Czech-Austrian Winter and Summer School: Promoting Renewable Energy: Targets, Strategies, Costs by Technology (2005 – 2015)

Javad Talesh Lar
Assylbek Igissenov
Karol Patricia Cruz

Co-operating Universities

Financial support by

Prague and Vienna, 2017

CONTENT

Abstract

1. Introduction

1.1. Motivation

For the past years the world has been changed significantly and our consumption as well. Every day people needs more and more, which means, that energy demand rocketed extremely. However, even if technology development shows great progress, inventions and new products, it effects on our environment and lives. It is clear, there are many ways how to turn the things on the right way, but one of the best is green and clean energy. Renewables give us a great opportunity to use more energy for supply and production; also, it has almost no effect on environment. Moreover, they do not suffer with oil and gas situation in the world. Many countries, like EU-28, tried to apply renewables and achieved different progress in it. In this paper, we want to present renewables' evolution in EU-28, Czech Republic and Austria from 2005 until 2015.

1.2. Problem Statement

European Union consists of 28 countries and all of them has different as potential as government policy to promote renewables. As members of EU Czech Republic and Austria has been cultivating green energy for a long period of time and reached different results. It caused by several factors, like economic conditions, political situation and technology development. To find out how they have been influencing on current situation in EU, Czech Republic and Austria from 2005 until 2015

1.3. Major Literature

[1]. M. Banja and N. Scarlat, "RENEWABLE ENERGY PROGRESS IN EU 27 2005-2020,"Eur. Comm., p. 124, 2013.

[2]. REN21, *Renewables 2015-Global Status Report*, vol. 4, no. 3. 2015.

2. Method of Approach

This research is based on the reports, statistics and databases of the respective renewable energy associations and by making a comparison between their growth, cost and their main strategies for the further developments and to draw conclusions about their effectivity with respect to fossil fuels. Furthermore, we have investigated different technologies used to produce renewable energies as well as their pros and cons to get a better understanding of the integration of renewable energies and their role in the Czech Republic and Austrian energy-mix.

3. STATUS AND OVERVIEW OF THE RENEWABLES TECHNOLOGIES.

3.1. Austria

Solar Energy

Solar power is in concept, the conversion of sunlight's energy into electricity, either by direct conversion "photovoltaics", or by indirect conversion, using concentrated solar power. Although the first method is matured enough and is readily available to use even at the household levels, the second method is still under improvement and is more expensive which needs the support and founding from the governments as well as the private sectors.

According to Austrian Solar Association, within a period of only eight years, from 2002 to 2010, the annual production of solar collectors in Austria increased al-most four times over. Since 2002, collector production has more than tripled from 328,400 square meters to 1.1 million square meters. In 2012, 918,000 square meters of solar collectors were exported, this is 81% of domestic production. 45% of the collectors go to Germany, 15% to Italy, 6% to Spain and Portugal, 4% to France. The rest went to the rest of Europe and the world, from Mexico to Brazil and China. Around 345 million euros were spent on solar systems in 2012, one third of which was in the installation industry. The solar sector secures 3,400 jobs in Austria, including the maintenance and renewal of existing solar plants.

At the end of 2014, 5.2 million square meters of solar collectors already generated a thermal output of 3,616 MW from clean solar energy in Austria alone. This means that 459,242 tonnes of CO2 emissions were avoided on the basis of the substitution of the Austrian heat mix. However, the total output of newly installed photovoltaic facilities in Austria in 2015 declined slightly from 2014. In 2015, grid-connected photovoltaic plants with a total output of 151,806 kW peak and self-sufficient photovoltaic facilities with an output of 46 kW peak were installed. On balance, this comprises growth of 151,851 kW peak. As a result, total output of all photovoltaic facilities in Austria amounted to 937.1 MW peak at the end of 2015. This means that compared to the year 2014, the solar thermal market in Austria recorded a decline of 11%. The turnover of the solar heating sector was estimated at 228 million euros for the year 2015. In 2014, Upper Austria was the front-runner in terms of the proportion of the installed collector area with 27% of the total number in Austria. Vienna had a share of only 1% and the federal states spent the total of 25 million euros in founding the solar projects as a strategy to promote the use of solar energy. But, it seems that for the time being, the main strategy that Austria is pursuing is a jobs-centric approach, meaning that creating jobs seems to have bigger priority than that of turning this technology into a common practice. The solar energy has indeed a few shortcomings that is hindering its growth. The geographical and space considerations are two very important factors to name a few. Unlike the wind farms where the farm space could be reused for other purposes, the solar farm needs a dedicated space only for this purpose. This can be problematic especially in densely populated areas such as Vienna for an example, which only saw a 1% growth despite the incentives. Also, this technology proves to be most effective in regions of Europe with a suitable geographical conditions (i.e. Spain) therefore unlike biomass or hydropower, it cannot be considered as the main solution to energy demands but more as a complementary method.

Wind Energy

Until about 20 years ago, Austria's meteorologists felt that there was not enough wind to produce electricity on a large scale. However, a few private pioneers founded the construction of wind turbines and carried out wind measurements on their own, concluding that the hills of the foothills of the Alps, as well as the plains of eastern Austria, show an outstanding opportunities for the use of wind energy. The first wind turbine in Austria went to the grid in 1994. But, it was only in 2002 that the wind power expansion really started. From then on, a green electricity regulation regulated electricity generation by means of wind power plants. From 2002 to 2006, the first phase of constructions began. Since 2012, expansion has continued with the Green Electricity Act[1]. The (Fig 2) shows the development of wind power in Austria since 2000 until 2017.

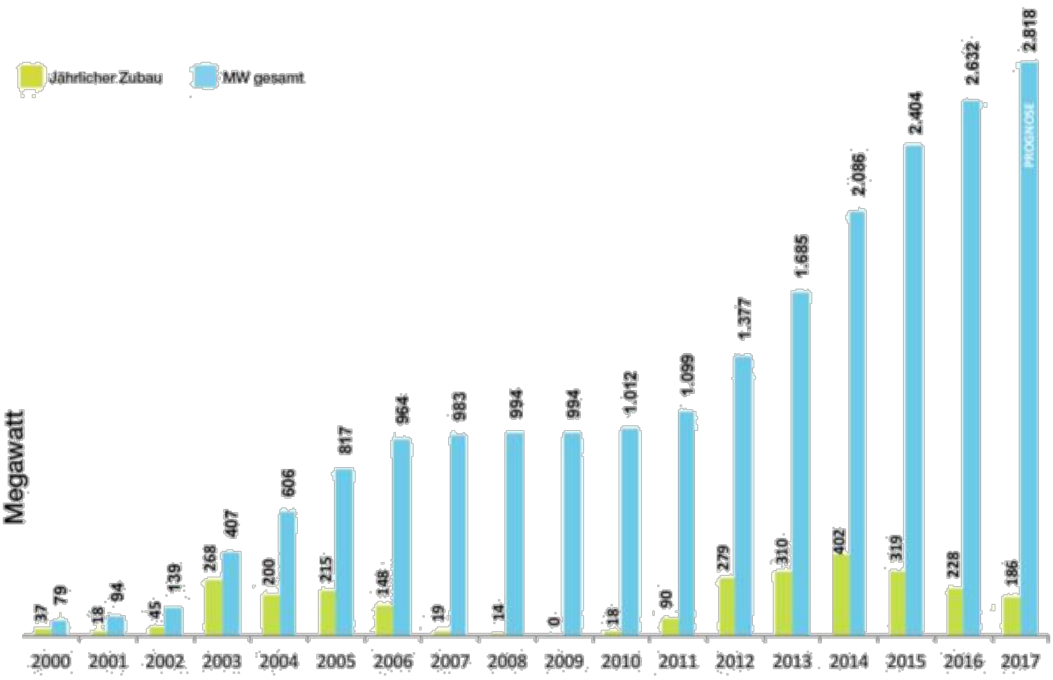


Figure 2: Development of wind power in Austria 2000-2017 (Courtesy of Wind Power Community of Austria)

By the end of 2016, about 1,191 wind turbines with a total output of 2,632 megawatts generated clean and environmentally friendly electricity for more than 1.6 million households, which accounted for more than 40% of all Austrian households. With this wind power production annually, a sum of 3.7 million tonnes of CO_2 can be avoided. A single modern 3 MW wind power plant save as much CO_2 as 2,000 cars in total. In 2017 the expansion phase of wind power will continue, with some 60 wind turbines with a capacity of more than 180 megawatts being added. The Austrian wind farm will invest around 300 million euros in just one year and provide a sustainable motivation for a clean energy future. The (Fig 3) shows the regional distribution of wind power by the end of year 2016 to give a better understanding on how each region contributes to wind power generation in Austria.

[1] The Green Electricity Act (implementing the EU Directive on Electricity Production from Renew-able Energy Sources 2001/77/EC) governs the aid for green energy and combined heat and power generation throughout the country

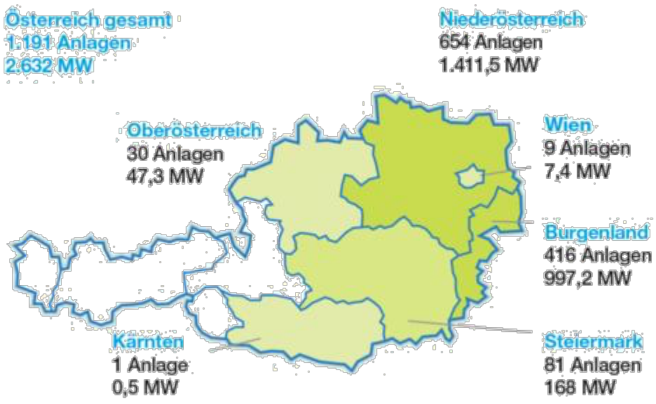


Figure 3: Regional distribution of wind power in Austria by the end of 2016

Here are some interesting facts about the wind power generated in Austria:

- The wind turbines installed in Austria in 2016 can generate 5.7 billion kWh of electricity annually.
- This is the electricity consumption of more than 1.6 million (40%) of Austrian households.
- An electric car could drive 38 billion kilometers that is 950,000 times around the earth with this amount of energy.
- That is more electricity than the nuclear power plant Zwentendorf[2] would have produced.

In the last decade, electricity imports to Austria have continued steadily. In 2015, it accounted for 16%, as high as never before. The main goal is to turn Austria into a power exporter again as it was 20 years ago, ousting the Czech nuclear power and the German coal power. To make this happen, Austria plans to increase the wind power generation within the next decade. By the end of 2016, wind turbines had generated about 9.3% of the domestic electricity demand. By the year 2020, wind power could already cover 13.5% of the electricity requirement. If around 100 wind turbines are installed every year, by the year 2030, the wind power could potentially cover 24 percent of the Austrian electricity demand. Even though wind farms are relatively cheap to build, there is a limit to their production that can in the future increase their cost and make their use economically questionable. Amongst all of the concerns regarding that, the two most important ones are mentioned here.

The scarcity of rare metals is hindering green technologies. This also applies to the production of wind turbines as the more the demand, the increased costs of the finished product is to be expected, to the point that the technology would no longer be rendered as economical to pursue.

[2] The Zwentendorf Nuclear Power Plant was the first commercial nuclear plant for electric power generation built in Austria, which went into construction in April 1972.

Wind farms need a lot of land and for the economical and efficient production of electricity, constant wind is needed which filters out many otherwise candidates for the use of this technology.

Biomass Energy

The importance of bioenergy in Austria has steadily grown in recent years. It is the most important renewable energy source, with a share of 58%. According to the Austrian Biomass Association, the share of bioenergy as a percentage of total energy consumption rose from 9% in 1990 to 17% in 2013 although energy consumption in Austria during this period actually climbed by one-third. In line with EU regulations, renewable energies must comprise 34% of the energy mix by the year 2020. At present, renewable energy sources account of 32.5% of the Austrian energy mix and The whole sector made a total turnover of 1,305 billion Euros thus creating 12,067 jobs. Provided that conditions are suitable, a much higher share than the required level of 34% may be reached by 2020. All in all, from the economics point of view, the biomass energy is favorable in comparison with conventional fuel sources. As an example, one can refer to the statistics provided by Austrian Biomass Association. As represented in (Fig 4), in April 2017, fuel oil prices rose from 7.13 cents / kWh to 7.17 cents / kWh compared to March. Natural gas prices remained the same. Pellets were 0.5% cheaper on a monthly basis at 4.69 cents / kWh. The costs for hardwood and wood chip remained unchanged. In the direct fuel cost comparison, pellets were 35% and the firewood was 37% and wood chip was 50% cheaper than conventional fuels like light oil. Furthermore, wood chip material was the most favorable energy carrier in comparison of fuel costs however it must be noted that although this technology is cost effective and cleaner in comparison with fossil fuels, (fuels from solid biomass contributed to a $CO2$ reduction of about 9.2 million tons in 2015), burning biomass still can result in air pollution which would propose a challenge to regions that are already struggling or investing in clean and environmental friendly alternatives of energy. The success of bio energy highly depends on the availability of suitable biomasses in sufficient volumes and at competitive prices, as well as regulative policy measures such as the Common Agricultural Policy of the European Union.

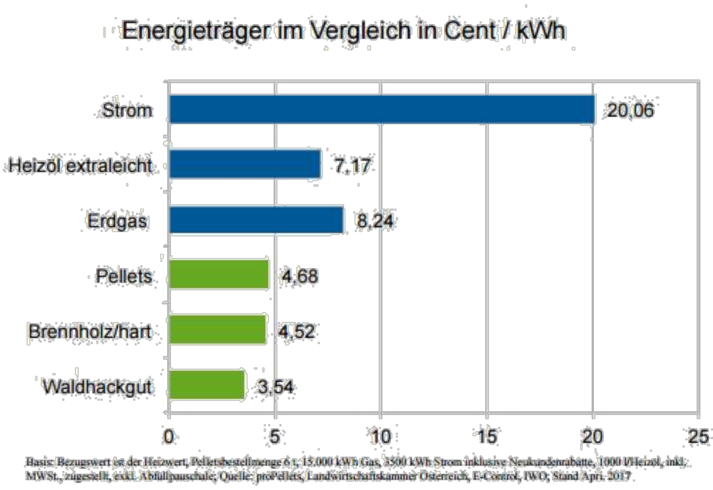


Figure 4: Energy Source Comparison in Cent/kWh

Hydropower

Hydropower is by far the leading renewable energy source in the EU. The construction of a large-scale hydropower plant requires the right kind of watercourse. The proportion of hydropower in the energy mix of countries such as Sweden, France and Austria, which have large differences in altitude and suitable watercourses, is therefore very high. Hydropower comprises over 99% of total electricity generation in Norway, Europe's largest hydropower producer. Countries such as Denmark, Germany and Poland, on the other hand, do not possess the conditions suitable for hydropower. Hydropower has very little impact on the climate and environment in the wider perspective. But, large-scale hydro power does have a major impact on the environment in direct proximity to the plant and watercourse. This leads to conflicts of interest. The (Fig 5) shows the natural water cycle to have a better understanding on the concept.

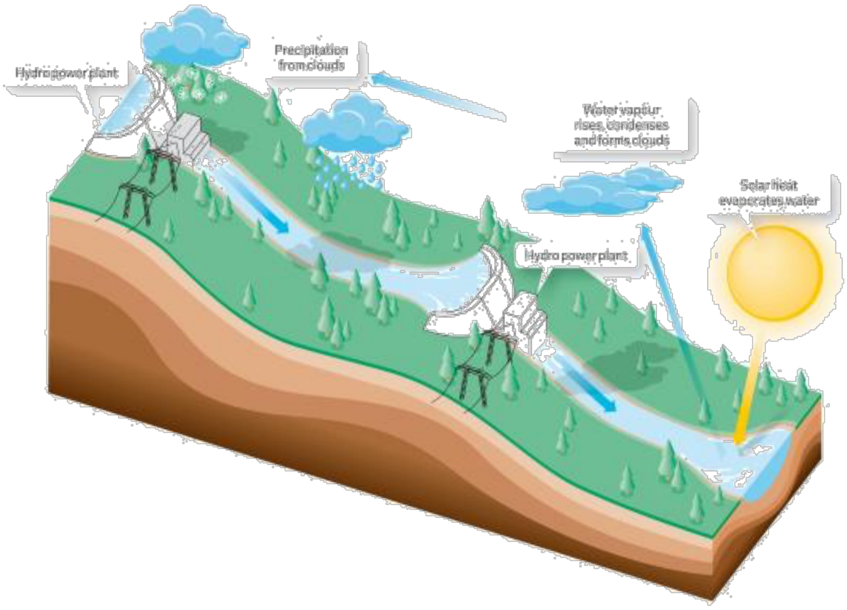


Figure 5: The natural water cycle

According to Eurostat[3], hydropower accounted for approximately 12% of the EU's electricity generation and about 40% of the total renewable electricity generation in 2014. At present according to ABA[4], more than 670 run-of-river power plants and some 1,800 small-scale hydropower stations are in operation, which generate approx. 60% of Austria's electricity needs.

- In supplying society with energy, a balance must be struck between three key dimensions:
- Competitiveness Security of supply
- Environment and climate

No single energy source is optimal from all dimensions. The energy triangle (Fig 6) illustrates the pros and cons of hydropower following a brief discussion about each side of it.

[3] Eurostat is the statistical office of the European Union situated in Luxembourg. Its mission is to provide high quality statistics for Europe

[4] The national investment promotion company operated by the Republic of Austria, and report di-rectly to the Austrian Ministry of Science, Research and Economy

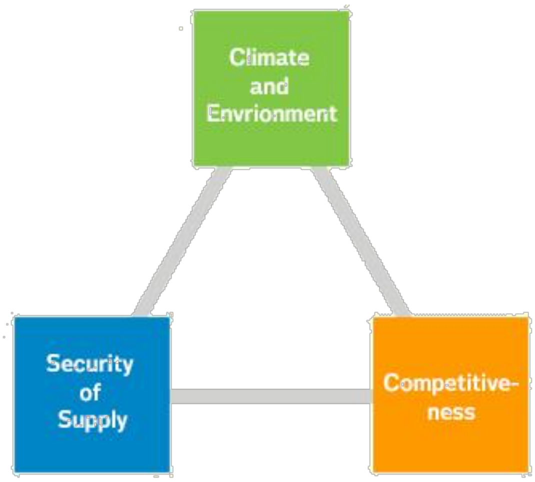


Figure 6: Energy triangle

Climate and environment: Hydropower is a renewable energy source that causes almost no emissions that impact the climate or the environment. However, power plants are a significant intrusion on the landscape and impact river ecosystems and more. A power plant may also affect animal and plant life in the vicinity.
Security of supply: Hydropower plants provide large-scale and stable electricity generation. But, sustained high generation levels are dependent on precipitation. Hydropower also functions as balancing power, since capacity can be rapidly changed to compensate for differences in generation and consumption in the mains supply.
Competitiveness: Hydropower has no fuel costs and competitive generation costs. Constructing a new power plant requires a substantial investment, but its economic life is long.

3.2. Czech Republic

Energy sector plays significant role in almost all countries and the Czech Republic is not an exception. Czech Republic, as a many other nations, wants to fulfill own energy needs for a long-term period. Key points for achieving this target are efficiency, sustainability, safety developments.

The Czech Republic in one of countries with the lowest energy dependency in the EU. Moreover, after France and Germany the Czech Republic is the largest electricity exporter in European Union and the most applicable source is coal [8,12].

Czech Government widely supports renewables, which shows in the next figure.

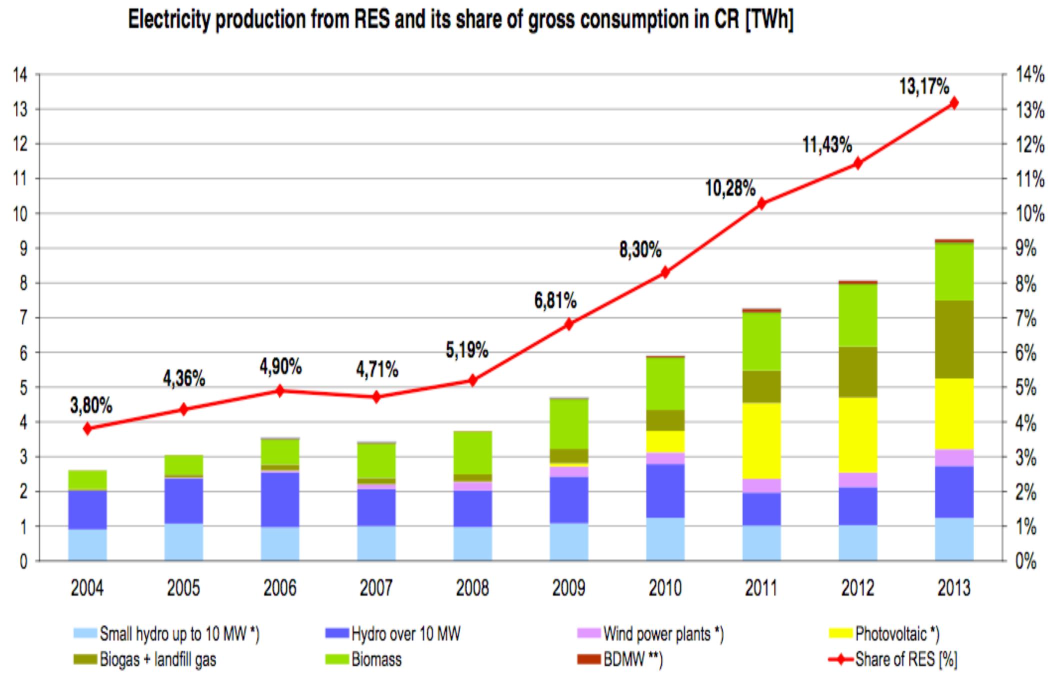


Figure 7: Electricity production from RES in Czech Republic [7]

As we can see renewables shares have been increasing year by year. Moreover, sources importance is also have been changed. For example, hydropower (both small and big hydropower plants) had the highest shares from 2004 till 2008, when biomass rocketed and still biomass and hydropower are developing. It must be noted, that solar photovoltaics made extremely high jump from 2009 till 2011. This point will be discussed in solar energy chapter.

Renewables are important for Czech Republic at least by the following points:

1) based on EU obligations they must to complete EU obligations with renewable shares for electricity production;
2) Kyoto Protocol.

According to International Energy Agency, main targets in renewables are 13.5 % of renewables share until 2020. The rest information is given in the next table [7].

Table 1 – Czech Republic National target until 2020 [7].

A. Share of energy from renewable sources in gross final consumption of energy in 2005 (%)	6.1
B. Target of energy from renewable sources in gross final consumption of energy in 2020 (%)	13.5
C. Expected total adjusted energy consumption in 2020 (kilotonnes of oil-equivalent [ktoe])	29 803
D. Expected amount of energy from renewable sources corresponding to the 2020 target (calculated as B × C) (ktoe)	4 168

Moreover, Czech Republic has other targets in renewable energy:

1) Heating and Cooling: to reach at least 14% of overall demand;
2) Electricity: to reach 14% of overall electricity demand;
3) Transport: to reach 11% of overall energy demand.

Finally, according to National Renewable Energy Action Plan, estimated trajectory of renewables developing are presented in the next table.

Table 2 – National target 2020 trajectory [7].

	2005	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
RES-H&C (1)	8.4	10.2	10.9	11.6	12.3	12.7	13.1	13.4	13.8	13.8	14.0	14.1
RES-E (2)	4.5	7.4	9.8	10.9	11.8	12.5	12.9	13.2	13.5	13.8	14.1	14.3
RES-T (3)	0.1	4.1	4.6	5.2	5.9	6.5	7.1	7.7	8.3	9.6	10.2	10.8
Overall RES share (4)	6.1	8.3	9.4	10.1	10.8	11.3	11.8	12.1	12.5	12.9	13.2	13.5

Solar Energy

According to [8], territory of the Czech Republic has the average insolation of solar radiation around 800 W/m^2, of course, depends on the region (location) and weather conditions. Moreover, county's features allow to 1 kW photovoltaic systems produce 0.9 – 1 MWh electricity annually [8].

Table 3 – Installed capacity of solar photovoltaics [9]

Name	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Czech Republic, MW	1	1	4	40	465	1,727	1,913	2,022	2,064	2,068	2,075

Today, there are more than 2000 MW of installed PV capacity in the Czech Republic. Since 2010, increasing in installed capacity has been small and could not be comparable. It is so called "PV boom". As we can see, there have been significant raise from 2008 and 2011. Just imagine from 40 MW of installed capacity to 465 MW next year and then 1727 MW. The reason of delaying in increasing was the Governmental law to decrease subsidies by 25%, while the Czech Republic had almost achieved the national solar target. Moreover, there are only two nations in European Union which completed their "National renewable energy action Plan" before a decade of expiration date. It was forecasted, that the Czech Republic, being a potentially capable county, had an opportunity to increase over 240 MW annually and they should easily reach no less than 4 000 MW of solar energy capacity by 2020 [10].

It must be pointed out, that the majority of residential sector, with more than 60% of installed capacity. For instance, in the year of 2012, overall increasing in installed solar capacity was 113MW, from this number just around 50MW gave commercial sector to the national grid and, moreover, there was not big utilities or plants. On the other hand, from residential part around 55 MW was installed and added into national grid. Solar thermal energy is also has been developing rapidly in the Czech Republic.

Table 4 - Solar thermal generation in Czech Republic [11]

Country	Water Collectors [MW$_{th}$]			Air Collectors [MW$_{th}$]		TOTAL [MW$_{th}$]
	unglazed	FPC	ETC	unglazed	glazed	
Albania		98.6	0.7			99
Australia	3,346.0	2,201.5	68.6	210.0	5.5	5,832
Austria	372.2	3,109.4	57.7		2.0	3,541
Barbados*		92.2				92
Belgium	31.5	264.1	45.8			341
Brazil	2,055.4	4,664.1	6.9			6,726
Bulgaria		86.6	1.8			88
Canada	550.1	44.9	27.5	261.2	20.8	905
Chile		97.5				98
China		19,437.3	242,824.7			262,262
Croatia		100.1	1.8			102
Cyprus	1.5	472.6	16.5			491
Czech Republic	352.1	257.7	70.1			680

As we can see, in the country all types of collectors are used, however, unglazed water collectors generate more than others.
Nevertheless, compare to European Union countries solar thermal capacity of the Czech Republic is not the highest.

Table 5 - Total installed capacity of solar thermal units in Czech Republic [11]

Country	Total collector area [m²]	Total capacity [MW_{th}]	Calculated number of systems	Collector yield [GWh/a]	Energy savings [t_{oe}/a]	CO_2 reduction [t_{CO2}/a]
Albania	141,885	99	18,188	99	10,664	34,473
Australia	8,023,000	5,616	1,024,556	4,992	536,591	1,734,637
Austria	5,056,098	3,539	503,348	2,044	219,716	710,276
Barbados	131,690	92	26,977	112	12,024	38,869
Belgium	487,783	341	99,922	199	21,379	69,112
Brazil	9,609,263	6,726	1,549,301	6,407	688,607	2,226,059
Bulgaria	126,200	88	23,209	66	7,071	22,859
Canada	889,370	623	14,894	423	45,489	147,051
Chile	139,309	98	17,525	105	11,232	36,310
China	374,660,000	262,262	85,403,747	217,841	23,413,743	75,689,608
Croatia	145,565	102	29,819	75	8,093	26,164
Cyprus	700,947	491	154,463	623	66,964	216,475
Czech Republic	971,269	680	68,205	332	35,636	115,202

According to the figure above, overall solar thermal capacity is 680 MW. Of course, it is not comparable with leaders, or China, but still, in Central Europe countries it is comparable.

Wind Energy

Basically, wind energy potential depends on geographical positions of investigated region. There need tremendous amount of wind data over years to estimate potential itself.
According to [8,12] territory of the Czech Republic has about 20400 km^2 with an average wind speed more than 6 m/s, which means that more than a quarter of all area of country considers as good point for wind development. Moreover, several studies claim such as [8,12] claims, that real wind potential in the Czech Republic could be estimated at the level of 2500-2700 MW of installed capacity, which means more that overall production is higher than 5.5 GWh. To be clear, it is around 8 % of overall consumption in country. For this calculation there were discovered more than 1200 expected regions. The following picture describes, how wind energy has been developing from 2005 till 2015.

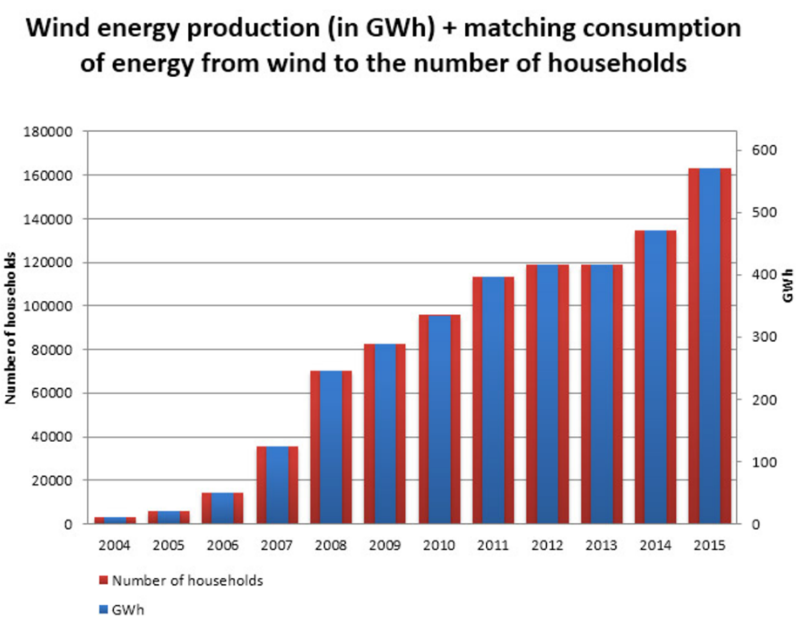


Figure 8: Wind energy production in Czech Republic [13]

According to the picture above, it can be seen, that total production has been raising year by year. For example, total production in 2004 was around 8.3 GWh, while in 2005 this value climbed more than twice and reached around 21.3 GWh. It must be pointed out, that in 2008 there was extremely high jump in generation with increasing more that 3 times and achieved 125 GWh per year. There had been also plateau time from 2012 and 2013 and after that again total generation climbed to around 570 GWh per year.
Installed capacity, as a production, has also been increasing over years. All necessary information is plotted in the next figure

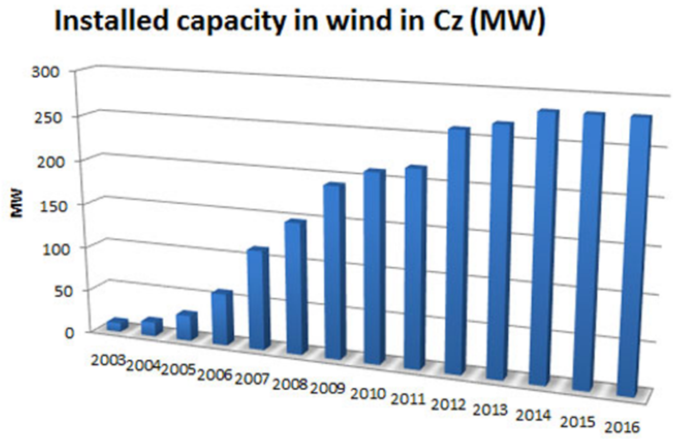


Figure 9: Installed capacity in wind energy in Czech Republic [13]

As it can be seen from the figure above, during 13 years installed capacity has been increasing. The highest increase in installed capacity was in 2007 from 54 MW to 116 MW, annual growth is 62 MW. Annual growth in installed capacity is presented in the next figure.

Total installation of WTGs (in MW)		
year	Total	Annual growth
2005	28	
2006	54	26
2007	116	62
2008	148	32
2009	192	44
2010	215	23
2011	217	2
2012	260	43
2013	269	9
2014	283	14
2015	283	0
2016	0	0

Figure 10: Annual growth of installed capacity in wind energy in Czech Republic [13]

The figure above provides us how annual growth has been changing from 2015 till 2016. It should be noted, that till 2011 growth was significant – from 26 MW to 62 MW annually,

then in 2011 there were just 2 MW added into national grid. From 2015-20016 there was not installed any power of wind energy, and this value stays at the level of 283 MW in 2016.
To sum up, it can be figured out, that wind energy is important for the Czech Republic in case of energy production. Moreover, wind energy might and should be a competitive source compare to other renewables.

Biomass Energy

According to [8,12] biomass is the most applicable sources in the Czech Republic compare to other renewables.

According to [14], agriculture area takes more than half of overall area of the Czech Republic – about 54% and it is 4.3 millions of hectares. From this value around 3.1 million hectares are farmable land. Moreover, around 40% of Czech Republic area is forest. Czech Republic considers biomass as an important source, thus future targets are: in 2020 80% of all renewables, 85% in 2030.

According to [15], technical potential of biomasses in the Czech Republic is presented in the next figure.

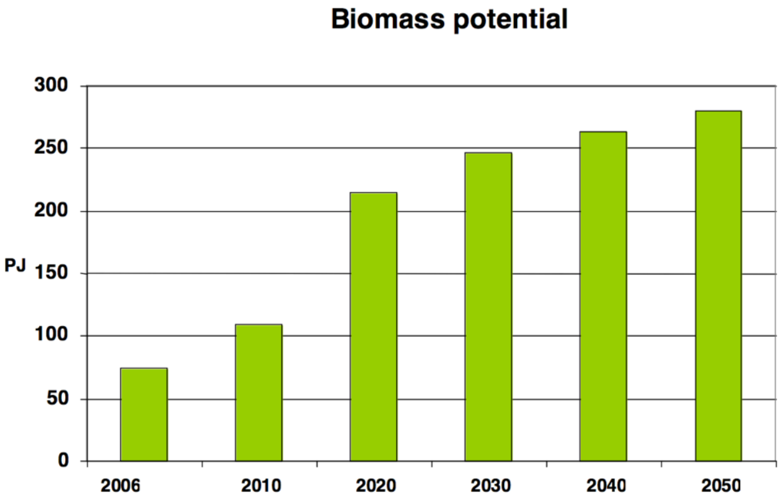


Figure 11: Biomass potential in Czech Republic [15]

It must be noted, that technical potential means, that all farmlands (agriculture, forest, residual) will be used not for food production, but for energy generation [8]
However, biofuels have been widely developed, according to the next figure.

Technology	1990	2000	2004	2008	2009	2010	2011	2012	2013	2014	Share in 2014
Biogases	-	-	25	71	96	118	177	300	361	367	6.8%
Solid biofuels	-	-	103	213	254	271	306	330	306	355	6.6%
Wind	-	1	17	150	193	213	213	258	262	278	5.2%
Waste	-	3	4	4	4	44	44	46	46	46	0.9%

Figure 12: Installed capacity in biomass technology in Czech Republic 1990-2014 [7]

As it can be seen from the figure above, for the past decade total installed capacity in biomasses has been increased from 132 MW in 2004 to over 750 MW. Moreover, in 2012 installed capacity of biogas units raised form 177 MW to 300 MW.

Hydropower

Hydropower is the oldest and one of the most applicable source of renewables for energy generation in the Czech Republic. With biomass hydropower take the majority of renewables shares. There are 5 main rivers in the country, where hydropower planets are based: Vltava River, Elbe, Eger, Morava and Odra rivers. Hydro energy generates around 3-4 % of overall electricity generation in country. Moreover, small hydroplants produce around 700 GWh annually, while large hydropower plants generate 1580 GWh per year [8,12].

According to [9], the following tables shows how total installed capacity of hydropower plants has been changing over years.

Table 6: Installed capacity of hydropower (lower than 1 MW) [9]

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
MW	123	122	128	132	135	141	142	149	155	150	154

Table 7: Installed capacity of hydropower (higher than 1 MW, lower than 10 MW) [9]

Year	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
MW	144	141	143	144	149	155	155	163	172	177	181

Table 8: Installed capacity of hydropower (higher than 10 MW) [9]

GEO/TIME	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
MW	753	753	753	753	753	753	753	753	753	753	753

As it can be clear, large power plant has not been introduced in this period, while small and medium sized plant were.

3.3. EU-28

The European Union continues to move away from fossil fuels and nuclear power generation to a higher share of wind, solar and other renewables. In this sense, since 2000 up to 2015, 443 GW of new power capacity has been installed where 58% has been renewables [28].

The installed electrical capacity in the EU-28 is presented in Table 1. It increased by 29.5% in the period from 2005 to 2015. In 2005, the highest share of installed capacity was accounted for by combustible fuels (57.4 %), followed by nuclear (17.8 %) and hydro (18.9 %), with all others at less than 6 %. When, the condition in 2015 was compared to previous years, the share of installed capacity of combustible fuels decreased to 47.4%, the share of hydro to 15.5% and the share of nuclear to 12.4%. On the other hand, the share of wind increased to 14.4% and the share of solar to 9.9%, while the changes in bioenergy, geothermal, tide, wave and ocean remained negligible.

Table 9: Electrical Capacity, MW, EU-28 [16]

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Nuclear	134,994	133,806	132,829	133,131	132,542	131,731	132,087	123,183	122,971	123,515	121,957
Hydro	143,363	143,551	144,379	145,150	146,430	147,299	148,401	148,987	150,113	150,287	152,400
Tide, Wave and Ocean	240	240	240	240	241	241	241	243	243	244	244
Geothermal	687	698	701	700	729	762	764	768	781	820	822
Wind	40,399	47,602	56,062	64,388	75,213	84,567	94,169	106,321	118,069	129,100	141,482
Solar	2,297	3,291	5,264	10,483	17,114	30,271	52,822	71,180	81,772	89,124	97,166
Solar Photovoltaic	2,297	3,280	5,253	10,422	16,830	29,537	51,671	69,178	79,470	86,822	94,864
Solar Thermal Electric	0	11	11	61	284	734	1,151	2,002	2,302	2,302	2,302
Combustible Fuels	435,099	445,866	453,675	461,757	468,427	488,175	491,882	495,550	482,426	479,838	465,830
Solid Biofuels	10,019	11,128	10,949	11,931	13,207	14,221	15,785	16,440	16,116	16,976	17,571
Liquid Biofuels	704	825	451	709	918	1,068	1,141	1,825	1,847	1,741	1,846
Biogases	3,091	3,526	4,055	4,424	5,176	5,965	7,106	8,403	8,837	9,724	10,014
Other Sources	943	1,115	866	873	886	883	2,162	2,044	2,111	2,037	1,970

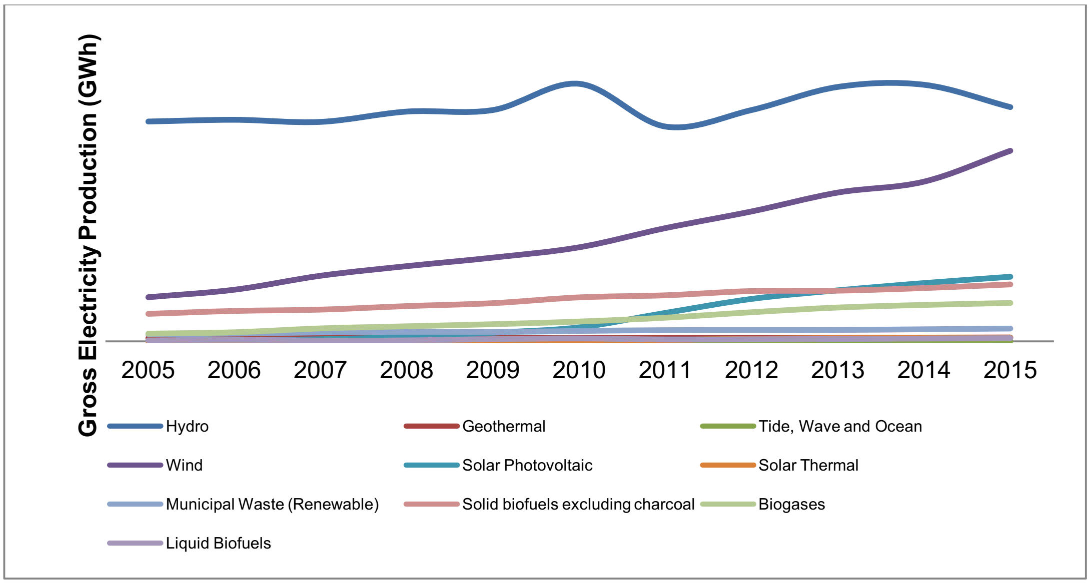


Figure 13: Gross Electricity production by fuel in EU-28, 2005-2015 based on [16]

The electricity generated from RES also has increased in volume. It was appreciated that there have been significant changes in the contribution of renewable energy sources to the gross electricity production between 2005 and 2015. In 2005, slightly more than 70% of gross renewable electricity was produced from hydropower, a share that dropped to 38% in 2015, while others like wind increased from 14.2% to 31% and solar photovoltaic as well growth from 0.3% up to 11%. The other important renewable energy sources in gross electricity production in 2015 were solid biofuels and biogases, while others have presented slower growth.

Solar Energy

The development of solar energy has advanced considerably during the last years. Up to the end of 2015, about 95 GW of photovoltaic and 2.3 GW of solar thermal accumulated power had been installed in the European Union (Table 1). It is the third renewable source in terms of installed electrical capacity, after hydropower and wind. Being Germany, Italy, United Kingdom, Spain and France the Member States with greater installed capacity.

When talking of the gross production of electricity from photovoltaic, by 2015 it reached 102,330 GWh with an average increase of 53% between 2005 and 2015. This growth in the generation of electrical energy from the use of PV has been due mainly to technological advances, cost reduction, support mechanisms and the relatively short project development times [5]20. This has motivated Member States to review their support mechanisms in response to cost reductions.

On the other hand, the gross production of electricity based on thermal solar technology increased on average by 29% per year during the period 2005 - 2015, growing from 462 GWh to 6,055 GWh. When performing an analysis to Table 1, it was observed that the solar thermal electrical capacity installed peaked in 2012, and since then declined and maintained, this may be due to a deceleration or inefficient support policies. Moreover, concerning the production of renewable heat from solar thermal technology increased by 14% per year between 2005 and 2013 [20]. However, despite the estimated increase the same source indicates that solar thermal energy has not been able to keep up against expectations set out in the NREAPs.

Wind Energy

According to [28], the share of wind power of total installed power capacity has increased more than doubled since 2005, from 6% in 2005 to 15.6% in 2015, overtaking hydro as the third largest power generation capacity in the EU and the first renewable energy technology in capacity installed, as it can be seen in the Figure 8. With this installed capacity, can be produced in an average year of wind about 315 TWh of electricity, which can cover up to 11.4% of the total electricity consumed in the European Union.

As well another remarkable fact of wind power in EU is that by 2015, the financial debts in new assets totaled 26.4 billion euros, making wind energy the largest renewable in investments. Of the new financial debts intended to RES during 2015, 66.7% were for wind energy sector and it was followed by solar PV (15%), biomass (6%) and geothermal (4%) [28].

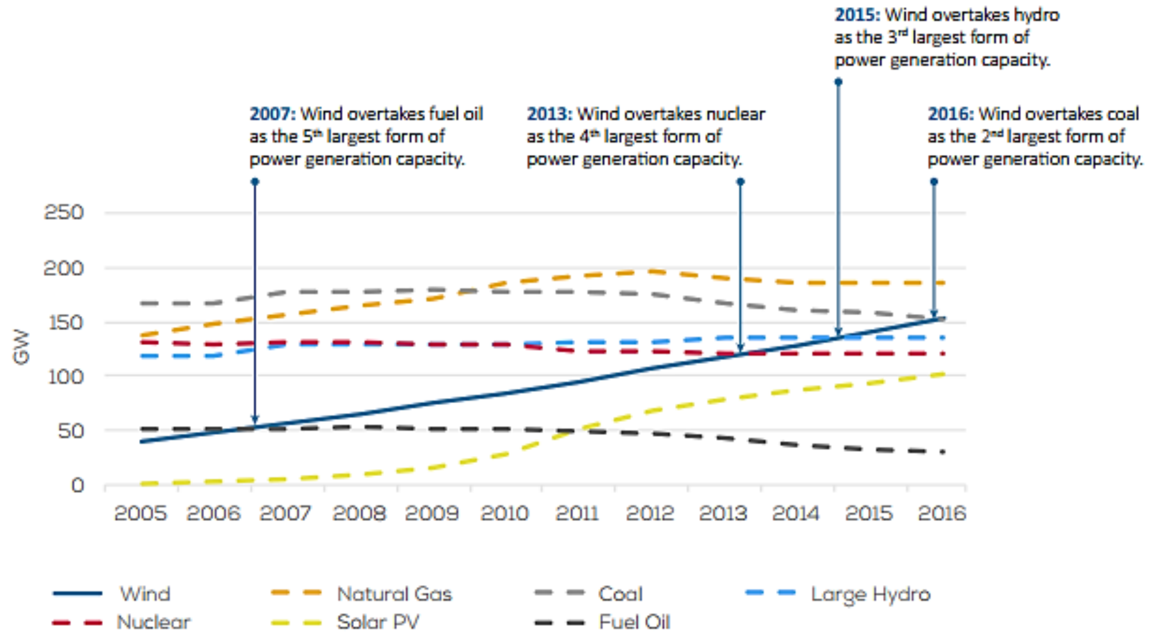


Figure 14: Cumulative Power Capacity in the EU 2005 – 2016 [28].

The Members States with the largest installed capacity are United Kingdom, Germany, France, Poland and Spain. However, for 2015, almost half of the new capacity installed came from the pioneering markets of Germany and Denmark, which may be due to the stability of the regulatory frameworks in these countries, which gives investors visibility on future projects' cash flows and favors investments in wind energy [28].

Biomass Energy

The contribution of bioenergy to achieving the 2020 targets is important, beyond that by 2020 it is anticipated that this energy source will be able to contribute half of the 20% of shares in RES [30]. In effect, bioenergy is the only renewable source capable to supply green energy for heating and cooling, power generation and transport sectors.

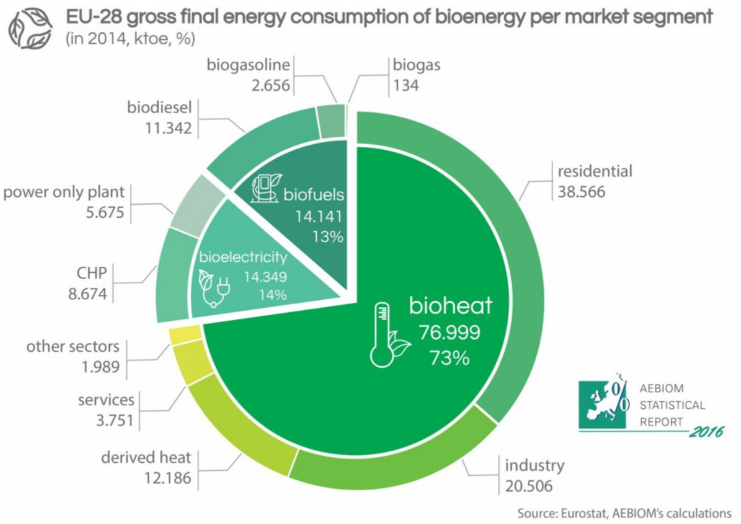


Figure 15: EU-28 Gross Final Energy Consumption of Bioenergy per market segment in 2014, ktoe,% [30].

According to [20], among the factors that could influence the development in the future of biomass could be the implementation of sustainability criteria but there are no plans to harmonize legislation for these criteria for solid and gaseous biomass at least before 2020. In addition, the European Commission through some reports has described the risks to the sustainable use and production of biomass among these: unsustainable feedstock production; emissions from land use, land-use change and forestry; performance in terms of life-cycle GHG emissions; indirect impacts; inefficient bioenergy generation; and air emissions.

As for the heating sector, solid biomass continues to grow as the most substantial RES, being the decentralized units where the majority of heat generation from biomass is given. For its part, the European Commission has estimated that biomass imports will threefold between the period of 2010 and 2020, but also it is expected that the demand of biomass for energy production will be supplied from biomass of the Member States [20].

Hydropower

In 2015, hydropower was the largest renewable energy resource accounting for 14.4% of total primary energy production of renewable energy in the EU-28. The installed electrical capacity increased 6.3% between 2005 and 2015, with an average increase of 0.6% per year. For this RES the countries with the most hydropower capacity are Norway, France, Italy, Sweden Spain and Austria [16]. Being the EU Member States with the highest small hydropower capacity installed Italy, France, Spain, Poland and the Czech Republic [30].

With regard to the development of hydroelectric projects (> 10 MW), the main investments took place before 2000, and the greatest potential of the EU has been realized. The same happens with the central small and medium capacity (<10 MW), where most have already been developed in viable sites [20]. Also, an important area of hydropower sector in Europe, especially in the central region of the continent, is in pumped storage. Besides providing additional power at times when energy demand is higher, the storage capacity pumping helps to balance power production and regulate the transmission grids, in view of the increased use of intermittent renewable sources, particularly the wind. Therefore, its development is necessary given the penetration of RES in Europe.

4. TARGETS FROM RENEWABLES SOURCES

The Renewable Energy Target Setting Report [17] defines renewable energy targets *as numerical goals established by governments or other actors (such as electric utilities) to achieve a specific amount of renewable energy production or consumption. Renewable energy targets can apply to the electricity, heating/cooling or transport sectors, or to the energy sector as a whole, and often include a specific time period or date by which the target is to be reached.*

The European Union has had a leading position worldwide with its aspiring energy and climate targets, but the process of setting these goals is not straightforward because of the challenges in setting RES targets both at the national level and at the community level. Table 2 shows the evolution of the EU's renewable energy targets.

Table 10: Evolution of the European Union's Renewable Energy Targets [17].

Name of Directive	Scope and time frame	Targets (s) and Units	Legal Status	No. of Member States
Directive 2001/77/EC on the promotion of electricity produced from RES in the internal electricity market.	Share of electricity in 2010	- Indicative target of 12% of gross domestic energy consumption by 2010 and 22.1% of electricity from RES in total European Community electricity consumption. - The 22.1% target was changed to a target of 21% with the accession of 10 new member states.	Voluntary	Originally EU-15. EU-25 after 2014
Directive 2009/28/EC on the promotion of the use of energy from RES, known as the Renewable Energy Directive, RED	Share of energy from RES consumed in transport, electricity and heating/cooling in 2020	- 20% of gross final energy consumption at EU level. - 10% for transport - National shares defined in NREAP	Binding at EU level and the national level	EU-27 EU-28 after accession of Croatia in 2013
2030 Climate and Energy Policy Framework as adopted by EU leaders at the European Council (EUCO169/14)	Share of energy from renewable sources in 2030; no target for transport; heat not mentioned	- At least 27% of gross final energy consumption at EU level. - Not deemed appropriate to establish new targets for renewable transport fuels	Biding at EU level but not at national level.	EU-28

Currently target is 20% EU RES target, set by the Renewable Energy Directive (RED). This objective was divided into national targets at different levels to reflect the situation in each country. As a result, each State has made great efforts to achieve these objectives.

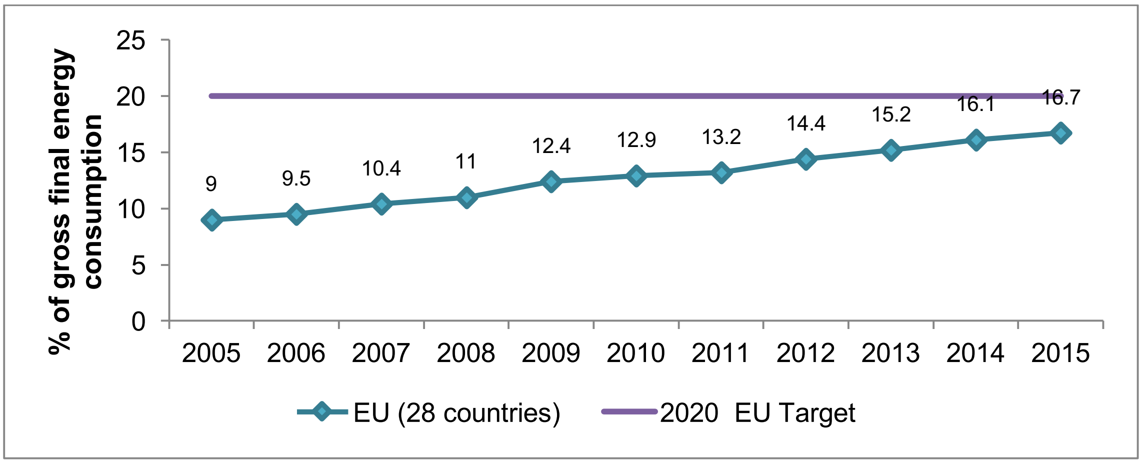


Figure 16: Share of energy from renewable sources in gross final consumption of energy, EU-28, 2005-2015 based on [16].

Appendix A shows the current progress of this target by country, it can be seen that some of EU-28 members have exceeded their targets in the RED. While countries like Netherlands, France and Luxembourg present shares below their indicative trajectory as is stated in [18]. To see how the progress of the RED targets has been between 2005 and 2015 for EU-28 respect it final objective presented on figure 10.

While referring to its target for 2020 concerning 10% of shares for transport, the EU is still below expectations. The evolution has been significant, and it is important to note on Figure 11, the decrease in 2011 in the growth that was occurring between 2005 and 2010, this can be attributed in part to the total lack of compliant biofuels reported by several EU countries [19]. After 2011, there was an increase in the share of RES in transportation, but even in 2015 it was 3.3% below the final target for 2020.

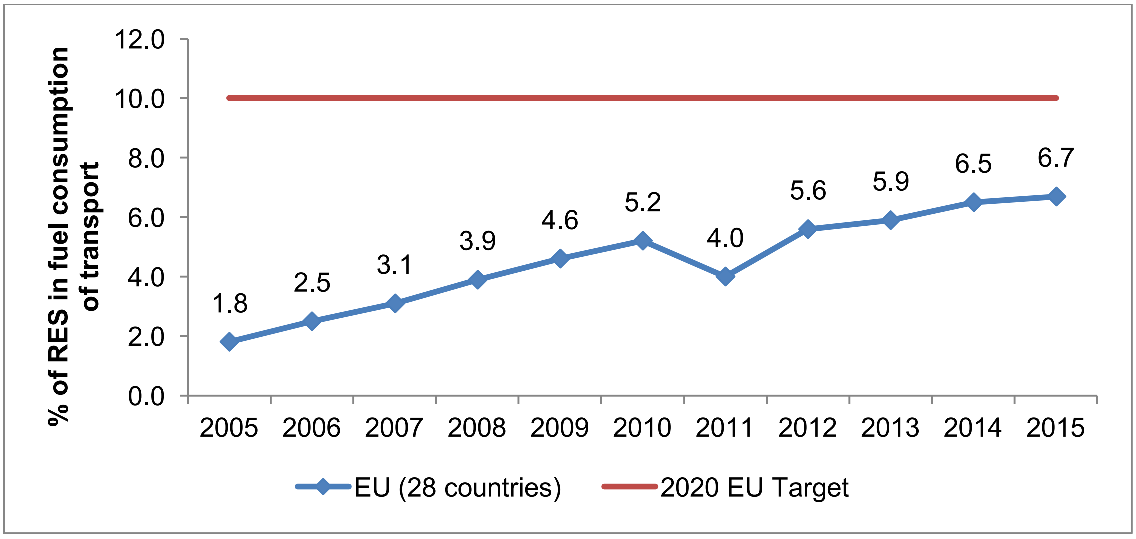


Figure 17: Share of renewable energy in fuel consumption of transport EU-28, 2005 - 2015 based on [16].

5. Policies and Strategies

A mix of different policy instruments to support the development of RES is implemented by each Member State of the EU to reach its individual RES target. The majority of policy instruments applied focus on the power sector, although also were introduced targets for specific RES shares in heating and cooling and for the transport sector. Types of policy instruments implemented include regulatory policies, fiscal incentives and public financing.

The policy mix has had many modifications due to varying economy and market conditions in the EU and due to the modifications of technology-specific targets by several member states, to mention some of these changes [27]:

- Different primary instruments have been integrated or combined.
- There have been shifts from FITs to FIPs and from FITs to tendering schemes
- Specific instruments have been applied for different technologies or projects.

Several sources on the RES support schemes implemented in EU countries were used in order to identify policy mix for RES-E support in the EU. They include the EurObserv'ER database [21], the RES legal database [22], and the IEA/IRENA Joint Policies and Measures database [23].

In addition, the changes of instruments over the period of analysis have been identified. Reports from REN21 in several years (2005, 2010 and 2015) have been used [24,25,26]. Those reports provide information on the implementation of instruments in countries all over the world. Therefore, their 2005, 2010 and 2015 editions allow the identification of the evolution of instruments. As well, the IEA/IRENA Joint Policies and Measures database provides details on the trends RES-E policies [23].

Table 11: Evolution of RES support instruments in the EU countries (2005–2015).

	Feed in tariff / Feed in premium	Renewable Portfolio Standard	Capital subsidies, grants, or rebates	Investment excise, or other tax credits	Sales tax, energy tax, or VAT reduction	Tradable renewable energy certificates	Energy production payments or tax credits	Net metering	Public investment, loans, or financing	Tendering	Biofuels Obligation / Mandate	Electric Utility Quota Obligation
2005	19	5	18	16	11	12	3	4	8	3		
2010	21	5	24	18	22	15	4	7	18	8		
2015	24	0	19	13	18	16	5	10	18	10	26	7

Source: Adapted from REN21 [2005, 2010, and 2015].

An analysis of the evolution of RES-E support instruments in the EU Member States since 2005 (Table 3) exposes that, with the exception of Renewable Portfolio Standard (RPS), the use of instruments has experienced an increase in the first sub-period (2005–2010), and a reduction in the majority of instruments during the second sub-period (2010–2015). The economic and financial crisis may have induced a reduction in the number of instruments, in order to reduce the load on consumers and taxpayers. The increase in the use of tenders during the whole period is likely to be related to the concern of governments about the asymmetric information problem in the setting of appropriate support levels in FITs and FIPs [27].

Czech Republic

The Government of the Czech Republic widely supports renewables for the past years. The logic of support schemes is: green energy producer can choose either feed-in-tariff (FIT) with guaranteed payment, either premium payment called green bonus (FIP). Moreover, there is also one big support from the Government side – subsidies [31].

	Hydro	Biomass	Biogas	Wind	Solar	**Sub-total RES**
2005	19.9	17.4	6.1	1.2	0.0	**44.7**
2006	21.9	24.2	9.2	2.7	0.1	**58.1**
2007	24.9	32.1	12.1	5.8	0.8	**75.6**
2008	29.2	42.2	20.0	9.6	5.6	**106.6**
2009	22.1	45.6	33.6	8.7	40.2	**150.1**
2010	54.6	78.3	70.0	13.9	265.3	**482.1**
2011	59.1	94.2	101.9	25.7	959.1	**1 239.9**

Figure 18: Cost of RES support schemes per technology, mln EUR [32]

From this picture, that the Government introduced enormous amount for millions euro.
For example, so called PV boom also caused with high amount of subsidies, thus, there were added more than 1300 MW of installed capacity.
General RES-E scheme is that FIT is fixed payments overall payment, however, FIP or green bonuses are payments which paid for each kWh on top of the market [31]. both schemes are granted for 20 years (small hydro for 20 years).
The following figure shows differences between feed-in-tariffs and green bonuses [31].

Type of RES	**Feed-in prices (€/MWh)**
Photovoltaic installations up to 30 kW	480
Photovoltaic installations over 30 kW	476
Wind power plants	89
Small water power plants	118
Geothermal energy	177
Biogas stations*	162
Pure biomass burning*	180

Type of RES	**Green bonuses (€/MWh)**
Photovoltaic installations up to 30 kW	451
Photovoltaic installations over 30 kW	438
Wind power plants	72
Small water power plants	80
Geothermal energy	138
Biogas stations*	124
Pure biomass burning*	142

Figure 19: Level of FIT and FIP in 2010 [31]

According to the figure above, it could be noted, that if electricity price is going to be decreased, then green bonuses are more suitable for people.
According to [32], the logic of support schemes:

1) To create a fair economic interest among investors for investment into renewable energy;
2) To minimize risk for renewables' investors and make them stable for a long-term period;

3) To create a soil for wide development in renewable energy sector in the Czech Republic.

6. Conclusions

The persistently low oil prices in 2015 had a negative impact on the renewable energies, especially on solar, wind, and biomass, but, interestingly, it also showed that the most resilient of the three was the biomass with a better recovery rate. As a conclusion one can say that although at the global scale, there is still a long way to go in order to be independent from the fossil fuels, some significant changes in the recent years, be it political, economic and environmental, has pushed us to step in the right direction and even though the progress is slow and fragile, the statistics show promising results. Austria and Czech Republic could be a good example, if not the best, to be used as a template for other countries around the world, that may want to begin this transition process with their years' worth of valuable experiences.

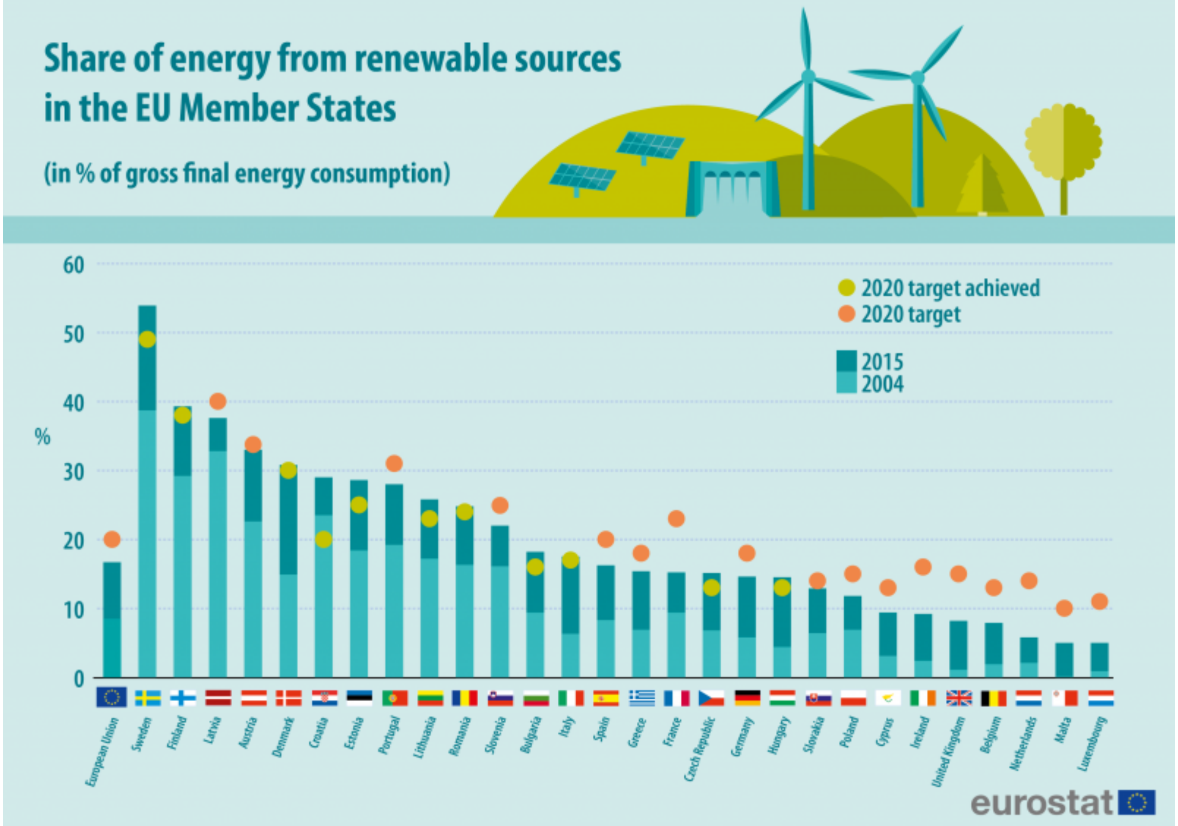
7. References

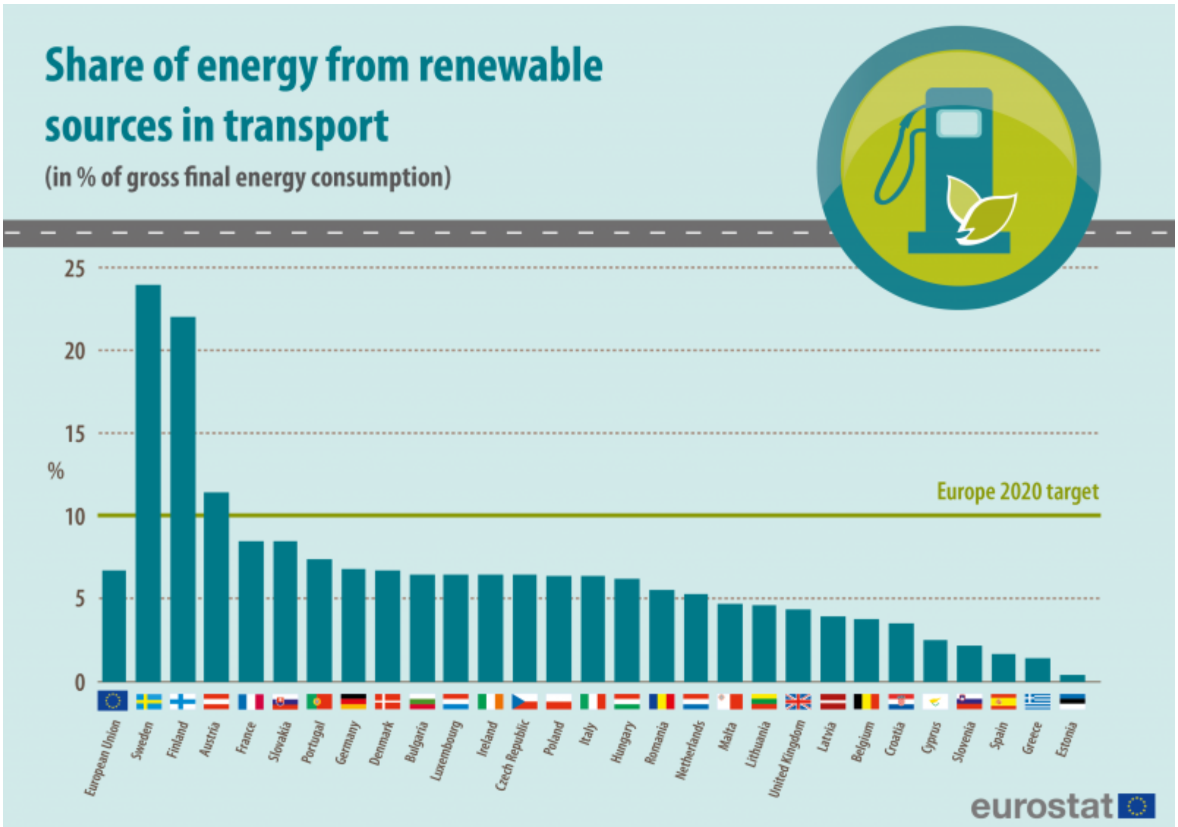
[1]. Austrian national investment Database. https://investinaustria.at/en/
[2]. Austrian Biomass Association Database. http://www.biomasseverband.at/home/
[3]. Federal Ministry of Agriculture, Forestry, Environment and Water Management Database. https://www.bmlfuw.gv.at/
[4]. Austrian Solar Association Database. http://www.solarwaerme.at/
[5]. Vattenfall Database. The Europe's biggest retailers of electricity and heat. http://www.solarwaerme.at/
[6]. Statistical office of the EU Database. http://ec.europa.eu/eurostat/web/main/home
[7]. International Energy Agency, Energy Policies for IEA Countries 2016 review https://www.iea.org/publications/freepublications/publication/Energy_Policies_of_IEA_Countries_Czech_Republic_2016_Review.pdf
[8]. Vukica Janković, Helena Mitwallyová, The potential of the usage of renewable energy in the Czech Republic. International Journal of Social Sciences Vol. III (4), 2014 http://www.iises.net/download/Soubory/IJOSS/V3N4/pp39-48_ijoss_V3N4.pdf
[9]. Eurostat, Energy from renewable sources, accessed 2017. Available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_from_renewable_sources
[10]. World Energy Council, Solar in Czech Republic [https://www.worldenergy.org/data/resources/country/czech-republic/solar/].
[11]. Franz Mauthner, Werner Weiss, Monika Spörk-Dür, Solar Heat Worldwide, edition 2015. https://www.iea-shc.org/data/sites/1/publications/Solar-Heat-Worldwide-2015.pdf
[12]. Vukica Janković, Potential of wind as a renewable resources in the Czech Republic, Velké Bilovicé, 2012 http://srsv.vse.cz/wp-content/uploads/2012/10/Jankovic_potential_of_wind.pdf
[13]. The Czech Wind Energy Association http://www.csve.cz/en/clanky/statistika/281

[14]. Eduard Ščerba, Biomass as a source and as a perspective of the renewable energetics in the world, europe and in the Czech Republic, May 2011, Železná Ruda-Špičák, University of West Bohemia, Czech Republic http://home.zcu.cz/~tesarova/IP/Proceedings/Proc_2011/Files/Scerba.pdf
[15]. Petr Tluka Vladimír Stupavský, Study on Biomass Trade in the Czech Republic, 2011, http://www.4biomass.eu/document/file/Trade_study_Czech_Republic.pdf
[16]. Eurostat, Energy statistics database, accessed 2017. Available at: http://ec.europa.eu/eurostat/web/energy/data
[17]. Kieffer, G., Couture, T. Renewable Energy Target Setting. IRENA. June, 2015. Available at: http://www.irena.org/DocumentDownloads/Publications/IRENA_RE_Target_Setting_2015.pdf
[18]. Study on Technical Assistance in Realisation of the 2016 Report on Renewable Energy, in preparation of the Renewable Energy Package for the Period 2020 2030 in the European Union. February, 2017 https://ec.europa.eu/energy/sites/ener/files/documents/res-study_final_report_170227.pdf
[19]. Eurostat, Energy from renewable sources, accessed 2017. Available at: http://ec.europa.eu/eurostat/statistics-explained/index.php/Energy_from_renewable_sources
[20]. Renewable energy in Europe 2016 Recent growth and knock-on effects. EEA Report. 2016
[21]. EurObserv'ER. RES Policy Reports. Available at: https://www.eurobserv-er.org/eurobserver-policy-files-for-all-eu-28-member-states/
[22]. European Commission. RES Legal Europe; 2017. Available at: www.res-legal.eu
[23]. IEA/IRENA. Joint policies and measures database; 2017 Available at: http://www.irena.org/menu/index.aspx?mnu=Subcat&PriMenuID=35&CatID=109&SubcatID=158&RefID=158&SubID=170&MenuType=Q
[24]. REN21. Renewables 2005 Global Status Report. Available at: www.ren21.net
[25]. REN21. Renewables 2010 Global Status Report. Available at: www.ren21.net
[26]. REN21. Renewables 2015 Global Status Report. Available at: www.ren21.net
[27]. DEL RÍO P, MIR-ARTIGUES, P. Combinations of support instruments for renewable electricity in Europe: A review. Renewable and Sustainable Energy Reviews. 2014
[28]. WindEurope, accessed 2017. Available at: https://windeurope.org/
[29]. European Biomass Association, accessed 2017. Available at: http://www.aebiom.org
[30]. Internationa Renewable Energy Agency, accesed 2017. Available at: http://www.irena.org/home/index.aspx?PriMenuID=12&mnu=Pri
[31]. National Renewable Energy Action Plan of the Czech Republic, Ministry of Industry and Trade, 2010, http://www.eclareon.com/sites/default/files/czech_republic_-_res_integration_national_study_nreap.pdf
[32]. European Enviroment Agency (EEA), Project Energy Support and Innovation, Czech Republic Case Study, https://www.eea.europa.eu/publications/energy-support-measures/case-study-czech-republic
[33]. Jaroslav Knápek, Jiří Vašíek, Risk inclusion in feed-in tariffs and green bonuses calculation, 10th IAEE European Conference, Wien, 2009

http://www.aaee.at/2009-IAEE/uploads/fullpaper_iaee09/P_568_Knapek_Jaroslav_31-Aug-2009,%2018:19.pdf

Appendix A





Summary of Country (IRENA)

Country	Overall 2020 target	Heating and	Electricity:	Transport:	Main support scheme

	RES in gross final energy consumption	cooling: Share of heat consumption met by RES	Share of electricity demand met by electricity generated from RES	Share of energy demand met by RES	
Austria	34%	33%	71%	11.5%	Feed-in tariff
Belgium	13%	12%	21%	10%	Quota and green certificate systems
Bulgaria	16%	24%	21%	8%	Feed-in tariff
Croatia	20%			10%	Feed-in tariff
Cyprus	13%	23.5%	16%	5%	Feed-in premium
Czech Republic	13.5%	14%	14%	11%	Feed-in tariff and green bonus
Denmark	30%	40%	52%	10%	Feed-in tariff
Estonia	25%	38.4%	17.6%	10%	Feed-in premium
Finland	38%	47%	33%	20%	Feed-in premium
France	32%	38%	40%	15%	Feed-in tariffs and auction system
Germany	18%	15.5%	37%	13%	Feed-in tariffs and auction system
Greece	18%	20%	40%	10%	Feed in tariff
Hungary	14.65%	18.9%	10.9%	10%	Feed-in tariff
Ireland	16%	12%	42.5%	10%	Feed-in tariff
Italy	17%	17%	26%	10%	Feed-in tariff
Latvia	40%	53%	60%	10%	Feed-in tariff
Lithuania	23%	36%	21%	10%	Feed-in tariff
Luxembourg	11%	8.5%	12%	10%	Feed-in tariff for RES and cogeneration
Malta	10%	6%	14%	11%	Feed in tariff
Netherlands	14.5%	9%	37%	10%	Feed-in premium
Poland	15%	17.05%	19.13%	10.14%	Power auctions
Portugal	31%	31%	55%	10%	Feed-in tariff for micro, mini generation and self-
Romania	24%		38%		Quota obligation
Slovakia	10%	14.6%	24%	10%	Feed-in tariff
Slovenia	25%	31%	39%	10.5%	Feed-in tariff
Spain	22.7%	18.9%	40%	13.6%	Feed-in tariff/in premium
Sweden	49%	62%	63%	14%	Norway-Sweden Green Certificate Scheme
United Kingdom	15%	12%	31%	10%	Renewables Obligation (RO)