CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Faculty of Economics and Management

Department of Economics

CZECH UNIVERSITY OF LIFE SCIENCES PRAGUE

Bachelor Thesis

Economy of Wind Energy in the Czech Republic and Germany

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BACHELOR THESIS ASSIGNMENT

Valentina Petrová

Economics and Management

Thesis title

The Economy of Wind Energy in the Czech Republic and Germany

Objectives of thesis

The aim of the thesis is to conduct analysis of energetic situation in the Czech Republic and Germany and to compare it.

Methodology

In the thesis were used comparative and descriptive methods. The thesis was based on exploration of literature, and internet resources.

The proposed extent of the thesis

40 pages

Recommended information sources

Pierre Bacher. Energie pro 21. století / Přel. J. Grospietsch. 1. vydání. Praha, HZ Editio, 2002. 182 s. ISBN 80-86009-40-8

Starý, Jaromír. Surovinové zdroje České republiky. 1. vydání. Praha : Ministerstvo životního prostředí České republiky/Geofond, 2005, 216 s. ISBN 80-7212-352-1

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Statutory declaration

I, the undersigned, hereby declare that the thesis „Economy of Wind Energy in the Czech Republic and Germany“ is result of my personal work and only sources I used are listed in the references.

In Prague, March 9, 2015.

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Valentina Petrová

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Economy of Wind Energy in the Czech Republic and Germany

Ekonomika větrné energetiky v České republice a Německu

Summary

The goal of this bachelor thesis is to conduct analysis of energy in the Czech Republic and Germany with focus on wind energy. Also, energetic situation in both countries is compared. To conduct analysis, data of both countries were firstly gathered separately and then compared with each other.

The thesis is divided into two parts. First part, theoretical part, explains basic terms connected with energy with focus on wind energy and its generation. Second part, analytical part, is based on results of comparison and description of situation in the Czech Republic and Germany. These results are shown in graphs.

Souhrn

Cílem této práce je analýza energetické situace v České republice a Německu se zaměřením na větrnou energii a její získávání v České republice a v Německu. V práci je porovnána energetická situace obou zemí. K této analýze byla sesbírána data obou zemí a ta byla následně porovnána mezi sebou.

Práce je rozdělena do dvou částí. První část vysvětluje základní pojmy týkající se energie se zaměřením na větrnou energii a její získávání a v druhé části, analytické, jsou získaná data popsána, zhodnocena a výsledky jsou vyobrazeny v grafech.

Keywords: Czech Republic, Germany, Renewable energy, Wind energy, Economy of wind energy

Klíčová slova: Česká republika, Německo, Energie z obnovitelných zdrojů, Větrná energie, Ekonomika větrné energie

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List of abbreviations

€ - Euro

bill. – billion(s)

ct – euro cents

CZK – Czech Crowns

e.g. exempli gratia, for example

etc. et cetera, and so on

FIT – Feed-in Tariff

kWh - kilowatt-hours

m – meters

MW – Megawatt

MWh - Megawatt-hours

O & M – Operational and maintenance costs

RES – renewable sources of energy

UK – The United Kingdom of Great Britain and Northern Ireland

1. Introduction

Energy is very important for life and it is used every day all around the world. There are two major types of sources of energy, renewable and non-renewable resources. Generating energy from renewable resources is more and more important nowadays, because Earth is losing its non–renewable resources. Combining renewable resources with recycling may ensure a cleaner environment for future generations and hopefully slow down climate change. Non-renewable resources such as fossil fuels, oil, and gas probably will not be available for future generations or they will be available only in limited amount and eventually, they will run out. A typical example of a fossil fuel is coal, and when coal is burned to get the energy from it, many particles harmful to the environment are released. Also, coal has to be mined first, and that is very dangerous for miners causing them health problems and there is a possible danger of death.

We have to protect Earth and its environment, and that is why it is necessary to find resources, which are a part of natural environment and are not harmful to the environment and have no undesired effects on Earth and its surrounding atmosphere. Renewable energy can be produced from many RES including wind, solar, hydro, biomass, etc. RES unfortunately cannot replace all sources of energy but can become a very valuable source of energy and also to contribute to lowering prices of energy.

In this bachelor thesis is compared situation in the Czech Republic and Germany with focus on one of the RES, on wind energy. There are compared productions of both countries and shares of both renewable and non-renewable resources and finances obtained by investors in wind turbines.

Wind energy is being developed very rapidly both in Europe and worldwide, but possibilities of particular countries must be taken into account. Some countries have higher shares of different RES, such as biomass, water, and solar energy and combining various RES in various countries can ensure higher total share of RES in production of energy in the world.

2. Objectives

The aim of the thesis is to conduct analysis of different sources of energy with focus on renewables, mainly wind, in the Czech Republic and Germany and to compare positions of both countries. Energetic situations in both countries are described and evaluated and their participation in target of European Union is described as well including future plans of the Czech Republic and Germany. Special attention is paid to wind energy and its generation.

3. Literature Review

3.1 Renewable and non-renewable resources

Renewable resources are resources that can be restored naturally during their use and those that can return by growth or replenishment, e.g. wind, water, wood. Renewable resources in general are those resources, which are supplied by nature. Non-renewable resources are defined as natural resources which are exhaustible and which cannot be regenerated after their usage, e.g. coal, natural gas, oil (OECD, 2001).

3.2 Wind

The atmosphere surrounds Earth and consists of air, which is a combination of gases and other particles. Wind is the movement of air, which is caused by unbalanced heating of the surface of Earth by the Sun. Its speed and direction is usually measured. Direction indicates where the wind is flowing from. Even though wind can be uncertain source of energy, it is quite predictable. Wind is one of sustainable resources of energy and during production of wind energy neither water nor air is polluted, which is very important for our planet and us. Therefore wind is a pollution-free source of energy (AWEA, 2013).

Wind is measured according to Beaufort Wind Force Scale, which was developed by Francis Beaufort in 1806, a Navy officer. Beaufort Wind Force Scale measures wind´s speed and describes how it can be seen on land or at sea (Britannica, 2013).

3.3 Wind Turbines

According to The European Wind Energy Association (2014), wind turbine is a machine that transforms kinetic energy of wind into mechanical or electrical energy.

There are many different types of wind turbines, e.g. there are three main types of wind turbines according to their size: small, middle, and large ones. They can be found both onshore (on land) and offshore (on water). A variety of styles exists – wind turbines can have either horizontal or vertical axis. There is a difference in their rotor shaft and also in the location of a generator. Vertical axis wind turbines have a generator and a gearbox at the bottom of a turbine while horizontal axis wind turbines have an electrical generator located at the top of the turbine. Nowadays the most common type is a horizontal axis wind turbine (Al- Shemmeri, 2010 and Manwell, James F. 2009).

The amount of power generated depends on their capacity, hub height and a diameter of a rotor, not only on wind speed and direction.

A wind turbine consists of four visible parts: a foundation, a rotor consisting of a hub and blades, a tower, and a nacelle. A foundation holds the tower so it does not fall over. Onshore and offshore wind turbines have different foundations. A rotor has two parts – a hub and blades, which are typically made from fibreglass-reinforced polyester or epoxy resin and new materials are being brought into use as well. A nacelle is a box where are components necessary for production of wind energy and it protects from atmospheric conditions what is inside. Wind turbines usually work for about 20 years (IRENA, 2012).

Wind turbines generate energy at wind speeds of 4 – 25 meters per second. In case the wind would be faster than 25 m/s, the turbine will be stopped so the possible damage is prevented (EWEA, 2014).

Wind turbines also vary in height, and in number of blades. Most of wind turbines have three blades, because it's the most efficient number of blades.

The most important condition for good functionality of a wind turbine is wind and its average speed in a particular area. Obtained energy lowers with every small decrease in wind speed. So before projecting an installation of a wind turbine, the developer should know the average wind speed throughout year. It is also very important to know whether there are some effects, which might cause temporary shutdown of a wind turbine, how often these effects might occur, and also for how long these effects might last.

In the table "Impact of turbine sizes, rotor diameters and hub heights on annual production" are compared different parameters of a wind turbine and how it affects their annual production. There is shown that in case of a 3 MW generator, there is different amount of produced energy depending on the diameter of a rotor and the hub height. A hub height is the distance from the rotor to the platform (3Tier, 2015).

Table 1 - Impact of turbine sizes, rotor diameters and hub heights on annual production

Generator size, MW	Rotor, m	Hub Height, m	Annual production, MWh
3.0	90	80	7 089
3.0	90	90	7 497
3.0	112	94	10 384
1.8	80	80	6 047

Source: IRENA, 2012.

Wind farms are groups of wind turbines in the same location and can be located either onshore or offshore. When planning a wind farm, there are many important factors. The location of a wind farm should be wide and open. The turbines also should be accessible without any difficulties for maintenance and repairs, which may occur. It is important to choose the right type of a wind turbine, which depends on the wind conditions and characteristics of landscape of the area. Also, possible risks should be taken into account – risks such as earthquakes (EWEA, 2014).

3.3.1 Onshore Wind Turbines

Onshore wind turbines are located on land. Most turbines have three blades but also other types are possible. Blades have a special shape to collect as much wind as possible. These blades spin a shaft, which connects to a generator that produces electricity. In the nacelle are a low-speed shaft, a gearbox, a high-speed shaft and a generator. Electricity from the generator goes to a transformer (EWEA, 2009-2014).

3.3.2 Offshore Wind Turbines

An offshore wind turbine works on the same principle as an onshore wind turbine but it is located permanently in the water. Therefore the main and the most obvious difference between an offshore and onshore wind turbine is in its foundation. The blades of an offshore wind turbine are usually longer and taller, which ensures more electricity (IRENA, 2012).

It is more costly than an onshore turbine, but more power is produced. There are stronger wind speeds available around water. Offshore wind turbines are usually much larger than onshore wind turbines. The diameter of a rotor can be up to 125 meters and it usually weights more than 1,000 tons (Windenergie A., 2015).

3.4 Wind Energy

Term wind energy refers to a technology, which results in energy generated from wind. This source of energy is one of RES and it is a form of solar energy. It is a result of a process where the wind movement is converted into electricity. Wind turbines are used for this process (The Office of Energy Efficiency & RES, 2015).

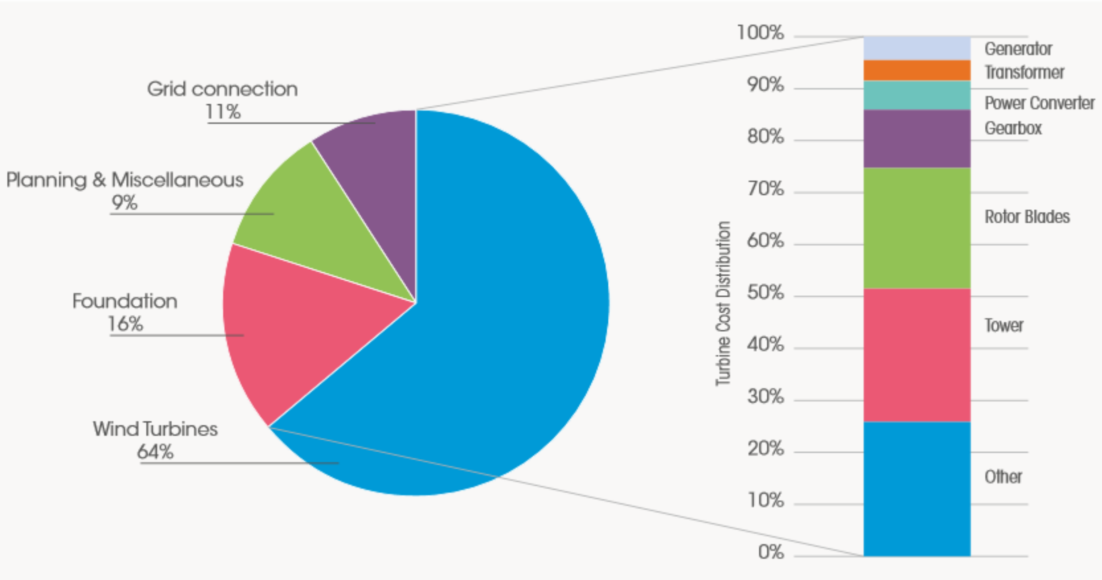
One of many benefits of wind energy is that the country's economy is not that dependent on price of fuel. The future prices of fuel will not affect the costs of generation of wind power, which is important for future generations (EWEA, 2009).

3.4.1 Basic costs of wind energy

One of many advantages of wind energy is that it lowers country's dependence on fuel price. Approximately 75% of the total costs of wind energy are costs such as the cost of the turbine, electrical equipment, grid-connection, and so on. Costs of fuel, which fluctuate a lot, fortunately don't have any impact on costs connected with generation of wind power (EWEA, 2009). The total costs vary among countries and according to a report The Economics of Wind Energy by the European Wind Energy Association (2009); in 2006 the costs were the lowest in Denmark and only slightly higher in Greece and the Netherlands.

The total costs are one of the benefits of wind energy and its generation, because besides the initial costs and maintenance and operational costs during the lifetime of a wind turbine, there are no other costs. Maintenance and operational costs are higher for offshore wind farms, which are caused by their location and its surrounding environment (IRENA, 2012).

Figure 1 - Capital Cost Breakdown for a Typical Onshore Wind Power System and Turbine



Source: IRENA, 2012

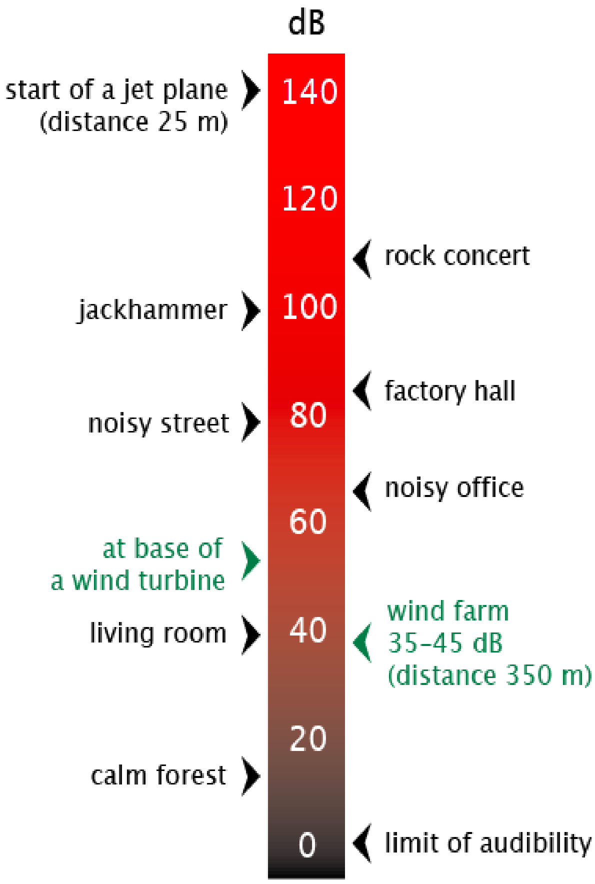
According to IRENA (2012), the main costs parts are the rotor blades, the tower, and the gearbox. These are stated altogether as "Wind Turbines" in the graph and represent up to 64% of turbine costs. The foundation represents up to 16%, and the third most expensive part of a turbine is grid connection, but this may vary according to the amount of grid connection already built. Also land rent, when the investor does not own the land, may add to the total costs. These costs also vary between onshore and offshore wind turbines, because for offshore wind turbines the costs depend also on wave conditions, water depth, etc. and are generally more expensive.

According to EWEA (2009), the turbine itself represents 75% of total costs and in case of a typical 2 MW wind turbine installed in Europe in 2006 this cost is believed to be 928 000 € per MW. Grid connection is on second position and represents approximately 9% of total costs; in case of a 2 MW turbine the investment in grid connection would be around 110 000 € per MW. Third most expensive part of a wind turbine is foundation, representing up to 7% of total costs; in case of 2 MW the investment would be around 80 000 € per MW. Other costs are land rent, electric installation, consultancy, financial costs, road construction, and control systems and these altogether are 1 227 000 € per MW.

3.4.2 Advantages and disadvantages of wind energy generation

There are some disadvantages of wind turbines, such as the look. Some people might think (and they do) that the wind turbines are hideous and that they ruin the look of a nature. The turbines have to be built on a hill or spacious flat lands, because there is the windiest climate and it makes them more visible to humans. Other disadvantage is that older wind turbines might be noisy and people living close to wind turbines have made some complaints about the noise. But according to Edvard Sequens (2006) the level of noise of a wind turbine is between 35 and 45 dB. For comparison, it is the same level of noise as in a living room and is even lower than in a noisy office. The noise is harmful for humans when louder than 80 dB, when it reaches 120 dB, it is considered painful and when it goes up to 140 dB, it can cause irreversible malfunctions of sense of hearing (Sequens, Holub, 2006).

Figure 2 - Levels of noise



Source: Sequens, Holub, 2006

Unfortunately, the blades of a wind turbine can cause death of birds and bats, which fly nearby, because a rotating blade can hit them and kill them. Many studies have examined this direct impact of wind turbines on wildlife; not only on birds. To ensure the least impact on wildlife, locations where these animals can be found should be avoided when planning a wind farm (Bennett, et al., 2014).

Another problem occurs during transport of particular parts of a wind turbine. These parts are very big and the transport has to be planned well. And the most important problem is if there is no wind, there is no generated electricity from it. Its availability is not the same over a certain period of time, but it can be more or less predicted.

But the advantages are more important. Some of the advantages are the costs and the independency on price of a fuel, which is different from fossil fuel power plants. As mentioned above, approximately 75% of costs are associated with initial construction of a wind turbine or wind farm.

The most important advantage for our planet and environment is that wind energy is a clean form of energy. Wind energy generation does not cause any pollution and it does not produce any emissions and therefore it helps to avoid any environmental impact. Generating more wind energy rather than using non-renewable can also lower the price of electricity in the future. The size of a wind turbine can be adjusted according to needs and possibilities.

3.5 The Czech Republic

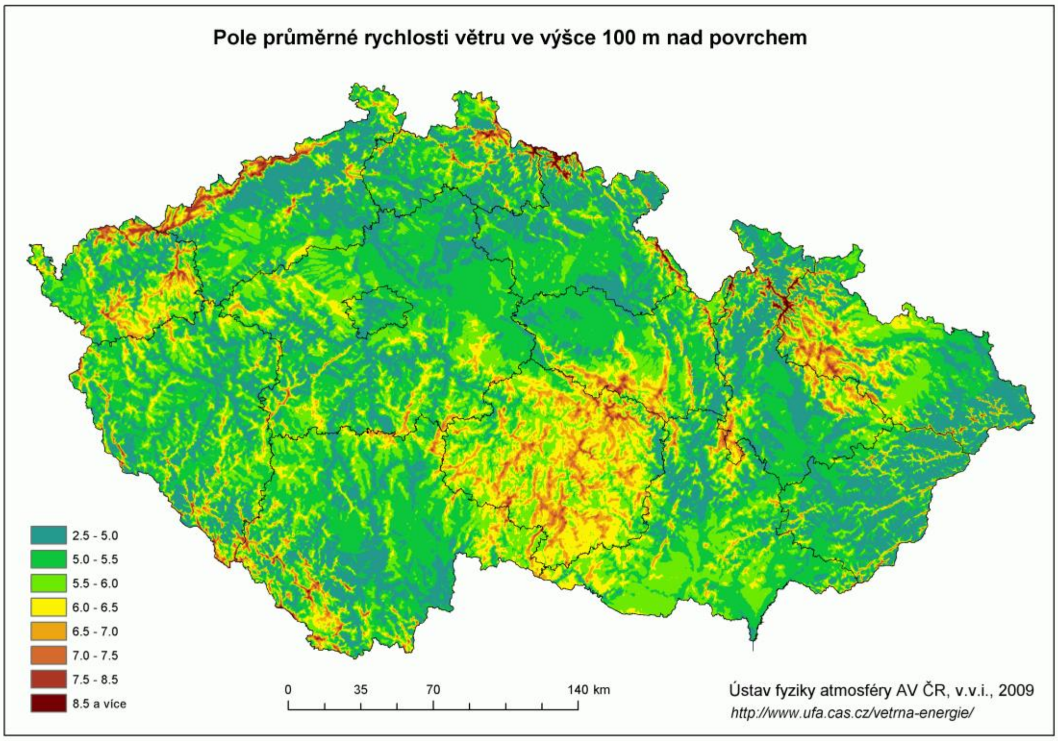
The Czech Republic is a country located in Central Europe. The total area is 78,866 square kilometres. The country's population is around 10,5 million people. The Czech Republic is bordered by Slovakia, Poland, Austria, and Germany. The surface varies a lot; there are both mountains and lowlands. Czech Republic is historically divided into 3 regions: Bohemia, Moravia, and Silesia. These three regions also vary in dialects, which are slightly different from each other.

The Czech Republic is also divided into 14 smaller regions according to bigger cities in the Czech Republic (such as Karlovy Vary, Liberec, etc.)

There are many mountain ranges in the Czech Republic and they are located mostly on the borders with other countries, e.g. Giant Mountains in the North (in Czech known as Krkonoše), The Bohemian Forest in South Bohemia (in Czech known as Šumava), and Jizera Mountains (in Czech known as Jizerské hory).

In the wind map of the Czech Republic below is shown where is the strongest wind. The Czech Republic is not very windy country, but the strongest wind is on the borders with Germany where are located the Ore Mountains (in Czech Krušné Hory), in the Giant Mountains in the North, Českomoravská vrchovina, and High Ash Mountains.

Figure 3 - Wind map of the Czech Republic



Source: Ústav fyziky atmosféry AV ČR, v.v.i, 2009.

3.6 Germany

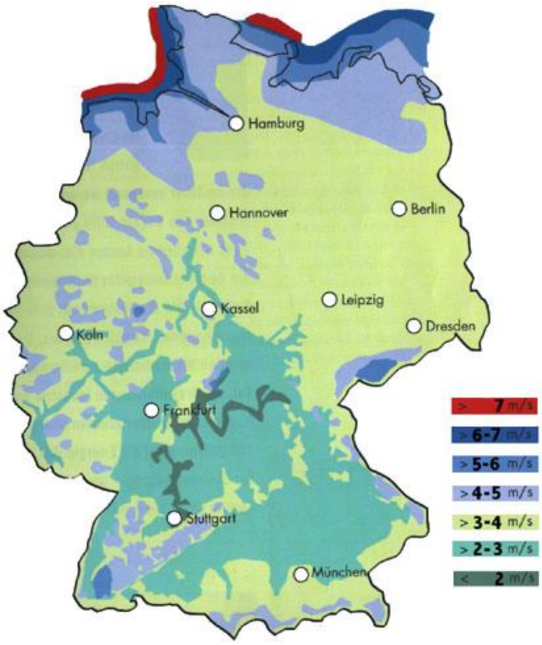
Germany is a country located in western-eastern Europe. The total area is 357,168 square kilometres of which almost 8000 square kilometres are covered by water. The country's population is around 82 million people. Netherlands, Belgium, Luxembourg, France, Switzerland, Austria, the Czech Republic, Poland, and Denmark border Germany. It is surrounded by two seas: the Baltic Sea and the North Sea, both from the North.

Germany is divided into 16 smaller regions (states); in German called Bundesländer.

The nature of Germany is very variable. There are also many mountain ranges and many of them are continued in the Czech Republic, e.g. The Bavarian Forest continues on the Czech side as The Bohemian Forest.

In Germany, the windiest part is on the sea, which is not visible in the map below.

Figure 4 - Wind map of Germany



Source: Espenergiania.blogspot.cz, 2012.

3.7 Feed-in tariff

Feed-in tariff is a policy designed to help bringing more investments in renewable energy. This tariff is implemented both in the Czech Republic and Germany. It also works in other countries, such as Ireland, France, The Netherlands, United Kingdom, United States, and many others. It was invented and first implemented in Germany, which became a so-called role model, in the early 1990´s, and has been modified since. This tariff states that energy obtained from renewable resources is more important than other sources of energy and those investors in renewable sources of energy are assured to have a certain amount of investment back, no matter what the electricity price is (Morris, Pehnt, 2012).

"*They put a legal obligation on utility companies to buy electricity from renewable energy producers at a premium rate, usually over a guaranteed period, making the installation of renewable energy systems a worthwhile and secure investment for the producer. The extra cost is shared among all energy users, thereby reducing it to a barely noticeable level. The FIT system means that the pay-back time for Photovoltaic is no longer several decades but several years instead*" (World Future Council, 2007).

This tariff differs by technology, and is stated every year for every type of RES. In the Czech Republic it is stated by ERÚ, Energy Regulatory Office and in Germany it is stated in Renewable Energy Act.

3.8 Wind turbines in the Czech Republic

Development of wind energy in the Czech Republic is unfortunately not as fast as in other European countries (Frantál, Kunc, 2011).

According to the CSVE (2013) purchase price was 2,014 CZK per kWh in year 2014, which is the lowest price out of all renewable sources of energy. In 2015 the purchase price is lower than in 2014, only 1,980 CZK per kWh. According to ČEZ (2015) the purchase price ensures that the payback period is approximately 15 years.

In the Czech Republic, there are only onshore wind turbines and are located mainly on the borders with Germany and Poland, in Moravia, and in Silesia because these are the best locations due to stronger wind.

In 2005 in the Czech Republic was created a "green bonus" – an alternative to FIT. Green bonuses are stated annually by Energy Regulatory Office (nazeleno.cz, 2008).

In the table "Purchase prices and green bonuses for the Czech Republic for year 2015" are listed purchase prices and green bonuses for year 2015 stated by the ERÚ in November 2014.

Table 2 - Purchase prices and green bonuses for the Czech Republic for year 2015

Wind Turbine			
Date of installation		Purchase price	Green bonuses
From	To	(CZK/MWh)	(CZK/MWh)
---	31.12.03	3 853	3 323
01.01.04	31.12.04	3 481	2 951
01.01.05	31.12.05	3 312	2 782
01.01.06	31.12.06	3 024	2 494
01.01.07	31.12.07	2 971	2 441
01.01.08	31.12.08	2 898	2 368
01.01.09	31.12.09	2 643	2 113
01.01.10	31.12.10	2 474	1 944
01.01.11	31.12.11	2 420	1 890
01.01.12	31.12.12	2 367	1 837
01.01.13	31.12.13	2 205	1 675
01.01.14	31.12.14	2 054	1 524
01.01.15	31.12.15	1 980	1 450

Source: ERÚ, 2014 b.

3.9 Wind turbines in Germany

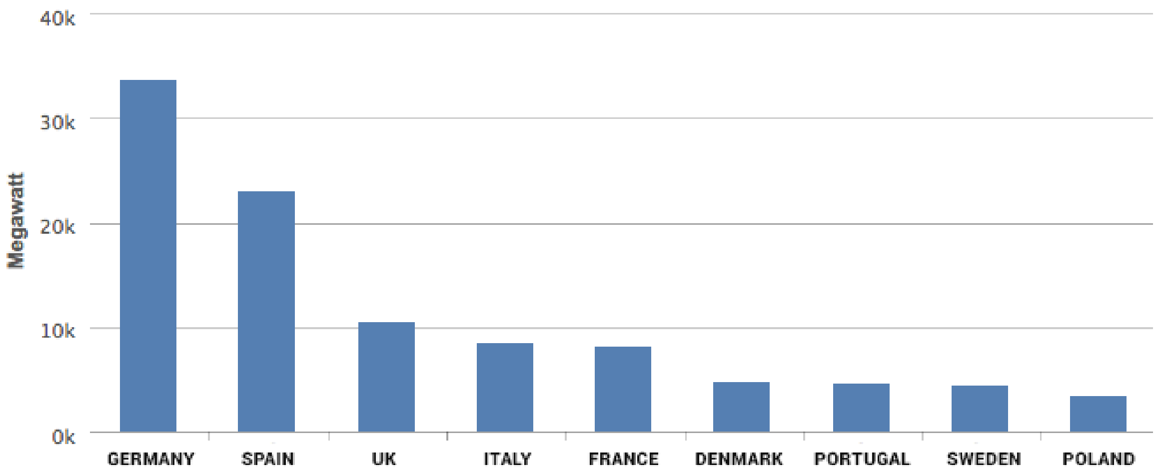
In Germany, there are both onshore and offshore wind turbines. Around the Baltic Sea and the North Sea, there is a very strong wind, which creates a good environment even for the offshore wind farms.

According to J. Phylip - Jones and T.B. Fischer (2014), Germany has now the biggest capacity in Europe. In the graph below is shown the capacity of Germany and other countries from European Union for comparison.

In Germany, Feed-in Tariffs are stated for 20 years, which is approximate lifetime of a wind turbine.

"Due to extensive research and development, wind turbine technology has made an enormous leap forward in recent years. A single wind turbine in the newest performance class can supply up to 4,800 three-person households with clean power. This is equivalent to 15 times the performance of wind turbines built in 1995. Even electricity yield at lower wind speeds is much higher today." (BWE, 2015)

Figure 5 - Germany total capacity in 2013 compared to other EU countries - Wind Energy



Source: BWE, 2013.

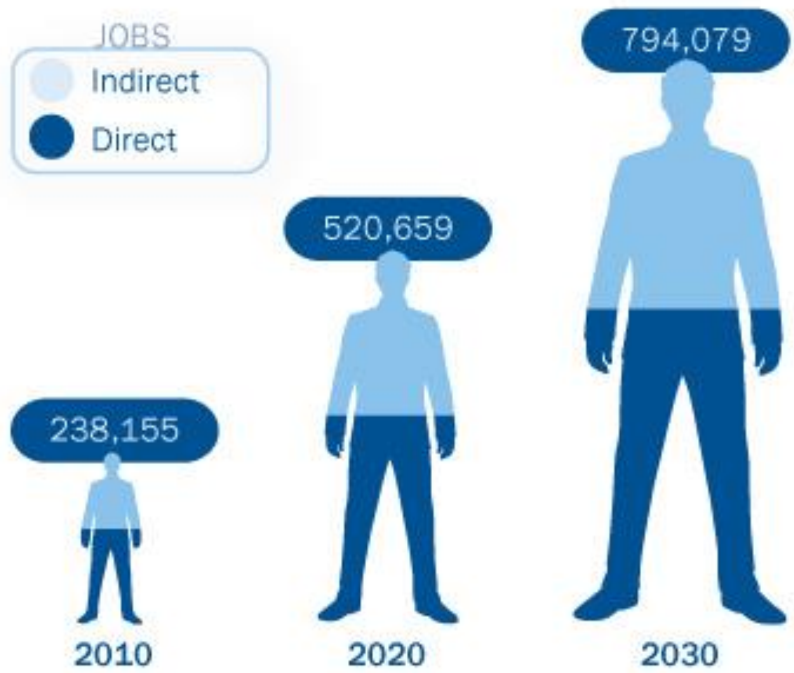
In the graph above is shown total capacity of Germany in 2013 in comparison with other European countries, which are in Top 10 countries. This graph shows how Germany has remained the leading country in Europe in 2013 (BWE, 2013).

3.10 Job positions in Europe

The wind industry, which is growing, also creates new job opportunities within Europe. According to EWEA (2014), the wind power sector employed around 238 000 people in year 2010 and according to their prediction for following years (2020 and 2030), the job positions will be rising. This industry creates jobs for both direct and indirect employees. Besides technical staff, it creates jobs e.g. for health and safety experts, programmers and meteorologists, lawyers and economists, and many others (WE, 2015).

Wind turbine manufacturers, an example of direct employment, are the largest group of employees, in year 2010; the amount of employed wind turbine manufacturers was around 45 thousand people (EWEA, 2012).

Figure 6 - Wind industry direct and indirect employment



Source: EWEA, 2012.

3.11 European Union Target

Energy is one of the major challenges for European Union nowadays. The main aim is to make certain a safe and secure energy supply, and by 2020 targets called "20-20-20" have to be reached. These "20-20-20" targets consist of 20% reduction in greenhouse gas emissions in comparison with levels of greenhouse gas emissions in year 1990, 20% of energy must be from RES and EU´s energy efficiency must be improved by 20% (EU, 2015). Renewable energy is very important and it is a key component of the EU energy strategy (European Commission, 2011).

The European Parliament and the Council of the European Union established a policy for the production and promotion of energy from RES, not only wind energy, in the European Union. Energy from renewable sources is stated as energy generated from non-fossil sources, such as wind, solar, aero thermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases. The Directive requires all countries within the EU to fulfil at least 20% of its total energy needs with renewables by 2020. It takes into account starting points and potential of all countries and it promotes cooperation amongst countries. Also, each of member countries has to ensure that at least 10% of their transport fuels originate in renewable sources by 2020 (European Commission, 2009).

Every two years, the countries have to make a report on their development towards the EU´s target in 2020 and the last report was issued in year 2013 (European Commission, 2015).

According to DIRECTIVE 2009/28/EC (2009), target for share of energy from RES in gross final consumption of energy for the Czech Republic in 2020 is 13% and 18% for Germany. In comparison, in year 2005 the share of the Czech Republic was 6.1% and the share of Germany was 5.8%.

In the table below, the countries are assessed against their 1st interim target, which is the average of their share from 2011/2012 (Directive 2009/28/EC, 2009).

Table 3 - National overall targets for the share of energy from RES in gross final consumption of energy in 2020

Member State	2005 RES share	2010 RES share	1st interim target	2020 RES target
Austria	23.3%	30.1%	25.4%	34.0%
Belgium	2.2%	5.4%	4.4%	13.0%
Bulgaria	9.4%	13.8%	10.7%	16.0%
Cyprus	2.9%	5.7%	4.9%	13.0%
Czech Republic	**6.1%**	**9.4%**	**7.5%**	**13.0%**
Germany	**5.8%**	**11.0%**	**8.2%**	**18.0%**
Denmark	17.0%	22.2%	19.6%	30.0%

<1% from or <2% above interim target

2% above interim target

Source: Report from the commission, 2013.

4. Methodology

In the thesis were used comparative and descriptive methods. The thesis was based on exploration of literature, publications of wind organizations in Europe and worldwide and Internet resources.

Firstly, in the theoretical part were explained and clarified basic terms according to gathered data. Also there were described situations in both countries, basic costs in Europe in general and European Union targets.

In analytical part were used comparative and descriptive methods. There were listed costs of wind energy compared to costs of energies from coal and gas, capacities in Germany and the Czech Republic from past three years, and production of energy in both countries in year 2013. Afterwards graphs were created to show shares of different sources of energy in the Czech Republic and Germany.

5. Results

The price of an offshore wind turbine is much higher than the price of an onshore wind turbine. It is caused by the difficulty to build it, and also more complicated foundation and cables in the sea. Construction costs depend on a location of a wind turbine, the further the wind turbine is from the land; the more cables must be placed.

The cost of offshore wind turbine per installed megawatt capacity is from 2.5 up to 4 million euros. In a 400 megawatt project the total investment can be over one billion euros. But if we compare it with an onshore wind turbine, it is still more effective, since and offshore wind turbine produces more power. According to Windenergie A. (2015), by comparison, a 5-MW plant at 2,000 full load hours produces 10 000-megawatt hours of electricity, while a 5-MW offshore wind turbine with 4 500 full load hours produces 22 500-megawatt hours, which is more than double the amount of power.

When a wind turbine is installed in a city or a village, the city hall can negotiate contract with the operator of a wind turbine or a wind farm. This contract can bring lots of money into a city account, which can be quite budget-wise.

5.1 Comparison of O&M prices of energies

Table 4 - Gas O&M costs

GAS

Cost component	Unit	2010	2020	2030
O&M costs	€/kWh	0.004	0.004	0.004
Percentage of Total costs	%	7.66	6.3	5.25

Source: EWEA, 2015.

Table 5 - Coal O&M costs

COAL

Cost component	Unit	2010	2020	2030
O&M costs	€/kWh	0.01	0.01	0.01
Percentage of Total costs	%	10.46	8.89	7.52

Source: EWEA, 2015.

Table 6 - Wind O&M costs

WIND ONSHORE

Cost component	Unit	2010	2020	2030
O&M costs	€/kWh	0.02	0.02	0.02
Percentage of Total costs	%	26.99	27.52	27.7

WIND OFFSHORE

Cost component	Unit	2010	2020	2030
O&M costs	€/kWh	0.02	0.02	0.01
Percentage of Total costs	%	24.55	24.55	23.41

Source: EWEA, 2015.

In these tables are compared operational and maintenance costs in euros per kWh for gas, coal, and wind (both onshore and offshore). According to these tables, the operational and maintenance costs are the highest for the wind energy, but also they represent about 25% of total costs. The highest expenses when building a wind turbine are initial costs, which is different from other sources of energy. It is shown, that the total costs of an offshore wind turbine are higher than the total costs of an onshore wind turbine.

5.2 Comparison of Fuel related costs of energies

Table 7 - Fuel related costs of Energy from Gas

GAS

Cost component	Unit	2010	2020	2030
Cost of fuel - assumptions	€/kWh	0.02	0.03	0.03
Risk - adjusted discount rate (fuel)	%	2.9	2.9	2.9
Percentage of Total Cost	%	61.86	60.21	59.61

Table 8 - Fuel related costs of Energy from Coal

COAL

Cost component	Unit	2010	2020	2030
Cost of fuel - assumptions	€/kWh	0.01	0.01	0.01
Risk - adjusted discount rate (fuel)	%	1.9	1.9	1.9
Percentage of Total Cost	%	24.92	18.12	15.9

Table 9 - Fuel related costs from Wind Energy

WIND ONSHORE

Cost component	Unit	2010	2020	2030
Cost of fuel - assumptions	€/kWh	0	0	0
Risk - adjusted discount rate (fuel)	%	0	0	0
Percentage of Total Cost	%	0	0	0

WIND OFFSHORE

Cost component	Unit	2010	2020	2030
Cost of fuel - assumptions	€/kWh	0	0	0
Risk - adjusted discount rate (fuel)	%	0	0	0
Percentage of Total Cost	%	0	0	0

Source: EWEA, 2015.

In the tables above are listed fuel related costs for several types of sources of energy. There are calculated assumed costs of fuel for gas, coal, and wind. The tables also show to which extent they affect total costs of particular source of energy.

Since wind energy does not need any fuel, there is no need to take into account any risk connected to the price of fuel and its fluctuation and that is what makes wind energy favourable to the future.

5.3 Comparison of total costs of energies

According to EWEA (2015) and their predictions for 2020 and 2030, the levelised cost of electricity per MWh will be the lowest for wind energy in both 2020 and 2030 in Europe.

Levelised cost of electricity generated from coal was in 2010 67.57 €/MWh, in 2020 it is expected to be 80.3 €/MWh, and in 2030 it is expected to be 96.11 €/MWh. For onshore wind, the prices were 64.84 €/MWh in year 2010. In 2020, the cost is expected to be 57.41 €/MWh, and in 2030 the levelised cost of electricity is expected to be 55.19 €/MWh.

For offshore wind the levelised costs of electricity are a bit higher, due to higher initial costs of wind turbines. For 2010, it was 89.62 €/MWh, while in 2020 the predictions state the price to be 73.8 €/MWh and in 2030, the levelised cost should be 63.31 €/MWh.

These predictions show that electricity from wind energy will be less expensive than electricity from coal. When predicting prices for coal energy, also risk has to be considered because of fuel price fluctuation.

5.4 Comparison of feed-in tariffs in the Czech Republic and Germany

In the table below are compared FIT of energy generated from wind in the Czech Republic from 2007 until 2015. The Energy Regulatory Office states these prices every year. The value of Feed-in Tariff for 2015 has been stated to be 1.98 CZK per kWh (71.27 € per MWh according to average exchange rate in 2015), which is 0.034 CZK per kWh lower than in 2014. In the Czech Republic are used also so-called green bonuses, which are an opportunity to FIT. The prices are converted from Czech crowns in which FIT are stated to Euros according to average exchange rate in particular year.

Table 10 - Feed-in tariffs comparison in the Czech Republic in CZK/kWh

Feed-in tariffs comparison in the Czech Republic									
Year	2007	2008	2009	2010	2011	2012	2013	2014	2015
Price in CZK/kWh	2.46	2.46	2.34	2.23	2.23	2.23	2.12	2.014	1.98
Price in CZK/MWh	2460	2460	2340	2230	2230	2230	2120	2014	1980
Price in EUR/MWh	88.49	98.64	88.49	88.18	90.72	88.71	81.64	73.16	71.27

Source: CSVE, 2015.

In Germany, there are used only FIT. The duration of FIT for onshore wind turbines is 20 years and during the first five years, the price is higher – according to EWEA (2009), the price obtained per MWh was 83.6 €. After the first five years, the FIT is lowered to 52.8 € per MWh with annual reduction of 2%.

The price is higher for offshore wind turbines. The FIT was set to be 91 € per MWh during the first 12 years and for the next 8 years, the FIT is 61.9 € per MWh with annual reduction of 2%.

In the Czech Republic, the FIT duration equals to lifetime of a wind turbine, which is approximately 20 years.

Table 11 - The Tariffs in the Czech Republic in year 2007

The Czech Republic Tariffs 2007			
Technology	**Duration**	**Fixed €/MWh**	**Premium €/MWh**
Wind onshore	Equals the lifetime	88-114	70-96
Wind offshore	X	X	X

Table 12 - The Feed-in Tariff in Germany in 2007

Germany Feed-in Tariff 2007			
Technology	**Duration**	**Tariff**	**Note**
Wind onshore	20 years	83.6 €/MWh	For at least 5 years
		52.8 €/MWh	Further 15 years, annual reduction od 2 % is taken into account.
Wind offshore	20 years	91 €/MWh	For at least 12 years
		61.9 €/MWh	Further 8 years, annual reduction of 2 % is taken into account.

Source: EWEA, 2009.

5.5 Production of energy in the Czech Republic and Germany

In the tables and graphs below is summarized what was the most frequent source of energy in the Czech Republic and Germany in year 2013. It must be taken into account that both countries have different conditions for production of energy.

The most frequent source of energy was coal in both cases. Coal is a non-renewable source and cannot be restored once used up. In the Czech Republic, the share of coal is 51% while in Germany it is 44% and according to Reuters (2014) they are working on a new law to make energy companies close some coal-fired power plants by 2020 in order to reach their climate goals.

In case of nuclear energy, the difference is about 20%. In the Czech Republic, the nuclear energy takes up to 35% of energy sources while in Germany it is only 15%. According to Lidovky.cz (2014) in the Czech Republic are planned 2 new reactors – one in Dukovany and one in Temelín. On the contrary, Germany is planning to shut down all of their nuclear power plants, which was announced by Angela Merkel on 29th May 2011. Klaus Deuse (2014) wrote, "It also remains unclear exactly how much it will cost to dismantle the power plants after they've been mothballed. Experts are certain that the 34 billion euros set aside by plant operators for this purpose will not be enough to do the job.”

The most important part of these graphs is the percentage of wind energy. In the Czech Republic wind energy represents only 1% of all energy sources while in Germany, it is more than 8%. This is influenced by the nature of countries, their location, and their possibility to use offshore wind turbines.

There is also a huge difference in gross electricity production since the countries have different areas and also different population, therefore different consumption. While Germany produced around 633 200 GWh, the Czech Republic produced only around 87 064 GWh, that is almost seven times lower production.

Table 13 - Production of energy in the Czech Republic and Germany in 2013

Czech Republic in GWh	
Gross electricity production total	87064
Coal	44737
Nuclear Energy	30745
Photovoltaic	2070
Water	3761
Wind	478
Natural gas	5272

Germany in GWh	
Gross electricity production total	633200
Coal	282600
Nuclear Energy	97300
Photovoltaic	31000
Water	23000
Wind	51700
Natural gas	67500
Biomass energy	41200
Household waste	5400
Mineral oil products	7200
Other	33500

Source: AGEB, 2014 and ERÚ, 2014 a.

Figure 7 - Production of energy in the Czech Republic in 2013

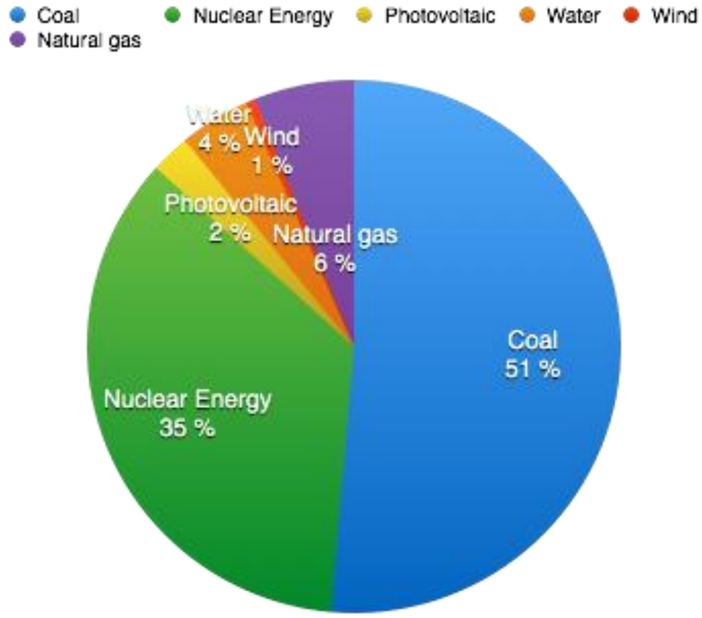


Figure 8 - Production of energy in Germany in 2013

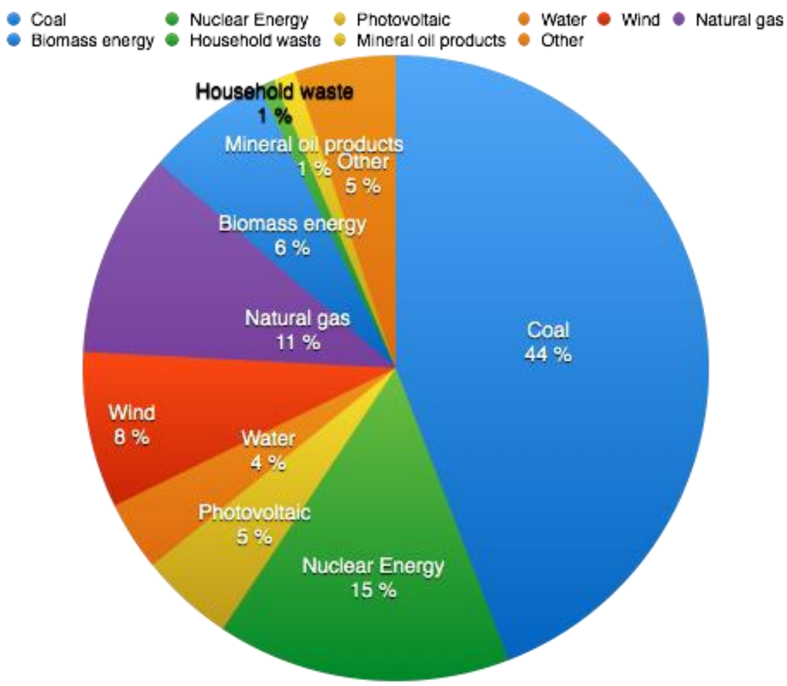
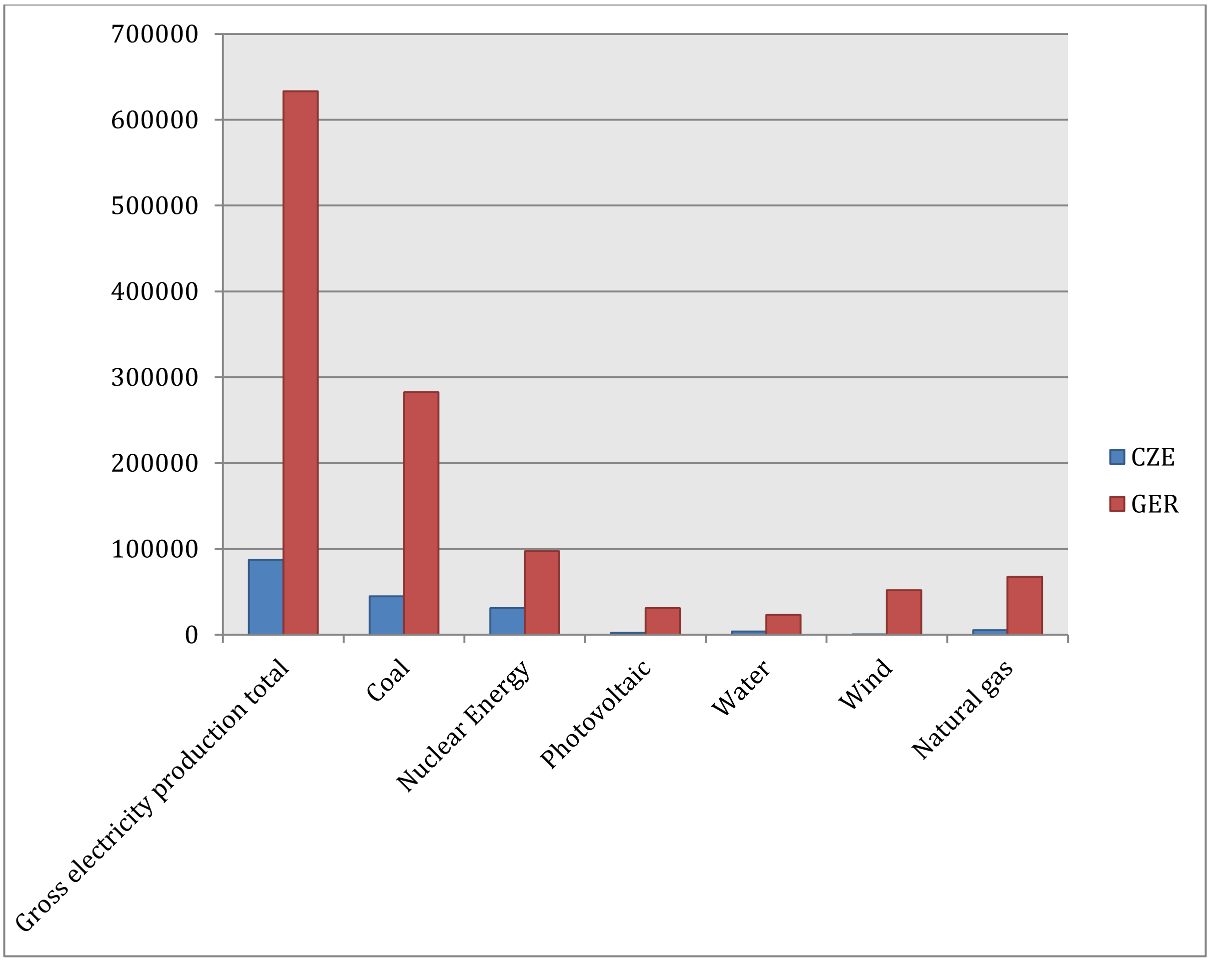


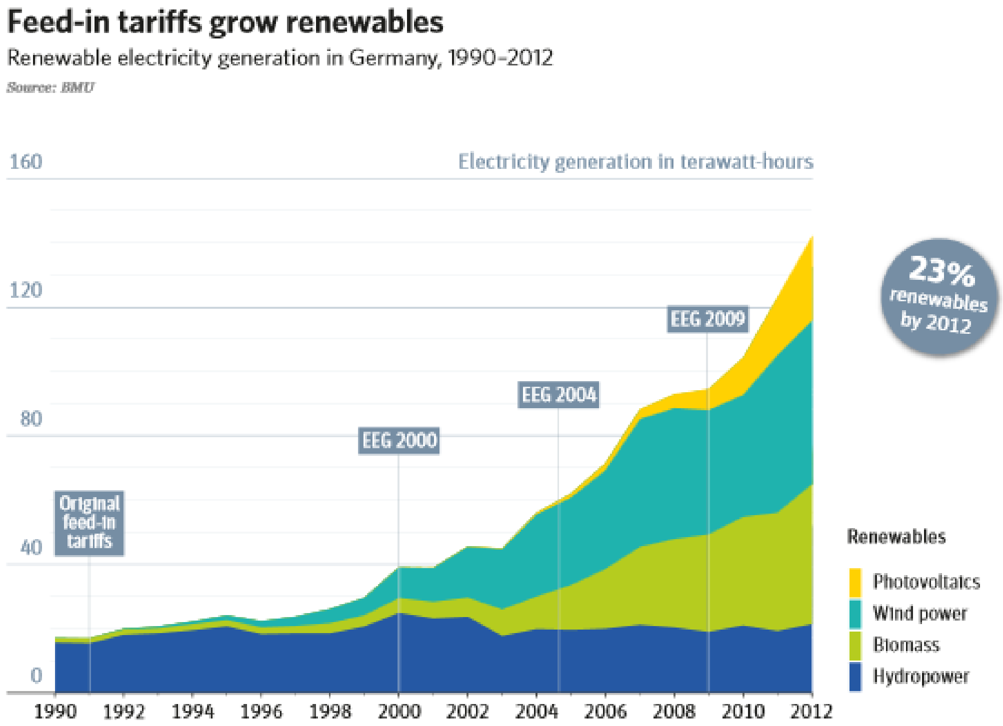
Figure 9 - Production of energy in the Czech Republic and Germany in 2013



On the first position is shown the total gross electricity production in the Czech Republic and Germany. Even though the percentage share of coal in the Czech Republic is higher than in Germany, in reality Germany produces approximately 6 times more energy from coal than the Czech Republic. But according to Reuters and International Business Times (2014), Germany is working on a new law that would force energy companies to close several coal-fired power plants and therefore reduce the carbon dioxide emissions obtained from coal.

5.6 Development of electricity generation from renewable energies in Germany

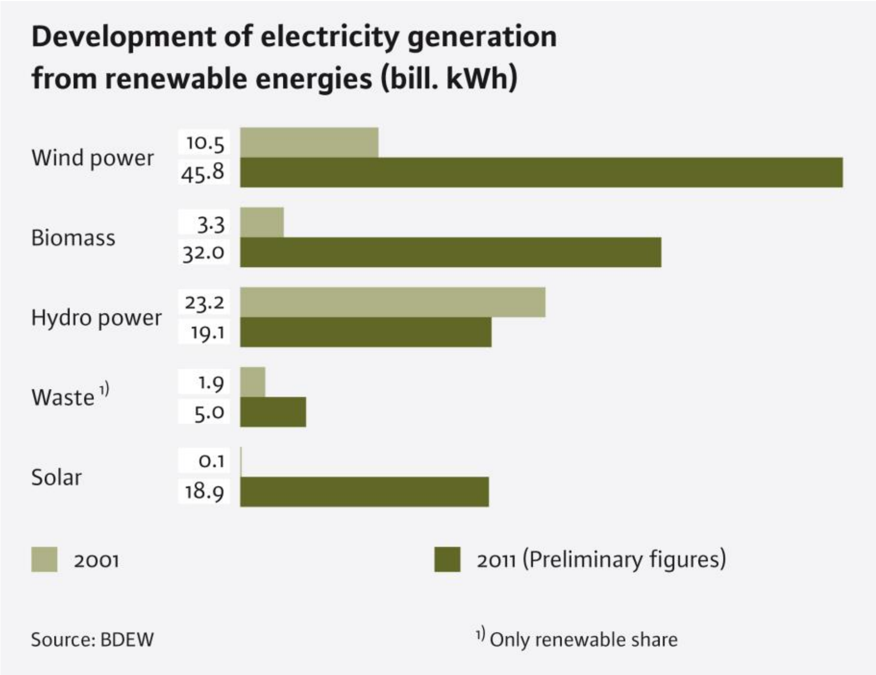
Figure 10 - Feed-in tariffs in Germany 1990-2012



Source: Morris, Pehnt, 2012.

In the graph above is shown how the feed-in tariff in Germany has increased the level of generated electricity from RES since the first version of feed-in tariffs in early 1990´s until 2012. The target of FIT is to support renewable resources and according to this graph, the FIT has been a great success not only for Wind power, but also for Photovoltaic, Biomass, and Hydropower. Germany is very successful in generating power from RES and is planning to continue in this policy, e.g. shutting down nuclear power plants.

Figure 11 - Development of electricity generation from RES in Germany (bill. kWh)



Source: BDEW, 2011

In the graph Development of electricity generation from RES is shown increased use of RES from 2001 to 2011 in Germany in billions kWh. The amount of generated energy from wind was 10.5 bill. kWh in 2001 and in 2011 it was 45.8 bill. kWh. In case of biomass, the increase was by almost 28 bill. kWh up to 32 MWh in 2011. Hydropower contrarily decreased from 23,2 bill. kWh in 2001 down to 19,1 bill. kWh in 2011. Other RES are important as well and the electricity generated from RES as a whole is increasing thanks to biomass, hydro power, solar, etc.

5.7 Installed wind turbines in past three years

In 2011, there were only 2 MW installed in the Czech Republic, which has increased the amount of total capacity to be 217 MW at the end of year 2011. The new instalments represent only 0, 9% out of total capacity at the end of 2011. In Germany, the increase was by 2 086 MW, which led to total capacity of 29 060 MW. The new instalments represent around 7% of total capacity of Germany (EWEA, 2012).

According to EWEA (2014), in 2012 in the Czech Republic was installed total capacity of 44 MW. In the end of 2012, the total amount of wind energy capacity was approximately

260 MW. The installed capacity during 2012 represents approximately 17% of total capacity in the Czech Republic.
In Germany, installed capacity during 2012 was approximately 2 297 MW. Total capacity of wind turbines in the end of 2012 was 30 989 MW. Therefore, installed capacity in 2012 in Germany comprises approximately 7% of total capacity.

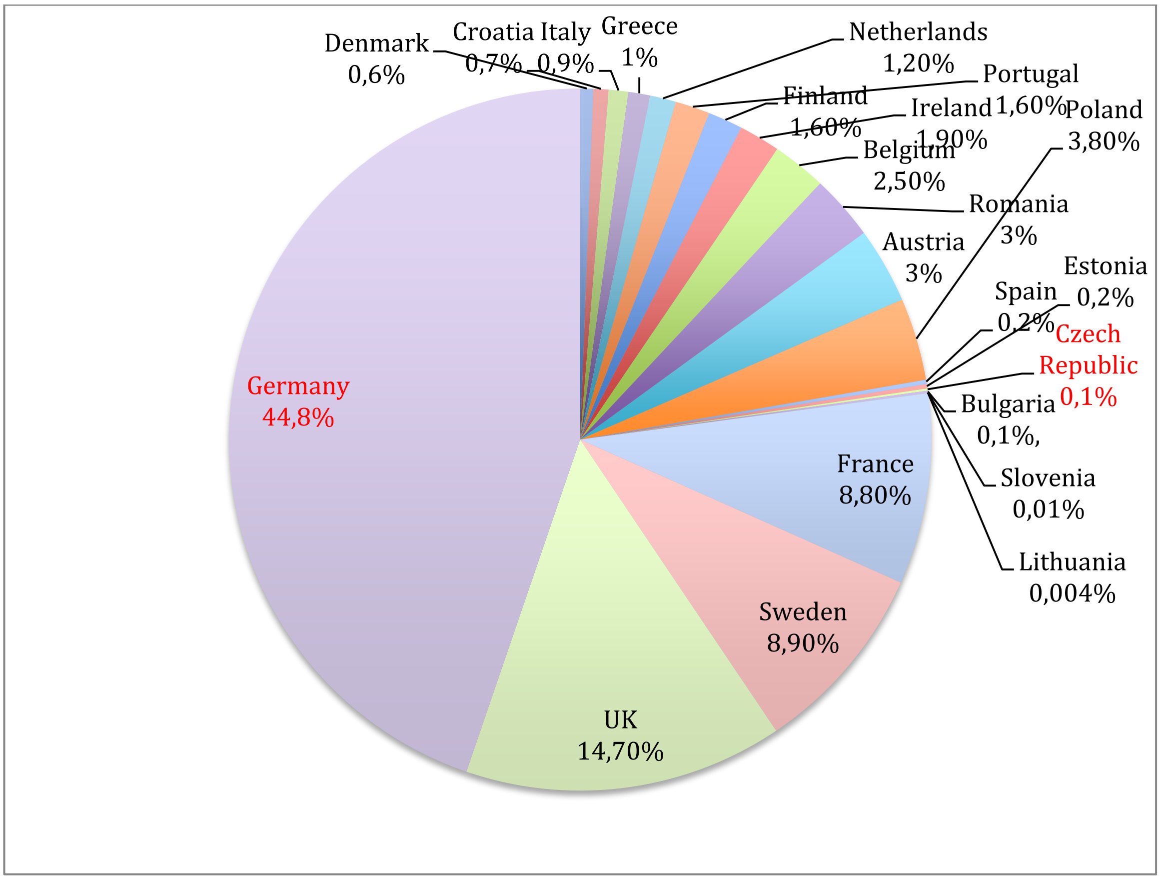
In 2013 in the Czech Republic was installed total capacity of 8 MW. In the end of year 2013, the total amount of wind energy capacity available was approximately 268 MW. The installed capacity during 2013 comprises approximately 3% of total capacity.
In Germany, installed capacity during 2013 was approximately 3 238 MW. Total capacity of wind turbines in the end of 2013 was 33 730 MW. The installed capacity in 2013 in Germany comprises approximately 10% of total capacity.

In 2014, in the Czech Republic was installed total capacity of 14 MW. At the end of 2014, the total amount of capacity was approximately 281.5 MW. The installed capacity during 2014 creates approximately 5% increase in total capacity.
In Germany, installed capacity during 2014 was 5 279.2 MW. Total capacity of Germany in the end 2014 was 39 165 MW. The installed capacity during 2014 in Germany comprises approximately 13.4% (EWEA, 2015).

As stated in these data, the trend of instalment of new wind turbines in Germany is increasing year after year. In the Czech Republic, the trend is more or less the same, but in year 2012; there was a huge increase in total capacity which was almost 17 % even though the capacity was raised only by 44 MW.

According to EWEA (2015), during 2014 was installed capacity of 12 819 MW in whole Europe. At the end of 2014, the total capacity in Europe was approximately 134 000 MW. In member states of European Union was installed majority of new installed capacity in Europe, in total 11 791 MW. The total capacity of member states of EU was approximately 128 750 MW. Out of all capacity within EU, Germany is the largest market with its 5 279 newly installed MW representing 44.77%. On contraire, the Czech Republic represents only 0.1% with its installed capacity of 14 MW and that is shown in a graph below.

Figure 12 - EU Member state market shares for new wind energy capacity installed during 2014 (MW)



Source: EWEA, 2014.

5.8 Electric power consumption

According to the World Bank (2015), the electric power consumption in 2011 was 6 289 kWh per capita. In Germany, it was 7 081 kWh per capita. In 2010, for comparison, it was 6 348 kWh per capita in the Czech Republic and 7 162 kWh per capita in Germany. That means that the consumption of both countries decreased a bit during 2011.

European Union requires member states to renovate 3% of floor area of central government-owned and –occupied heated or cooled buildings to fulfil the minimum energy performance requirements that each Member State got stated in order to reduce electric power consumption in the European Union (European Commission, 2013).

5.9 Future development in the Czech Republic and Germany

Both countries are member countries of European Union and that is why their future development in terms of RES is very similar. The Czech Republic and Germany are focusing on renewable resources and by 2020; there are certain targets they should meet. These targets are called 20-20-20 and they consist of three main goals: 20% reduction in greenhouse gas emissions in comparison with levels of greenhouse gas emissions in year 1990, 20% of energy must be from RES and EU´s energy efficiency must be improved by 20% (EU, 2015).

6. Conclusion

Wind energy industry has been growing worldwide for past couple years but each country has different possibilities. The Czech Republic and Germany are very different countries in their nature and area even though they are sharing borders. Germany has access to seas from the North, which the Czech Republic does not have. That has a huge effect on the total capacity of wind turbines, because offshore wind turbines are very important due to stronger wind on seas and usually, they have higher capacity than smaller onshore wind turbines. In the Czech Republic and in Germany are used feed-in tariffs, which ensure the investors in the RES to have a certain amount of investment back. In the Czech Republic are used also so-called “green bonuses”.

The Czech Republic and Germany have different energy policy; Czech Republic is planning to build new nuclear reactors in Dukovany and Temelín while Germany is planning to shut down all of their nuclear power plants by 2022 in response to what happened in Fukushima in 2011. In both countries is highest the share of coal-fired power plants around 50%, but the shares of RES are rising. In comparison, the total gross electricity production in Germany is almost seven times higher than in the Czech Republic, so even though the share of coal is higher in the Czech Republic, Germany still produced more energy from coal in year 2013.

Both the Czech Republic and Germany are member states of the European Union and therefore they have the same RES target to fulfil but with different conditions. Both countries are planning to focus on generating more and more energy from RES and to contribute to European Union target called 20-20-20. All member states issue a progress report each two years, which show whether the member countries have reached their interim targets. The latest progress reports of the Czech Republic and Germany show that both countries are above their interim target and therefore that they are successful.

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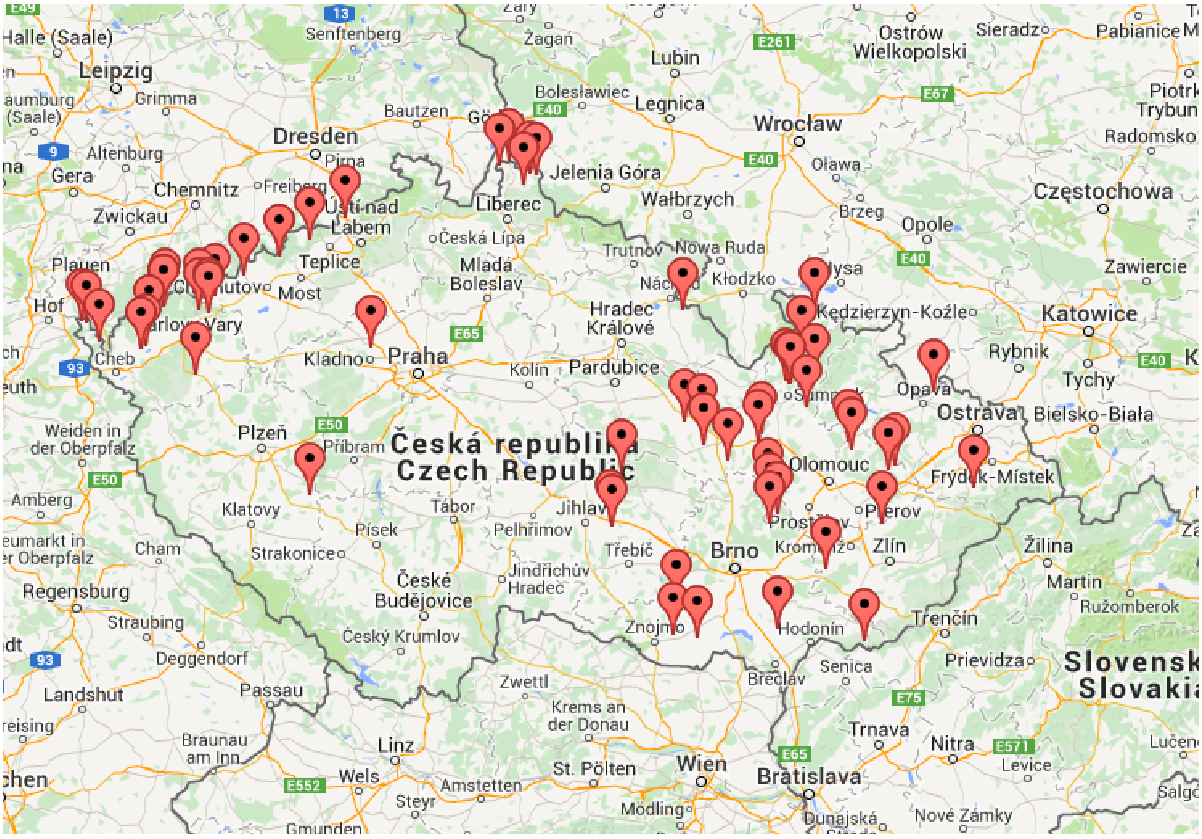
7. Appendices

7.1 Beaufort Wind Scale

Force	Wind speed km/h	WMO Classification	Appearance of Wind Effects on Land
0	less than 1	Calm	Calm, smoke rises vertically
1	1 - 5	Light Air	Dust, leaves, and loose paper lifted, small tree branches move
2	6 - 11	Light Breeze	Wind felt on face, leaves rustle, vanes begin to move
3	12 - 19	Gentle Breeze	Leaves and small twigs constantly moving, light flags extended
4	20 - 28	Moderate Breeze	Dust, leaves, and loose paper lifted, small tree branches move
5	29 - 38	Fresh Breeze	Small trees in leaf begin to sway
6	39 - 49	Strong Breeze	Larger tree branches moving, whistling in wires
7	50 - 61	Near Gale	Whole trees moving, resistance felt walking against wind
8	62 - 74	Gale	Twigs breaking off trees, generally impedes progress
9	75 - 88	Strong Gale	Slight structural damage occurs, slate blows off roofs
10	89 - 102	Storm	Seldom experienced on land, trees broken or uprooted, "considerable structural damage"
11	103 - 117	Violent Storm	Widespread damage.
12	118 - 133	Hurricane	Rare, severe widespread damage to vegetation and significant structural damage possible.

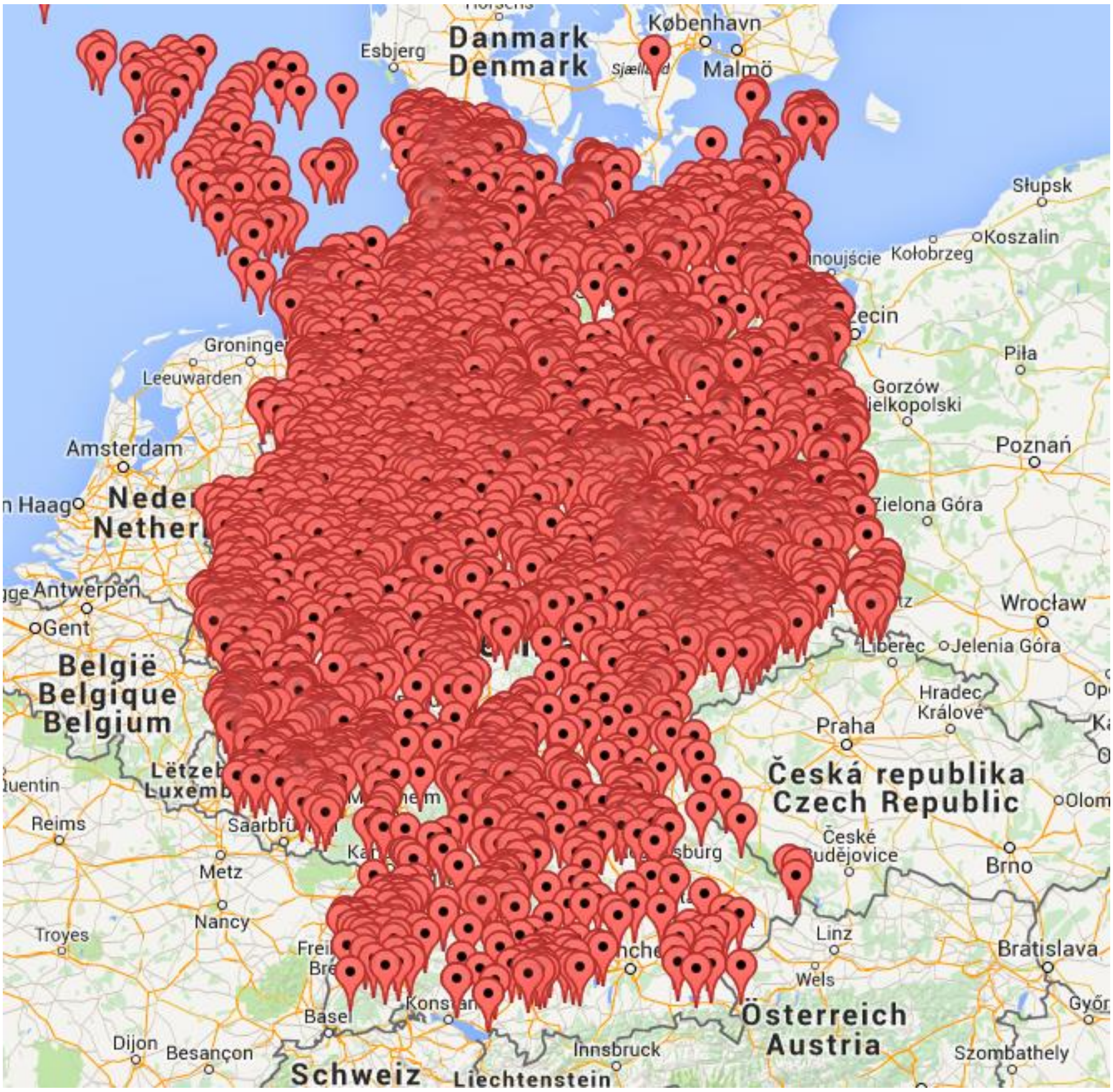
Source: Storm Prediction Center (US) and Government of Canada, 2015. Available at: http://www.spc.noaa.gov/faq/tornado/beaufort.html and www.ec.gc.ca/meteo-weather/default.asp?lang=En&n=80C039A3-1

7.2 Map of installed wind turbines in the Czech Republic



Source: thewindpower.net, 2015.

7.3 Map of installed wind turbines in Germany



Source: thewindpower.net, 2015.