrasound is even below the common limit of perception (below 20 Hz). Infrasound is always a part of environment coming from different sources: ambient air turbulence, ventilation units, waves on the shore, distant explosions, traffic, aircraft and other machinery. (Rogers, A., L., & Coll., 2002, amended 2006) Fortunately, this study as well as study of Jiráska. (Cetkovský, S., & Coll., 2010) confirm a fact that low frequency sound and infrasound do not have significant impact on human health mainly because of modern type of turbines.

For better experience visit a link The Telegraph (2011) to experience the noise from wind turbine and further places which surround us.

Landscape character issue

Threat of landscape character is very disputable issue in the Czech Republic. Mainly it is due to a small scale landscape which is characteristic for domestic landscape. This fact forms a strong contrast with high vertical installation of wind turbines. In some cases their pylon can be even 100 meters high. (Vorel,I., 2009) Therefore, some experts and scientists warn against degradation of historical and natural landscapes. Even Sklenička (2006) claims that installation of wind turbines delete all current conventions of landscape character and thus participates in the decisions of principal landscape change.

More specifically, richness of landscapes, abundance of forests and woods mosaic and dense network of urban areas make the Czech landscape intimate and homemade. This all can be in contrast with uniformity of wind turbines. Moreover, the landscape horizons, panorama, and the existence of landscape and cultural dominants are at stake. Mightiness of the turbines could totally destroy the unique character. The previous description is used in a paper *Current problems on protection of landscape character* (Vorel, I., Kupka, J., & coll., 2008), in article of Culek. This author also provides caution against an effect which can arise from lush development of wind turbines. Culek concretely describes a possible threat of landscape by secondary expansion of further technical or urban development.

From this point of view, the localization of wind power plants is the most problematic issue. Also this issue, however, has the other side of coin. As Linhartová, P., (Veronica, 2007) discusses in her article *Experience with landscape character assessment for construction and operation in territory of the South Moravian Region,* disturbance of the landscape character is limited by short service life around 25 years. Moreover, the impact of wind turbine installation is minimal; basically all functions of the landscape are untouched.

Wind power plants impact on wildlife

In general, the impact can be divided into three categories: disturbance of animals by noise and the actual construction, mortality associated with wind turbines collisions (especially the clash with blades) and loss or distortion of the environment and biotopes of animals. (Cetkovský, S., & Coll., 2010) This impact is observed mainly in case of birds and bats.

It is impossible to ignore this issue and thus opinions of Czech Society for Ornithology and Czech Society for Bat Conservation are needed for building wind power plants. (Kočvara, R., 2008)

Despite the fact that birds and bats are threatened by wind turbines, research of Erickson & coll. (2001) presents interesting results showing that other kinds of technical constructions are more dangerous for birds. Author compares collisions of birds with cars, buildings and windows, high tension lines, communication towers and wind turbines at territory of United States. According to this study, 100 million to 1 billion of birds in total die every year. There is an assumption that 60-80 million of birds die due to car accident, 98-980 millions of birds die by hitting the glass. Also, high tension lines kill annually around tens to 174 million of birds, communication towers are responsible for the deaths of 4 to 50 million birds and 10 to 40 million birds die due to collision with wind turbine. Models evaluating the previous data are (besides wind turbines) loaded by error causing inability to obtain absolute data on birds killed within the territory of US. From this research, the impact of wind power to mortality of birds is not very significant even if other kinds of human structures and actions such as pesticides, petroleum products, diseases, electricity, and other chemical poisons are not taken into consideration.

In similar way, Kočvara (2008) describes the situation of a sea eagle. Again, the impact of wind turbine to mortality of sea eagle is indisputable. However, studies from Germany show that the collision with wind turbine blades does not represent the most significant source of mortality.

In case of bats, wind turbines represent higher risk because reasons of their mortality are closely connected to natural behaviour. According to Gaisler. (Veronica, 2007), bats hunt food in the form of insect which is lured by heat emanating from the turbine. Further wind turbine attractiveness is caused by a potential opportunity of shelter. The last but not least, mortality of bats occurred during migration when the ways of migration of bats are interrupted by wind power array. Contrary on that, it is very unlikely that bats are attracted by physical or noisy effects of turbines. As a solution for warding off the bats could be used ultrasound. Unfortunately, ultrasound is fast fading in the air and thus this method cannot be totally effective. Therefore another method, which should be more effective, is to install radio transmitters. This method is based on fact that birds and mammals are able to detect electromagnetic waves, respectively microwave frequency of 300 MHz - 300 GHz because of thermal effect. However, this method still must be observed and tested.

Mortality decrease could be ensured by activity limitations of turbines. This method rises from fact that bats flying activity decrease with wind speed around 5-8 m/s, hence starting speed of wind turbine is 4 m/s. This method was tested in Canada where the turbine's starting speed was set on 5, 5 m/s and thus the mortality was decreased over 50%. It is therefore very likely that the mortality could decrease almost over 90% if the starting speed is limited up to 6 m/s. (Cetkovský, S., & Coll., 2010)

Load transmission grid

Such situation can occur in case huge amount of electricity start to flow within the electricity grid and it happens due to renewable energy sources including wind power plants. Current experience of load transmission grid is detected because of wind power plants erected in North of Germany. The worst scenario is called blackout and usually can occur if more than one element of transmission grid is disconnect. (Ekolist, 2009) As a solution it is suggested a new transformer close to Germany's border. This intention cost is estimated to 2 billion CZK. (BIOM, 2013b)

Another way how to deal with unstable electricity in the transmission grid is a reconstruction of current central system into decentralized transmission grid. Within this system a "Smart grid" conception can be used. More about Smart Grids and decentralized transmission grid is written in one of following chapters "New technologies and methods". That chapter also includes possible option for dealing with blackout, concretely conception of storage of generated energy.

Shadow flicker effect

The existence of wind turbine has caused several serious issues which are described above. Still, minor problems remain. In case of shadow flicker, the scale of seriousness is in each country different. Even Czech Republic does not have any concrete legislation dealing with this issue.

Shadow flicker is an effect caused by rotating wind turbine blades periodically which cast shadows through constrained openings such as the windows of neighbouring properties. However, the shadow flicker occurred only under specific environmental conditions such as the position and height of the sun, wind speed, direction, cloudiness, and position of the turbines to a sensitive receptor. (Brinckerhoff, P., 2011)

According to study Wind Turbine Health Impact Study: Report of the Independent Expert Panel of the Massachusetts Department of Environmental Protection (2012) there is no proven fact that shadow flicker possess a risk for eliciting seizures as a result of photic stimulation.

The same conclusion proved a report written by Brinckerhoff (2011) claiming that shadow flicker does not constitute a significant harassment. Although, under specific conditions, the increased demand for the mental and physical energy might meet the criteria of substantial nuisance. Due to these circumstances, shadow flicker issue has to be solved by mitigation measures, such as turbine shut-down systems or installation of defensive systems.

Price drop of property

A trend of price drop of property was confirmed by article Collins in Great Britain. (The Telegraph, 2012) Following action, to reduce the impact, was to move certain houses located close to wind farm into lower council tax bands. Similar trend can be also observed in the Czech Republic. According to Fránek. (Aktuálně.cz, 2010) domestic citizens worry about their property due to wind power development. The decreasing value of their properties is currently threatened by economic crisis and thus their fear is understandable.

However, this price drop property effect can be seen in all cases of technical development close to urban areas. It is only under consideration of each buyer how much is against or for wind power development.

Tourism

Impact of wind power development in specific locality on its tourist attractiveness is very treacherous issue. Unfounded claims are ery often used such as in case of presentation Impact of wind power plants on human health by Kubina (2008). In general, it is rather a problem of marketing and advertisement then the real threat to touristic areas.

This fact is proven by a study of Frantál and Kunc (2008) in which is observed a possible impact of wind turbines via survey. Respondents from localities Silesian Harta and Ore Mountains claim that the wind turbines do not have any impact on the decision if they spend the vacation in the locality again (Silesian Harta: positive effect 4%, any effect 90%, negative effect 6%; Ore Mountains: positive effect 1,5%, any effect 95%, negative effect 3,5%). Moreover, 65% respondents from both localities are interested in visiting wind turbine. Representatives of business entities confirmed neutral impact on wind power plants on tourism.

Use a wind turbine for attracting tourists is not a common practice; nonetheless in some localities it is already used. As an example can be used a city of Bruck an der Leitha at Austria where is installed observation deck on the top of turbine. (Srdečný, 2012)

NIMBY

The “not in my back yard” syndrome is not only the issue of wind power but all of infrastructure and social facilities. The principle is based on phenomenon that people are generally in favour of wind power but are against the wind power development in their surroundings. Smith (Smith, E. and Klick, H., 2007) presents results of Kraft`s and Clary`s (1991) study where the nimbyism is described as an extreme opposition to local projects characterized by: distrust of project sponsors, high concern about project risks, limited information about project sites, risks and benefits, highly emotional responses to the conflict and parochial and localized attitudes toward the problem which excludes broader implications. Those items in the list raise questions about the reasonableness or rationality of the objections and selfishness. However, Smith warns that no all protests against proposed project are only locally resistible.

Přikryl (2007) agrees with the Smith`s objection that interests and motives of opponents are not discriminated, and furthermore claims that there could be several reasons why people do not want to have a wind turbine in their back yard such as noise issue, visual disruption of landscape perception, environmental aspects, decline in real estate prices or outflow of potential tourists.

New technologies and methods

Development in wind power industry moves forward very quickly and is focused on field that is the most controversial. The development can be divided into three categories: facility, location, and storage and distribution. Despite the fact not all of them are currently known in the Czech Republic, they still have to be included in this thesis.

Development of the facility

Markham. (Treehugger, 2012) presents a new possible way how to build a turbine pylon. Using wood instead of steel is more cheap, more stable and more environmental friendly. Structure of the pylon is made from timber or laminated wood panels which are all from sustainable and certified suppliers, and the structure is covered by a plastic skin. The company using this method claims they are able to save 300 tons of steel for each 100-meter tall tower. Advantage of the wooden construction is to ease transportation to the construction site. Individual parts can be imported via standard cargo containers. This can be a strong advantage if the normal transportation limits are taken into consideration. Especially, the transportation of bottom diameter of the steel turbine is currently very difficult as it cannot be transported feasibly via highway with diameters larger than 4.2 meters due to clearance under bridges and overpasses.

Development of the location

According to legislation, in the Czech Republic it is not possible to erect a wind turbine in forests as they are protected as significant landscape elements and thus are not permitted to build turbines within these areas, nor in their protection zone.

Different attitude is set by Germans in the issue of using forests for wind power plants. The article written by Meier (2011) shows the example of this kind of wind turbines` localization. As a crucial, Meier highlights one attribute of turbines: hub height up to 150 meters. This kind of machine has a power capacity around 6 MW. One of the forest areas used for wind power development is near Hof in Bavaria. This wind farm with 5 installations produces 22, 5 million kWh/ year. It is clear that this method of location has also several disadvantages. First issue is deforestation which is required for wind turbine construction. Although, these areas can be re-forested after the wind turbine's service life is complete. Meier claims that the deforestation, in case of Bavaria forest, has a positive ecological impact on local ecosystems. Unfortunately, studies about impact on wildlife or landscape character are not available.

Similar idea is proposed on area of the United Kingdom by RWE Company. (RWE, 2013) The wind farm proposed by this company should be erected in Clocaenog Forest in the counties of Denbighshire and Conwy. The farm has contained 32 turbines and thus has installed capacity of between 64-96 MW. More information about the permitting process is available on the RWE company website.

Development of storage and distribution

The objection against wind turbine erection is often unstable energy production and subsequent overloading of the grid. First option for solving the issue is to consume electricity locally. However, this solution does not cover whole issue as turbines are not always located close to consumers. Therefore, second option is based on storage system that can lock the energy for times when the wind does not blow.

One way of storage and transportation system has been discovered in Germany. There was the energy from renewables, precisely solar and wind power, stored in methane and further transported via natural gas pipelines. Capacity of the pipeline system is equal to 220 TWh, which corresponds to several months` consumption of Germany. Whole process contains two phases: hydrogen electrolysis and methanisation. Moreover, during the methanisation, that has been called Sabatier reaction, is released a large amount of waste heat which can be used in suitable heat utilisation process. Presented degree of efficiency of converting power to natural gas is more than 60%. The commercialisation is planned for 2014. (Biogas, 2011)

Current inelasticity distribution system is inadequate for modern society and their needs. The system is used in the Czech Republic as well as in other states from all over the world. New Zealand`s case from 1998 is a perfect example of what tragedy can arise from blackout. (Ekolist, 2009)

The basis for safer electricity distribution and easier integration of renewable sources is transition to decentralized smart distribution grid. This system allows to utilize sources of energy more effectively or to regulate the consumption. (Ekolist, 2009) The first test smart region in the Czech Republic has been built within the territory of Vrchlabí municipality in 2010. This pilot project has planned to involve: installation of smart meters to all supply points, new technologies within the distribution network of low and high voltage, greening transport and integration of renewable energy sources. The project evaluation is set by 2014, anyhow, until that time the legislation setting could be modified or at least discussed because without an efficient tool the implementation of smart grids and decentralized distribution systems is not possible. (Ekolist, 2010)

Details about decentralized energy system, its advantages and examples from The Czech Republic environment are available in diploma thesis of Holub (2007). The thesis also contains an appendix with theses of support system for heat production from renewable energy sources.

Conflict of interest

There is no proper binding methodology for assessing wind power potential as was already mentioned. Therefore, the assessments follow the legislations having a relationship with wind power development. This traditional way relies on legislations and limitations which have been established before application of wind power plant technology, or is based on inconsistent and unclear conditions of landscape protection such as National Parks or Protected Areas. In the chapter "Negative impacts of wind power" are described several issues connected to wind power development. All of them are really important elements of decision-making process leading to building permission. On the other hand, in most of the cases decision-makers access to them with prejudice and thus the intention of wind power development gets disadvantaged position.

Environment protection and territorial limits

The issue of inconsistent and unclear conditions of landscape protection, specifically in cases of National Parks, is observed by domestic as well as foreign researchers and scientists. The most famous domestic conflict about landscape protection and human intervention in protected areas has been controversial cutting forest within the area of the National Park Šumava due to bark beetle calamity. (Prach, K., & coll., 2011) The conflict represents an unstable conception of National Park management as well as an unclear vision what National Park should precisely protect. Similar problem occurs in case of tourism within National Parks; there is discussion about touristic development in these kinds of protected areas.

Another example is work of Mels from Kalmar University studying the issue of spatiality, historical development and relationships among nature, national identity and landscape. In his paper (2002), Mels explores past and present official spatialities of Swedish national parks and debates about ways in which rhetorical mediation secures the naturalization and nationalization of parks spaces. Concretely, Mels argues about three interrelated spatialities to constitute the abstract space of Swedish national parks; empty, organic, and optical space. The conclusion is finished by claim that these spatialities are maintained and policed. Similarly, the conception of Czech national parks (and all kinds of protected areas) has own interrelated spatialities constituting their space. However, in case of Czech national parks these spatialities are probably forgotten according to conflict described above.

Further issue except the loss of spatialities is changing conditions of landscape/environment protection. Even though the Czech national parks neither other kinds of protected areas are basically very young subjects, they already have to deal with the issue of mass tourism. The increase of visitors is positive in a way that it shows that people still have a strong connection with a nature. The meaning of nature in this matter represents untouched landscape with wild and natural character. On the other hand, in case these places are full of visitors, they are no more wild because visitors have to be protected against dangerous situations nor natural as the area is full of humans elements such as routes, boards, trash cans, abodes and similar human utilities. Moreover, each visitor leaves a footprint at the place; not only trash. One of the main problems is cars that are the most common way of transport. They pollute the air of the local environment. Furthermore, the surrounding was changed partly onto a parking place. Spirn describes the same problems in her paper (1995).

The last but not least issue, which is connected to location of wind power development, is homogenization of built-up areas. The study of Pasqualetti., Gipe and Righter (2002) contains confirmation of the fact that several countries, e. g. Denmark or Netherlands, locate the wind turbines within villages and even within large cities. Turbines are visible also near lock gates and busy highways, at fast-food restaurant, in the parking lots of shopping centres and at parks and playgrounds. Thus the reason of strict boundaries of built-up areas is at least questionable in the Czech Republic.

Current implementation issues of wind power plants

There are three issues, which have significant influence on the entire investment plan that needs to be taken into account during development of wind power plants. These issues are closely connected to facts described in the previous chapter, nevertheless in this chapter the issues are concretely named and described according to current legislation.

Legislation framework of landscape character protection

The protection of landscape character is established in Act on Environment and Landscape Protection (Act no. 114/1992 Coll.). Landscape character includes mainly natural, cultural and historical characteristics of special place or district and it is protected against action decreasing its esthetical or natural value. Therefore, the interventions to landscape character are performed only with regard to maintaining of significant landscape elements, specially protected areas, cultural dominants, harmonic scale and relationships in the landscape. The main protection tool is agreement of Nature Conservation Authority (NCA) which is required during permitting and siting of buildings process. This agreement has a form of mandatory attitude and it is not an administrative decision. The purpose of the agreement is thus inclusion into following decision making process. Nevertheless, the NCA procedure of consent to the placement of wind power plant is based on Methodical guideline which is actually not obligatory. On the other hand, the Ministry of environment has expressed its statement about strict tackle of the guideline requirements. (Birklen, P., 2011)

Unfortunately, in the decision-making process in practice, it is possible to encounter a standpoint which unable to get the permission for site location of wind power plant due to impact on landscape character. But this NCA's standpoint is not supported by the legal system and, furthermore, theoretically excludes any implementation of wind power development. (Cetkovský, S., & Coll., 2010)

Nevertheless, the methodical guideline purpose does not preclude the wind power development, only adjusts concrete conditions when the development is acceptable and when is not. (The Ministry of Environment, 2009)

Basic conditions for the protection of specially protected animals

According to Act No. 114/1992 Coll.,(Acts Collection of the Czech Republic, 2010) the protection applies to all development stages of specially protected animals, natural as well as artificial residence, and their biotope. Unfortunately, natural development of specially protected animals may be affected specifically by interference, wounding and occasionally killing individuals. All can happen during operation of wind turbine. On the other hand, the NCA is allowed to release an exception in case of another public interest prevails under nature protection.

The practice shows (Cetkovský, S., & Coll., 2010) the fact that the NCA deduces opinion containing protection of localities where specially protected animals historically lived. According to NCA, there is an assumption the animals could live here again in the future. This opinion is nevertheless contradictory and the protection, according to the Act, is valid only for localities where the animals are currently living. (Acts Collection of the Czech Republic, 2010)

Wind power plant connection to the distribution network

A current crucial issue in wind power implementation is the possibility or impossibility of connection to local distribution network. In case of LAG Moravian Karst the distribution network is administered by E.ON Company. Statement of Eon in summer 2012 claims there will be no further connection into the network because the acceptable capacity of E.ON Distribuce, a.s. supply point was filled. (Eon, 2012a) Next message of Eon Company from winter 2012 brought better news. Almost 55 MW of capacity in distribution network were released for new sources. (Eon, 2012b)

However the theoretical capacity of distribution network can be filled the reality could be different. According to Cetkovský, & Coll., (2010), requiring a connection into the distribution network is possible if application is provided already during the early stages of the project, often before the zoning decision. Thus the permissions for unfinished projects are calculated into the network capacity, despite the fact turbine does not exist. As a possible solution is thus legislative change. The permission for network connection could be given to an applicant only after evidence of the zoning decision to be ensured that the network capacity will not be blocked by unrealistic projects.

Locality

Local Action Group Moravian Karst

Local Action Group Moravian Karst (LAG MK) has been established according to law n. 83/1990 Collection about association of citizens on May 2006. The group's purpose is to create conditions for support and promotion of sustainable development. Currently, the group contains 56 members from South Moravian and Olomouc Region with total area of 575 km² and 65 000 inhabitants. The territory is divided into five micro-regions: Časnýř, Drahany Highland, Protivansko, Moravian Karst and Černohorsko.

(MAS Moravský Kras, 2008)

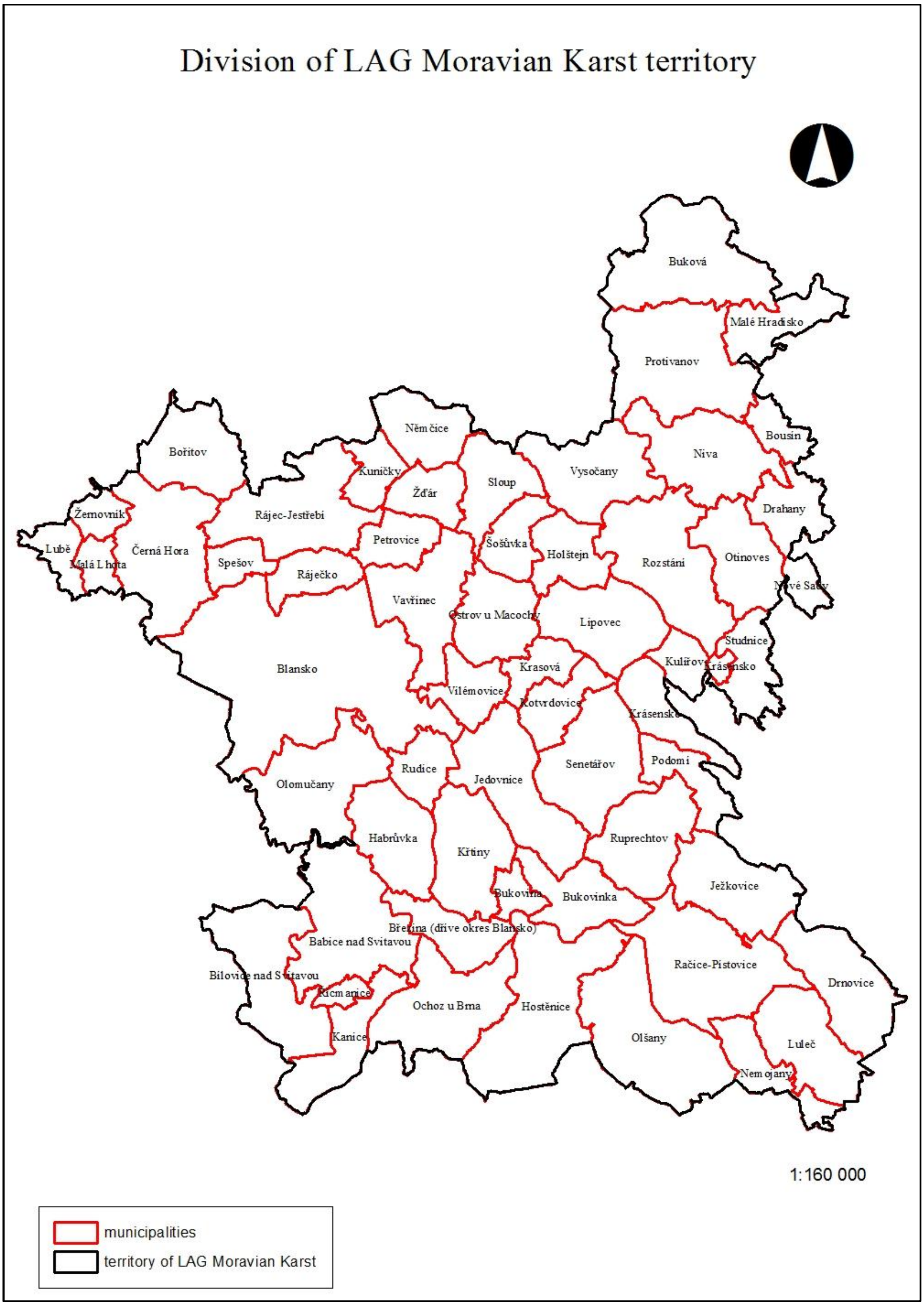
List of members: Blansko, Březina, Bukovina, Bukovinka, Habrůvka, Holštejn, Hostěnice, Jedovnice, Kotvrdovice, Krasová, Křtiny, Kulířov, Kuničky, Lipovec, Němčice, Olomučany, Ostrov u Macochy, Rájec-Jestřebí, Rudice, Senetářov, Sloup, Spešov, Šošůvka, Vavřinec, Vilémovice, Vysočany, Žďár, Petrovice, Lubě, Drnovice, Ježkovice, Krásensko, Luleč, Nemojany, Nové Sady, Olšany, Podomí, Račice-Pískovice, Ruprechtov, Studnice, Bousín, Buková, Drahany, Malé Hradisko, Niva, Otinoves, Protivanov, Rozstání, Babice nad Svitavou, Bílovice nad Svitavou, Kanice, Ochoz u Brna, Řícmanice, Bořitov, Černá Hora, Malá Lhota, Žernovník. (MAS Moravský Kras, 2008)

Territory characterisation

Landscape character of whole territory of LAG Moravian Karst has been influenced by human activities, especially agriculture, since always. Firstly, this landscape change is connected to agriculture expansion following local urbanisation, secondly, caused by intensification of the agriculture. Consequence of these changes is the invasion of non-native thermophile species of plants and animals. (EkoWATT, 2013)

The deterioration of the situation of agro ecosystems occurred after agriculture intensification in early sixties. This intensification has had adverse impact on surface and underground karst phenomena. Moreover, the local soil has started to be affected by erosion, mainly by special type of erosion within the locality of karst phenomena - the erosion into sinkholes. Another dangerous problem has come with the intensification of such an issue - increased use of fertilizers. (EkoWATT, 2013)

Climatic conditions are strongly influenced by the rich relief and thus the territory has a specific microclimate conditions. Those circumstances caused noticeable temperature fluctuations. The difference of air an average annual temperature on south and north is around 2 °C. The same character has the weather also in case of precipitation conditions. The south area has the average annual precipitation around 550 mm contrary to north part, where the average annual precipitation is around 700 mm. The specific relief has got the influence also on wind condition. The south part has two different wind paths; one direction path leads to west-north or north whereas in the centre and north area wind path direction is mainly to north. (EkoWATT, 2013)



Picture No. 4: Reprezentation of municipalities in LAG Moravian Karst (data source CUZK)

Geomorphology

Geomorphological scheme	
Category	Name
Systém	Hercynian
Province	Czech Highlands
Sub-province	Czech - Moravian systém
Locality	Brno Highlands
Unit	Drahany Highlands
Sub-unit	Moravian Karst, Konice Highlands, Adamov Highlands

Chart No. 3 Geomorphology of the locality LAG Moravian Karst (Inspire, 2010 – 2013)

Significant geomorphological units are mostly situated in the district of Moravian Karst and Drahany Highlands. Relief of the Moravian Karst is typical for valleys and small plateau. The area is also well known for karst caves and other formations or rocky limestone columns and walls (for example rock formation Rudice). Drahany Highlands take a form of highlands with significant valleys and flatter crowns such as on the north part where parallel oriented group of karst valleys are located and creates a dominant for the surroundings. (EkoWATT, 2013)

Phytogeographical division

Almost every territory of LAG Moravian Karst includes the phytogeographical area of Mesophyticum, precisely in circuit of Czech-Moravian Mesophyticum and districts: Moravian Highlands foothills, Drahany foothills, and Moravian Karst. Small area situated on south near Nemojany and Luleč belongs to area of Thermophyticum, Haná Highlands circuit and Haná Highlands district.(Inspire, 2010 – 2013)

Potential natural vegetation

Hornbeams can mostly be found on west and south of the territory whereas beech forests are usually located on north and centre of the territory. Following types of vegetation are included among the potential natural vegetation of the territory: Pruno-Fraxinetum, Melampyro nemorosi-Carpinetum, Carici pilosae – Carpinetum, talus and ravine forests, Melico-Fagetum, Carici pilosae-Fagetum, Dentario enneaphylli-Fagetum, Luzulo Fagetum, Pruno mahaleb -Quercetum pubescentis, Corno –Quercetum, Potentillo albae –Quercetum, and Luzulo albidae-Quercetum petraeae, Abieti-Quercetum. (Inspire, 2010 – 2013)

Protected areas

Within the territory of LAG Moravian Karst six different kinds of protected area can be determined. The biggest protected area belongs to category of Large protected areas and name of LAG carries the same name. The total area is about 90, 5 km².

Total amount of Small protected areas is 40 with total area 16, 6 km². Moreover, areas of NATURA 2000 cover almost 74 km². Therefore it is not surprising plenty of protected birds have nests within the territory. Concretely 58 species of birds is under the protection. (Šťastný & col, 2010) The table with specific protected bird species is available in appendix.

Current wind turbines

- Municipality Rozstání: type of turbine Vestas V100, 1x 1, 8MW
- Municipality Protivanov: type of turbine Fuhrlander, 1x 100kW
- Municipality Protivanov: type of turbine Repower MD77, 2x 1, 5MW
- Municipality Drahany: type of turbine Vetsas V90, 1x 2MW
  (ČSVE, 2013)

Methodology

Analysing wind power potential is about calculation of how many turbines are possible to erect in suitable area. The definition of three kinds of potential was explained in the theoretical part of this thesis whereas their evaluation, concretely of climatological, technical, and realizable potential, is used for answering questions about *how big is the wind power potential within the territory of LAG Moravian Karst and which obstacles could threaten the future wind power project*.

Materials

Basic data was obtained from database of the Czech Office for Surveying, Mapping and Cadastre via student official request. The package comprises whole area of LAG Moravian Karst and data of its planimetry and altimetry. The source is Data200, and corresponding scale is 1:200 000. The maps are available in vectors and they can be used in GIS software.

Map of wind speed at 100 meters above the ground in the Czech Republic is available from database of CENIA - National Geoportal of the Ministry of Environment. Data about protected areas belongs to office of LAG Moravian Karst.

Individual layers used in analysis

- Map of wind speed in 100 meters above the ground: source CENIA. This raster layer is supposed to be vectorised manually. For this process scale range of 1: 50 to 1: 100 was used.
- Map of land cover: vector layers of forests, rivers, wetlands, roads and rails were in package of DATA200.

Climatological potential

The analysis of the climatological potential is based on wind condition within locality. The limit wind speed for profitable wind power plant is 6 m/s., according to Decree No. 475/2005 Coll. (Acts Collection of the Czech Republic, 2005b) Localities with appropriate wind conditions are suitable for wind power development and in further step is this area divided by minimal area per one turbine. Result of this calculation is required number of turbines.

Parameters of considered turbine

Intended turbine has rotor diameter equal to 90 meters. Its capacity is 2 or 3MW and depends on wind speed. 2MW turbine is more suitable for localities with wind speed limit up to 7 m/s. For localities with higher wind speed is considered placing turbines with capacity of 3MW. Spacing between turbines is set as a constant value equal to 540 meters plus distance equal to rotor diameter (90 meters) to eliminate reduction of planned production caused by mutual shading.

Procedure

- Manually vectorised layer of wind speed in 100 meters above the ground is reclassified into five categories of wind speed: <6, 0 – 6, 5>, <6, 5 – 7, 0>, <7, 0 – 7, 5>, <7, 5 – 8, 0> and <8, 0 – 8, 5>.
- The unification of categories <6, 0 – 6, 5>, <6, 5 – 7, 0> by tool *Union* is defined as the area where is advisable to erect 2 MW turbines.
- The rest categories are unified by the same tool into area of 3 MW turbines.
- Required climatological potential results from a sum of the proportion of both previously defined areas and the distance between two turbines. The distance between two turbines is understood as a content of circle with diameter 1260 meters.

Technical potential

The analysis of technical potential is defined as a sum of all possible positions of wind turbines when meeting the technical and legislation criteria. The legislative limits include areas of nature protection, significant landscape elements, areas of territorial system of ecological stability, urban areas, transportation routes, water elements, protected deposit areas and their protective zones. Technical criteria correspond to suitable wind condition and minimal distance between turbines.

Diversity of the earth's surface (land cover) must have been be neglected due to inadequate data.

Procedure

- To upload all layers to the system: forests, urban areas, protected landscape areas, national nature reserves, national natural monuments, nature reserves, natural monuments, areas of NATURA 2000 (bird habitats and Sites of Community Importance), wetlands, water areas, rivers, roads, railroads and protected deposit areas.
- To use tool *buffer* so the protective zones are added to layers: forests - 150 meters, urban areas (first unify multiple polygons of urban area by function Aggregate polygons) – 750 meters (this distance were used to comply the noise limits), all categories of specially protected areas – 50 meters, roads: highway 1 class – 100 meters, highway 2 classes – 50 meters, highway 3 classes – 15 meters, and railroads - 30 meters. For simplification, the buffer zone has been always considered from the border of the territory.
- To use Tool *Union* for unification of the resulting layers.
- To upload the layers of climatological potential while the area of unsuitable locations for wind power development is removed from the layer via function *Erase.*
- To make the final technical potential and to set up area calculations into the attribute table.

Realizable potential

The methodology is based on the previously mentioned facts about experience with the implementation and construction of wind turbines, impacts on environment and other factors determining their development. Final evaluation of realizable potential is set as an intersection of two methods described in the theoretical part by Hanslian. (Hanslian, D. & coll., 2008)

For further discussion about achievements and prediction of future ways of wind power development maps of individual factor on landscape are made.

1) Method of derivation of realizable potential with respect to the density of VTE in neighbouring countries. Calculated density for South Moravian region is 0, 0214 turbines per square kilometre. The same calculation is used for territory of LAG Moravian Karst.
2) Deductive method of limitation factors. Three variants of future social acceptance towards wind power are set. Each variant contains a scenario of future attitudes about the wind power development and its promotion. More information about the scenarios' description is available in the study of Hanslian. (Hanslian, D. & coll., 2008)

Variant A: low scenario. This variant corresponds to a low acceptance and promotion for wind power. However the purchase prices are still preserved, the wind power development restrictions come from legislations.

Variant B: middle scenario. The attitude towards wind power is perceived by rational aspects. Wind power plants are considered as a clean energy source but anyhow not all of projects will succeed.

Variant C: high scenario. This scenario is based on high wind power promotion. The development is almost without any obstacles and almost all projects without serious impact on environment get the building permission.

Procedure

- Step one: to recalculate factor of standpoint onto a wind power development distributed by local municipalities and citizens, the amount of turbines analysed as technical potential and its capacity is reduced by: variant A 30%, variant B 55%, variant C 80%
- Step two: to recalculate factor of local technical limits the amount of turbines analysed as technical potential and its capacity is reduced by: variant A 35%, variant B 45%, variant C 50%
- Step three: localities recalculated by this step were already detached from analysis of technical potential. Therefore further limitations are not considered.
- Step four: to recalculate the grid capacity and results of landscape character assessment the area of those localities needs to be reduced by:
    - 1) territories under the elevation of 400 meters – within 1 kilometre zone of each turbine are accepted other turbines in amount of 1 for variant A; 2 for variant B; and 4 for variant C;
    - 2) territories above the elevation of 400 meters – within 1 kilometres zone of each turbine are accepted other turbines in amount of 2 for variant A; 4 for variant B; and 9 for variant C. The Hanslian values are decreased under the ratio of the Czech Republic area considering area of LAG Moravian Karst.

For better insight of individual factors considered above a series of additional map layouts need to be prepared:

- Random placement of wind turbines: according to result of technical potential, 16 turbines are placed in locations of technical potential according to the rule of maximal usage of the localities, plus 4 current turbines are displayed as well. Subsequently, these turbines are analysed according to step four described above, concretely a buffer zones of 1000 meters distance are implemented to them. Also, a criterion of step four is depicted as an individual layer when altitude is 400 m.s.l. or less.
- Map of visual impact onto areas of increased natural value: map layout contains all areas previously characterized as areas with increased nature value protected by legislation and the visual impact of wind turbines on them. Tool *viewshed* was used in order to depict the visual impact however the entering layer includes only ground elevation and ignore the terrain relief and land use.
- Map visual impact of randomly placed wind turbines on land cover: map layout contains all types of land cover, concretely the layer CORINE from CENIA and the visual impact of wind turbines expressed by tool *viewshed.*

Results

Climatological potential

Total area of suitable localities is equal to 188, 458 km² and corresponds to 32, 7% of total area of LAG Moravian Karst. Suitable locality for 2MW turbines has an area about 177, 994 km². The rest area, approximately 10, 464 km² is suitable for erection 3MW turbines. Climatological potential of LAG Moravian Karst is equal to 8 turbine of capacity 3MW and 142 turbines with capacity 2MW. Total possible installed capacity is 308 MW.

Technical potential

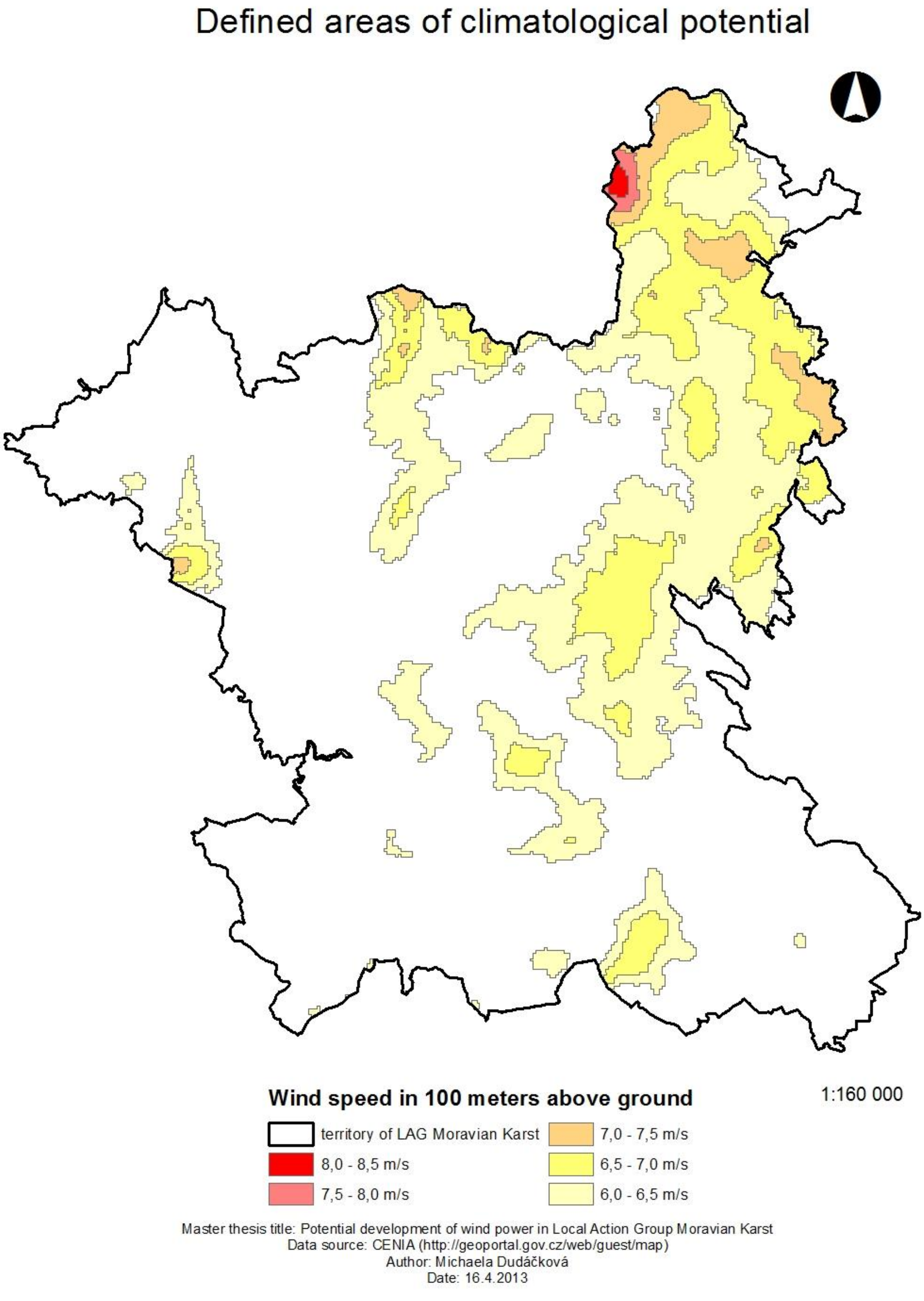
Total area of suitable localities is equal to 20, 915 km² and corresponds to 3, 6% of total area of LAG Moravian Karst. Total suitable locality is divided between 20, 854 km² for 2MW turbines and 0, 0603 km² for 3MW turbines. Technical potential of LAG Moravian Karst is equal to 16 turbines of capacity 2MW.Area suitable for 3MW turbines is inadequate for any development and thus is added to suitable area for 2MW turbines. However the technical potential is still 32 MW of possible installed capacity.

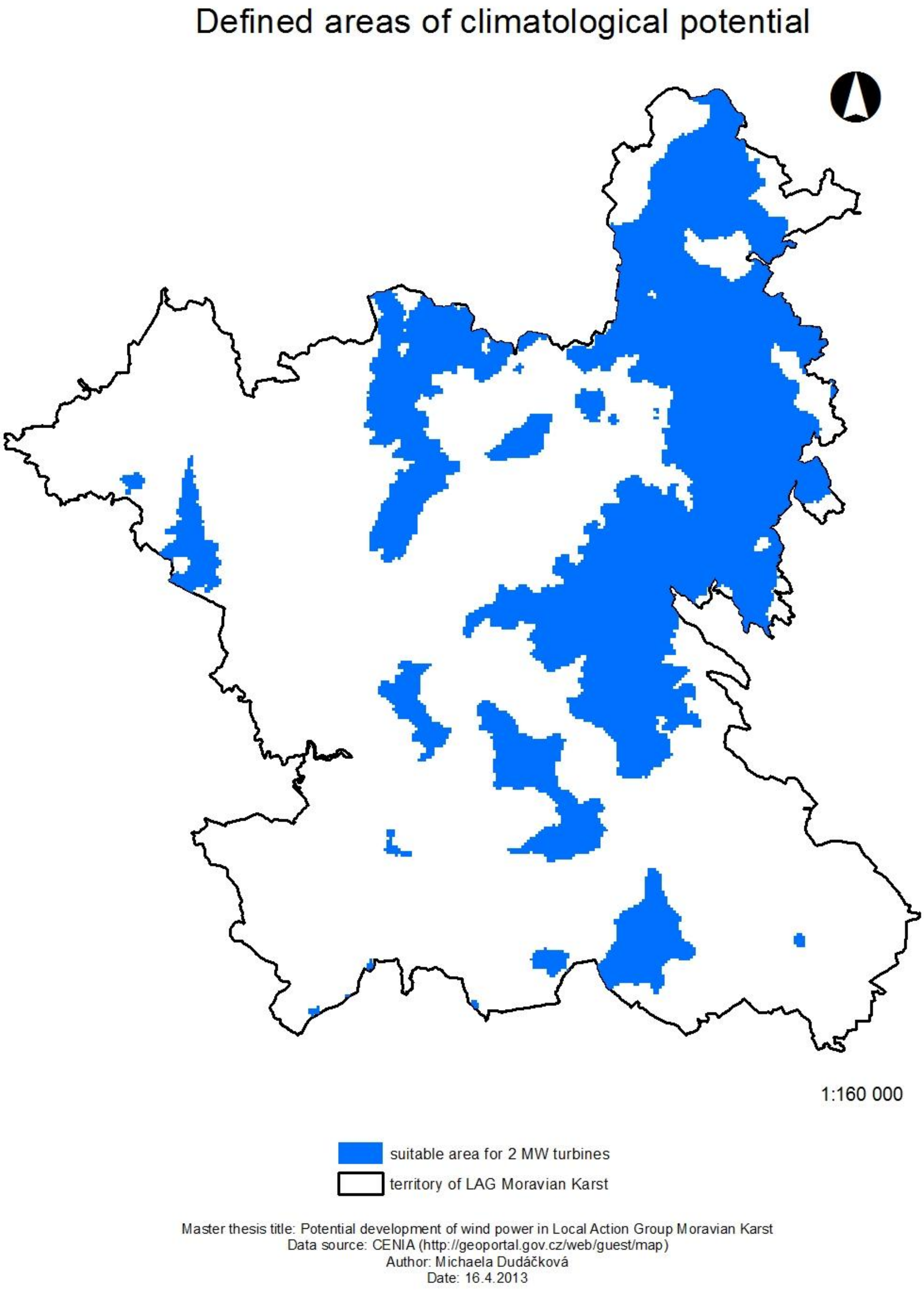
Realizable potential

According to first method, where the total area of the LAG Moravian Karst territory was recalculated towards trend of wind power development from abroad, the realizable potential is equal to 12 turbines. If this result of technical potential is related, the possible capacity of realizable potential is 24 MW.

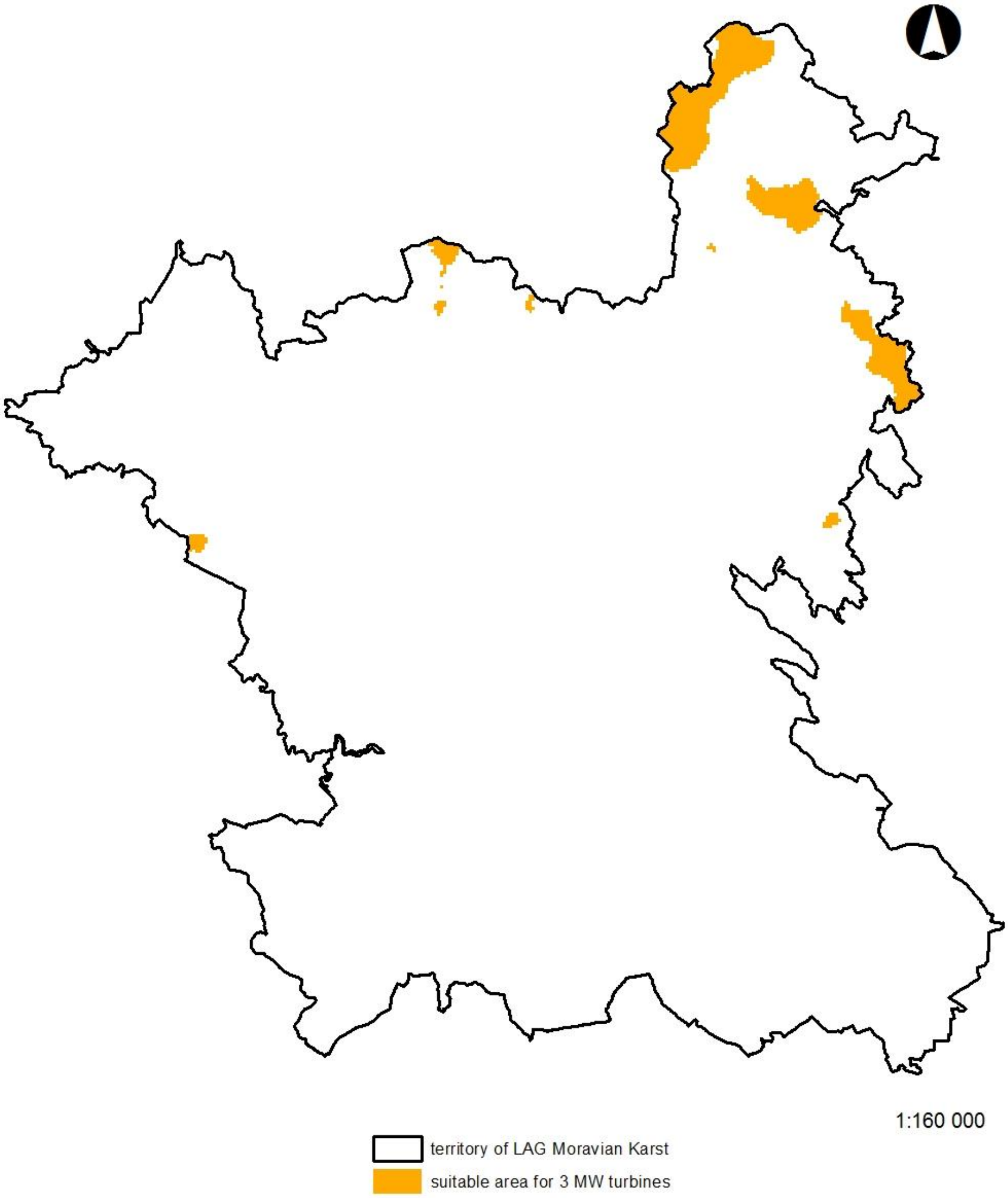
	Variant A	Variant B	Variant C
technical potential		**16**	
step one	4,8	8,8	12,8
step two	1,68	3,96	6,4
step three	1,68	3,96	6,4

Chart No.2 Reduction of technical potencial according to Hanslian (2008)


Defined areas of climatological potential
Wind speed in 100 meters above ground
1:160 000
territory of LAG Moravian Karst
8,0 - 8,5 m/s
7,5 - 8,0 m/s
7,0 - 7,5 m/s
6,5 - 7,0 m/s
6,0 - 6,5 m/s
Master thesis title: Potential development of wind power in Local Action Group Moravian Karst
Data source: CENIA (http://geoportal.gov.cz/web/guest/map)
Author: Michaela Dudáčková
Date: 16.4.2013


Defined areas of climatological potential
1:160 000
suitable area for 2 MW turbines
territory of LAG Moravian Karst
Master thesis title: Potential development of wind power in Local Action Group Moravian Karst
Data source: CENIA (http://geoportal.gov.cz/web/guest/map)
Author: Michaela Dudáčková
Date: 16.4.2013

Defined areas of climatological potential



Master thesis title: Potential development of wind power in Local Action Group Moravian Karst
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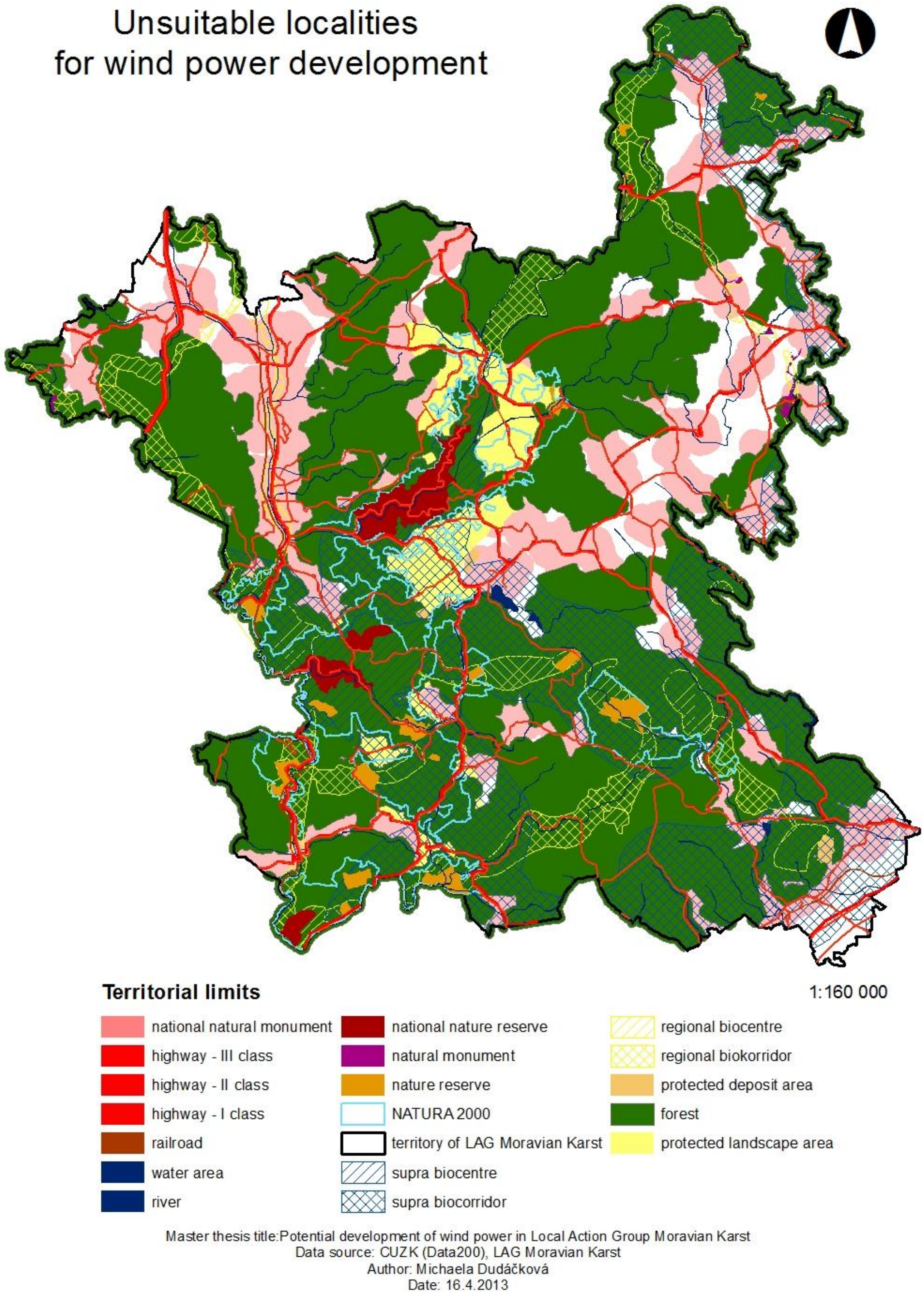
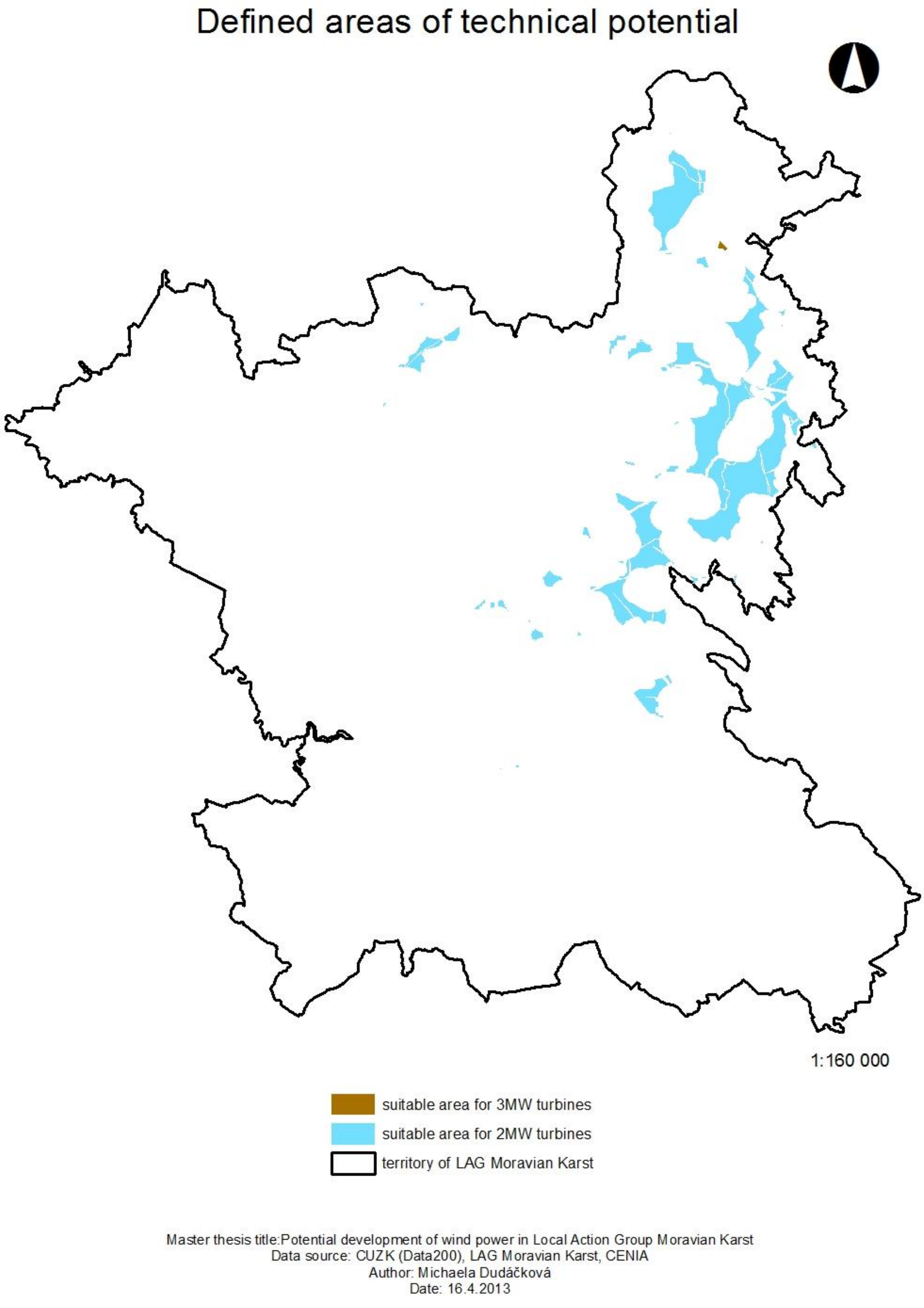
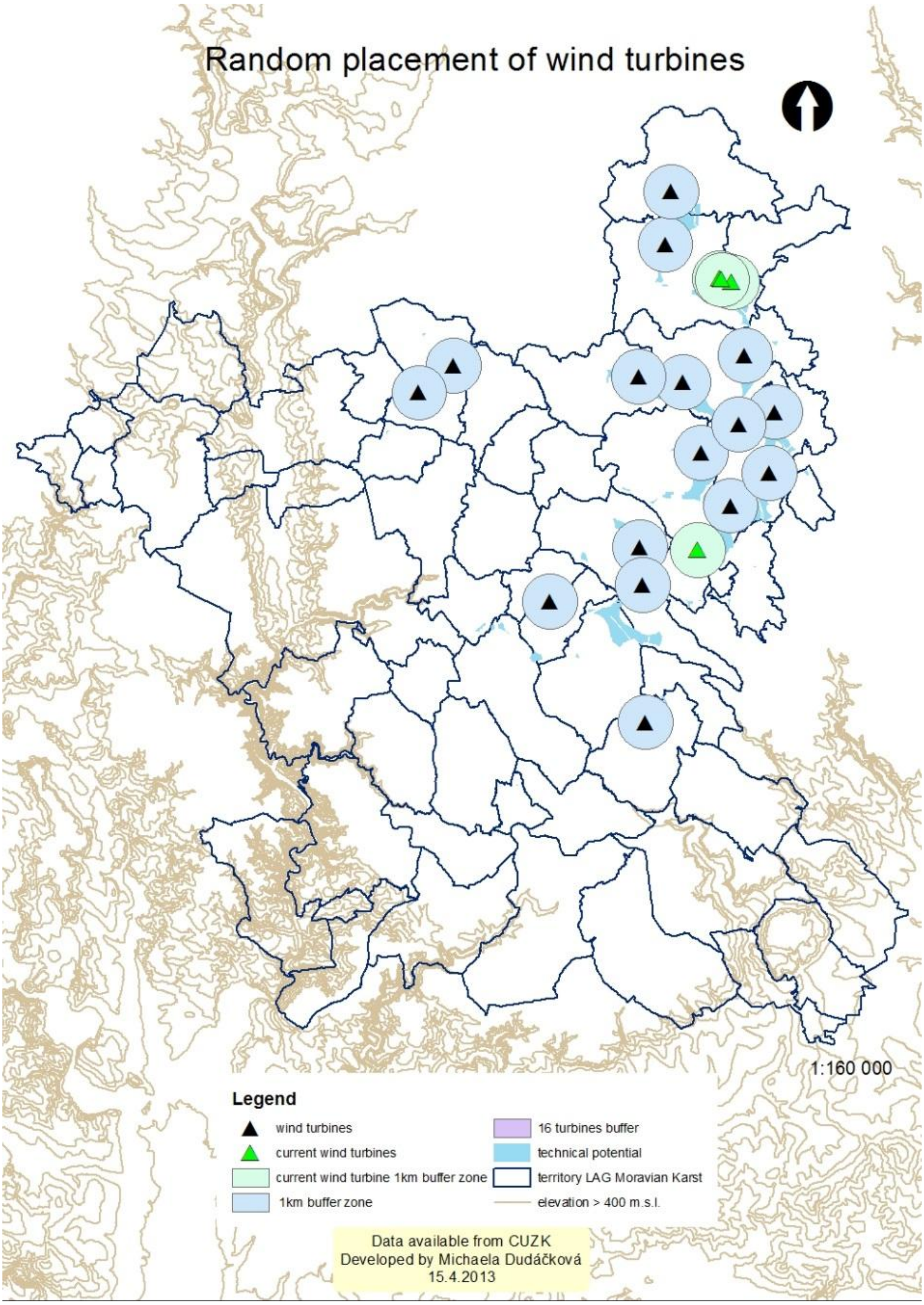
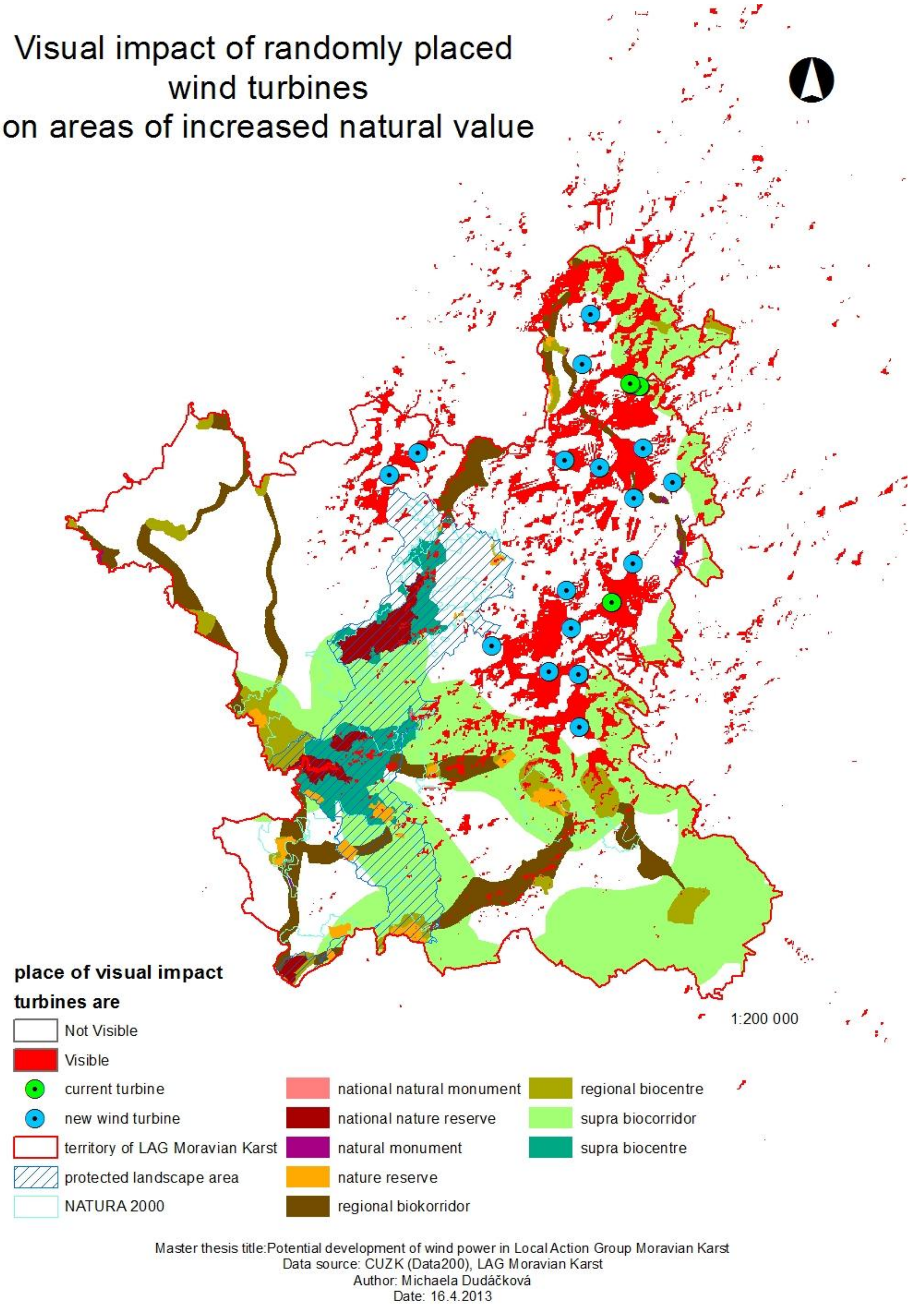
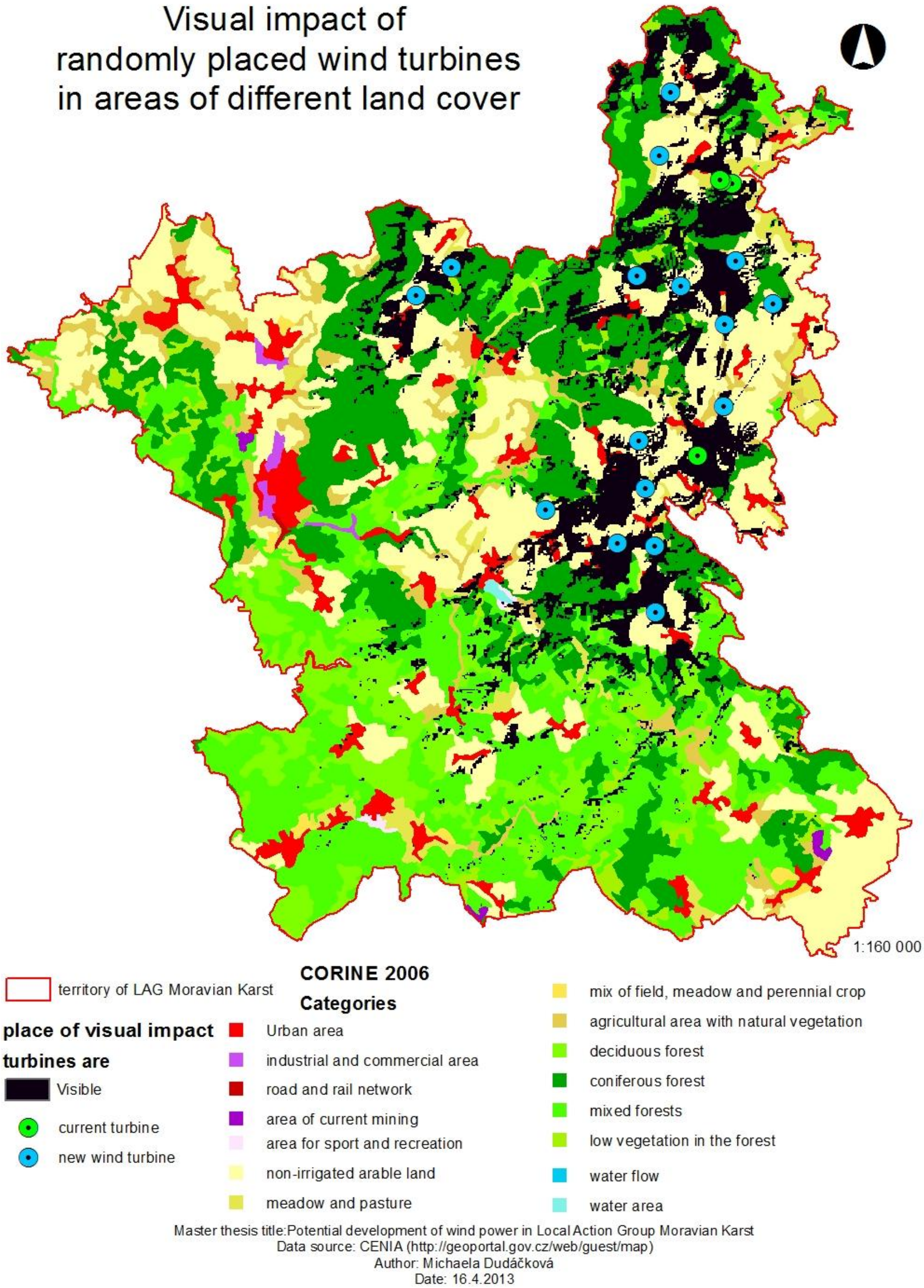

Unsuitable localities
for wind power development
Territorial limits
1:160 000
national natural monument
highway - III class
highway - II class
highway - I class
railroad
water area
river
national nature reserve
natural monument
nature reserve
NATURA 2000
territory of LAG Moravian Karst
supra biocentre
supra biocorridor
regional biocentre
regional biokorridor
protected deposit area
forest
protected landscape area
Master thesis title:Potential development of wind power in Local Action Group Moravian Karst
Data source: CUZK (Data200), LAG Moravian Karst
Author: Michaela Dudáčková
Date: 16.4.2013


Defined areas of technical potential
1:160 000
suitable area for 3MW turbines
suitable area for 2MW turbines
territory of LAG Moravian Karst
Master thesis title:Potential development of wind power in Local Action Group Moravian Karst
Data source: CUZK (Data200), LAG Moravian Karst, CENIA
Author: Michaela Dudáčková
Date: 16.4.2013


Random placement of wind turbines
1:160 000
Legend
wind turbines
current wind turbines
current wind turbine 1km buffer zone
1km buffer zone
16 turbines buffer
technical potential
territory LAG Moravian Karst
elevation > 400 m.s.l.
Data available from CUZK
Developed by Michaela Dudáčková
15.4.2013



Visual impact of randomly placed
wind turbines
on areas of increased natural value
place of visual impact
turbines are
Not Visible
Visible
current turbine
new wind turbine
territory of LAG Moravian Karst
protected landscape area
NATURA 2000
national natural monument
national nature reserve
natural monument
nature reserve
regional biokorridor
regional biocentre
supra biocorridor
supra biocentre
1:200 000
Master thesis title:Potential development of wind power in Local Action Group Moravian Karst
Data source: CUZK (Data200), LAG Moravian Karst
Author: Michaela Dudáčková
Date: 16.4.2013


Visual impact of
randomly placed wind turbines
in areas of different land cover
1:160 000
territory of LAG Moravian Karst
place of visual impact
turbines are
Visible
current turbine
new wind turbine
CORINE 2006
Categories
Urban area
industrial and commercial area
road and rail network
area of current mining
area for sport and recreation
non-irrigated arable land
meadow and pasture
mix of field, meadow and perennial crop
agricultural area with natural vegetation
deciduous forest
coniferous forest
mixed forests
low vegetation in the forest
water flow
water area
Master thesis title:Potential development of wind power in Local Action Group Moravian Karst
Data source: CENIA (http://geoportal.gov.cz/web/guest/map)
Author: Michaela Dudáčková
Date: 16.4.2013

Conclusion and discussion

Previously presented results of wind power potential suggest further development within the territory of LAG Moravian Karst. According to estimation of realizable potential, it is possible to erect 12 turbines. If the five current turbines are deducted, still 7 turbines can be built. But the second used method estimates more moderate future development, meaning only 2 – 6 turbines. Therefore, according to this method after deducting current turbines the future development could not change.

However the local landscape can include 16 turbines, concretely 11 new instalations according to the technical potential. The municipalities with auspicious localities are: Žďár, Němčice, Vysočany, Protivanov, Buková, Niva, Rozstání, Otinoves, Drahany, Lipovec, Kulířov, Krásensko, Senetářov, and Ruprechtov. Small areas of suitable localities are situated also in municipalities: Vilémovice, Kotvrdovice, Studnice, Nové Sady, Bousín, Petrovice, and Bukovina.

Climatological potential is also crucial for future wind power development. New technologies and methods allow using areas of forest as new localities for wind power development. Therefore, currently forest areas with sufficient wind speed, concretely huge areas in Buková, Protivanov, Blansko, Němčice, Senetářov, or Ruprechtov, can be used for wind power localities in the future. The possible use of forest as localities for wind power was not allowed yet and thus a debate about this issue has to come first. Moreover, the landscape protection has to be kept in mind and therefore possible conflict with protected areas or territorial system of ecological stability needs to be dealt initially with the competent authorities.

If any of municipality or investor would decide to erect wind turbine, several obstacles would have to be faced up firstly. These obstacles are connected mainly with conflict to landscape character, problems with connection into the distribution network, animal protection and social unacceptability.

The conflict with landscape character is very conceivable due to an extensive visual impact depicted on map “Visual impact of randomly placed wind turbines on areas of increased nature value” or “Visual impact of randomly placed wind turbines on areas of different land cover”. Areas with the highest potential conflict are situated on the east part of territory LAG Moravian Karst. The impact intervenes partly also in the centre and on the north of the micro-region Moravian Karst. Fundamental fact is the presence of current landscape dominant. If the dominants are situated in a small scale landscape, possible wind turbine could completely overshadow them. In this case the development would be rejected. This fact is attested by landscape character assessment. Nevertheless the fact that the turbine has got only 20 years of life-time and after removal of construction the landscape will be again without this negative dominant should be kept in mind during the evaluation process.

The issue of involvement the turbines into the distribution network depends only on Eon, the distribution company. The question is how fast the company can renovate the current network. According to actual situation, the turbines are still allowed to connect. Nevertheless to prevent the problems with the grid capacity there is the possibility to rebuild the current electrical network into smart grid. This issue is although the future one.

Third obstacle is the conflict with avifauna, concretely with bats and birds. According to common practice at least one year observation of locality of wind power development is needed. 58 species of protected birds are already recorded. It is therefore difficult to determine in advance if this fact can reject the wind power development.

The last main obstacle is the acceptation of local citizens. The citizens` participation in wind power project can be organized by LAG Moravian Karst. The staff can arrange workshops and seminars for citizens or prepare a field trip to cognitive visit of similar wind power turbine. In this case, the most important factor is to get enough information about possible impacts and profits.

Originally intended evaluation of specific location by special wind power software WindPro is not involved in the thesis. Unfortunately, the initial cooperation with course of Karin Hammarlund and Tore Wizelius from The Swedish University of Agriculture Sciences were cancelled due to complete abolition of the course. Any other way to get the licence was not possible. Usage the student licence of WindPro is excluded by cooperation with EnergyRegion project and LAG Moravian Karst.

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Appendix

Economic evaluation of wind power plant development in south Moravia, concretely Vranov platform

- Variant A: Vestas V90-2, 0 MW, 105,7 db(A), rotor diameter 90 meters
- Variant B: Vestas V80-2, 0 MW, 101,0 db(A), rotor diameter 80 meters
- Variant C: Enercon E66-20.70, 103,0 db(A)rotor diameter 70 meters, non-transmission type

Operating costs

	Variant A	Variant B	Variant C
wages and insurance	230 000 CZK	230 000 CZK	230 000 CZK
repairs	200 000 CZK	200 000 CZK	200 000 CZK
maintenance	500 000 CZK	500 000 CZK	500 000 CZK
turbine insurance 0,5%	405 889 CZK	337 207 CZK	313 317 CZK
overhead costs	50 000 CZK	50 000 CZK	50 000 CZK
energy	90 000 CZK	36 000 CZK	22 500 CZK
total	**1 475 889 CZK**	**1 353 207 CZK**	**1 315 817 CZK**

Chart No.3: Annual operating costs (Veronica, 2007)

Operation of wind turbine is considered as unattended. The condition will be controlled remotely by a system notifying failures via SMS. The insurance for the turbine is crucial, mainly for case of lightning damage and other extreme wind condition. Also, annual service controls are required. Considered operating costs are same for all variants, except insurance costs which are dependent on turbine's type.

Annual energy production

	Variant A	Variant B	Variant C
Annual production of electricity (netto) MWh	4 244,20	3 115,00	2 665,60
Annual utilization of installed capacity hours	2 122,10	1 557,50	1 332,80

Chart No.4: Comparison variants according to annual energy production (Veronica, 2007)

Investments costs

	Variant A	Variant B	Variant C
Technology (wind turbine)	58 800 000 CZK	52 164 000 CZK	47 628 000 CZK
Grid connection HV/UHV	3 375 000 CZK	3 375 000 CZK	3 375 000 CZK
Building part	7 210 764 CZK	7 210 764 CZK	7 210 764 CZK
Project documentation	635 000 CZK	635 000 CZK	635 000 CZK
Energy audit	96 000 CZK	96 000 CZK	96 000 CZK
Total (VAT does not included)	**70 116 764 CZK**	**63 480 764 CZK**	**58 944 764 CZK**
Total (VAT included)	**83 438 949 CZK**	**75 542 109 CZK**	**70 144 269 CZK**

Chart No.5: Investments costs (VAT – income tax rate is 24%; according to §19 par. d) Act no. 586/1999 on income tax, the installation is exempt from income tax for 5 years since the beginning of production.) (Veronica, 2007)

Evaluation

	Variant A	**Variant B**	**Variant C**
Investment costs	70 116 800 CZK	63 480 800 CZK	58 944 764 CZK
Net present value (NVP)	14 722 000 CZK	-4 441 000 CZK	-10 321 000 CZK
Internal rate of return (IRR)	9,62%	6,09%	4,66%
Simple payback period	9 years	11 years	13 years
Discounted payback period	14 years	>Le years	>Le years
Year of evaluation	2008	2008	2008
Lifetime of the equipment (Le)	20 years	20 years	20 years
Discount	7%	7%	7%

Chart No.6: Result of economic evaluation of three variants (Veronica, 2007)

Economic parameters

Discount	Energy purchase price	Average increase in purchase price	Average increase of energy consumption
7%	2,46 CZK/kWh	0%	2%
Average increase of other costs	Period of valorisation	Income tax	Exemption from income tax
2%	20 years	24%	5 years

Chart No.7: General economical parameters (Veronica, 2007)

According to the economic evaluation showed in the charts above the only economic profitable variant is variant A – Vestas V90. This turbine has a higher electricity production due to rotor diameter. On the other hand, the investment costs are higher over 6, 6 million CZK comparing to variant B which could be a decisive factor for investor.

(Beranovský, J.Srdečný, K. , 2007)

Species of protected birds

SPECIES	CATEGORY OF PROTECTION	6565	6665	6765	6566	6666	6766	6567	6667	6767
LITTLE GREBE	VU	1B		3C		5C	6A			9C
GREAT CRESTED GREBE	VU			3C		5B		7A		9C
LITTLE BITTERN	CR				4B					
BLACK STORK	VU	1C	2C	3C	4C	5C	6B	7A	8C	9C
MUTE SWAN	EN		2B	3C		5B		7C	8B	9C
GADWALL	VU			3B						
COMMON TEAL	CR					5B				9B
GARGANEY	CR			3B		5B	6B			9B
NORTHERN SHOVELER	CR					5A				
EUROPEAN HONEY-BUZZARD	VU	1A	2A	3A		5C	6B	7A	8C	9C
BLACK KITE	CR			3A						
WESTERN MARSH-HARRIER	VU	1B	2B	3C	4B	5B	6A	7A	8B	9C
NORTHERN HARRIER	EN				4A					
NORTHERN GOSHAWK	VU		2C	3B	4A	5C	6B	7C	8C	9C
EURASIAN SPARROWHAWK	VU	1C	2C	3C	4A	5C	6B	7C	8C	9C
EURASIAN HOBBY	EN							7C		9A
PEREGRINE FALCON	CR	1A				5B			8A	
WATER RAIL	EN				4B				8B	9B
CORNCRAKE	VU		2B				6B	7B		9B
LITTLE RINGED PLOVER	EN					5B			8C	9C
NORTHERN LAPWING	VU		2A	3C	4B			7A	8C	9C
COMMON SNIPE	EN					5A				9A
EURASIAN WOODCOCK	VU		2B	3B	4B	5A	6A	7B	8B	9B
COMMON REDSHANK	CR									9A
GREEN SANDPIPER	EN			3A						
COMMON SANDPIPER	EN		2A		4B	5B				
COMMON BLACK-HEADED GULL	VU				2A	5A		7A	8A	9B
STOCK PIGEON	VU		2C	3C	4C	5C	6C	7B	8C	9C
BARN OWL	EN							7B	8A	9C
EURASIAN EAGLE-OWL	EN		2C	3C	4B	5C	6A		8C	9C
EURASIAN PYGMY OWL	VU		2A					7A		
LITTLE OWL	EN									9A
BOREAL OWL	VU		2B	3A	4B	5A			8B	9C
EURASIAN HIGHTJAR	EN								8A	9A
COMMON KINGFISHER	VU	1C	2A	3A	4C	5A		7C	8C	9C
EUROPEAN BEE-EATER	EN									9C
EURASIAN HOOPOE	EN						6A	7A	8A	9A
EURASIAN WRYNECK	VU	1A	2B	3B	4B	5B	6B	7C	8C	9C
GREY-FACED WOODPECKER	VU		2A	3C	4B	5B	6B	7A	8B	9A
SYRIAN WOODPECKER	EN							7C	8B	9C
MIDDLE SPOTED WOODPECKER	VU		2C	3C	4B	5C	6B	7C	8B	
LESSER SÚOTTED WOODPECKER	VU		2B	3B	4A	5B	6B	7C	8B	9B
CRESTED LARK	EN		2B			5B		7B	8C	9B
WOOD LARK	EN			3C			6C		8C	
YELLOW WAGTAIL	VU							7A		9B
COMMON STONECHAT	VU	1B		3C	4B	5B	6C	7C	8C	9C
NORTHERN WHEATEAR	EN								8C	
SAVI´S WARBLER	EN				4B					
GREAT REED WARBLER	VU				4B	5B				9B
BARRED WARBLER	VU	1B			4C			7C	8B	9C
RED-BREASTED FLYCATECHER	VU		2A	3C	4B	5B	6B	7B	8B	9B
GREAT GREY SHRIKE	VU		2C	3C	4A	5C		7C	8A	9C
SPOTTED NUTCRACKER	VU		2B			5B	6A		8A	
ROOK	VU								8A	
COMMON RAVEN	VU		2C	3B	4C	5C	6C		8B	9C
COMMON ROSEFINCH	VU		2A							
ORTOLAN BUNTING	CR									9B
CORN BUNTING	VU			3B			6C	7C	8B	9B

Category of protection: VU – vulnerable species, EN – endangered species, and CR – critically endangered

Letters: A - Possible nesting, B - Probable nesting, and C - Documented nesting

Four digit numbers indicate the number of square where the nest is located.

Šťastný & col, 2010