Development of renewable energy market in the EU with particular regard to solar energy

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Abstract: Solar energy is the fastest growing energy sector in the world, with growth rates of 40-50% per year. Solar energy creates the possibility of industrial use of new technologies, materials and structures of solar cells, modules and power plants. The aim of this paper is to present renewable energy sources and their use in the EU in the years 2004-2015. This paper analyzes the use of photovoltaic (PV) technology in Europe, discusses what this technology is, and the rate of its development. Also, a list of advanced countries that are actively using solar energy is given. The biggest part in renewable energy is occupied by biofuels and renewable waste. Our analysis confirmed the highest increase in the share of electricity from renewable sources in gross electricity consumption in the years 2004-2015 in Estonia (2,416.7%), Belgium (805.9%) and the United Kingdom (540%). The conducted analysis showed that Malta (1181.1%), the United Kingdom (685.8%) and Luxembourg (283.3%) achieved the highest increases in the share of renewable energy sources in heating and cooling in the years 2004-2015. In the same period Portugal (2.8%), Latvia (21.9%) and Croatia (31.3%) achieved the lowest increases in the share of renewable energy sources in heating and cooling. This paper finds a reduction in excise taxes stimulates the demand for "green" energy. European countries have achieved very impressive results in the development of solar energy. The results are of great interest to investors, politicians and others interested in the development of PV power plants.

Keywords: solar energy, photovoltaics, concentrated solar power, alternative energy, capacity, solar market

JEL: D40, N54, N74

Introduction

The theory of sustainable development has been heavily researched and is rapidly developing and becoming ever more popular in the last decade. All of the developed countries of the world have expressed their desire to follow a direction towards sustainable development.

One of the concepts of this theory for non-renewable natural resources is the maximum slowdown in the rate of depletion of their reserves with the prospect of replacing them in the future with other unlimited resources. For example, partial replacement of oil, gas or coal with alternative sources of energy – solar, wind, etc. [Sustainable Development… 2011, p. 11].

Renewable energy is the fastest growing energy sector in the world. It includes: biofuels and renewable wastes, hydropower, wind, solar, and geothermal energy.

Viewed by the main energy source, energy production has many industries, such as nuclear, coal, hydropower, gas and alternative, which are based on the use of non-traditional renewable energy sources. Alternative energy includes: wind energy, solar, geothermal, biomass, etc. If we compare all these sectors based on environmental, economic, and safety criteria, we can conclude that solar energy is the most promising [Udell, 1980, p. 88].

The solar energy industry develops methods and resources for using solar emissions or solar radiation to produce electrical, thermal and other types of energy. Scientists have estimated that utilising even a small percentage of the available solar energy will be enough to satisfy the needs of transport and industry now and in the future.

Today, solar energy produces 4% of the electricity in the EU. In Italy, Greece and Germany, the solar share exceeds 7%. In a pessimistic scenario of development, solar energy will provide 10% of European electricity by 2030. It is also obvious that it is extremely important that mechanisms of state regulation are correctly structured. They allow the formation of a market, creation of the appropriate production capacity, and ensure a long-term reduction in the price of solar electricity.

However, this industry has a significant disadvantage. The sun's rays that fall on the earth's surface do not have a specific concentration point, which is why it needs to be captured and converted into an energy form that could be used more readily. There is also a problem with the availability of solar energy at night and on dark days. But these problems can be solved. Now the main thing is to make the cost competitive [Ionov, 2006, p. 82].

The aim of this paper is to present renewable energy sources and their use in the EU in the years 2004-2015. To achieve this goal, the authors of the paper analysed changes in renewable energy, in particular biofuels and renewable wastes, hydropower, wind, solar and geothermal energy. Particular attention has been focused on solar energy. Within the main objective, two specific objectives were pursued: 1) to analyse the changes in share of electricity from renewable sources in gross electricity consumption, in heating and cooling, and in transport; 2) to find out whether a reduction in excise taxes stimulates demand for "green"

energy. The authors of the paper used descriptive, tabular and graphic methods to analyse the results.

Renewable Energy Market Evolution in Europe

At the present stage of development, there is a strong interest of countries in energy security and environmental protection. In the world, there are more than 20 countries which have a share of renewable energy sources in their total energy usage that exceeds 20%. These include Iceland, Norway, Scotland, Denmark, Germany, and others. According to the energy strategy adopted in the EU, by 2020 the EU countries must achieve a 20% reduction in greenhouse gas emissions, an increase to 20% in the share of renewable energy and a 20% improvement in energy efficiency. By 2050, Germany plans to achieve a 60% share of renewable energy in the country's total energy balance and 80% in electricity generation.

Renewable energy is an effective way of addressing the energy crisis. In terms of installed capacity among European countries in 2015, wind power is in the lead. Taking the average annual growth rate of wind power plants (WPP) – 15%, and solar photovoltaic power stations (PV) – 31%, by 2020 the installed capacity will be: WPP – 845 GW, PV – 867 GW.

Renewable energy is a way to get new energy that can replace or supplement energy needs. The share of renewables in gross inland energy consumption is diverse in Europe. The highest share of renewables in gross inland energy consumption in 2015 was in Sweden (42.2%), Finland (31.6%) and Latvia (35.1%). The lowest share of renewables in gross inland energy consumption in 2015 was found in Malta (2.6%), the Netherlands (4.7%) and Luxembourg (4.9%).

The biggest share of renewable energy is occupied by biofuels and renewable waste. Analysis of the information in table 1 suggests that the biggest share of biofuels and renewable waste can be seen in Latvia (31.2%), Finland (26.7%) and Sweden (24.8%). The smallest share from biofuels and renewable waste was observed in 2015 in Malta (1.0%), Cyprus (2.1%) and Ireland (3.0%).

Table 1. Share of renewables in Gross Inland energy consumption 2015 (%)

Country	Renewable energy	Biofuels and renewable wastes	Hydropower	Wind	Solar	Geothermal
EU-28	13.0	8.4	1.8	1.6	0.8	0.4
Belgium	6.7	5.2	0.1	0.9	0.5	0.0
Bulgaria	10.8	6.5	2.6	0.7	0.8	0.2

Country	Renewable energy	Biofuels and renewable wastes	Hydropower	Wind	Solar	Geothermal
Czech Republic	10.1	9.1	0.4	0.1	0.5	0.0
Denmark	28.4	20.5	0.0	7.2	0.5	0.0
Germany	12.2	8.2	0.5	2.2	1.3	0.1
Estonia	14.5	13.5	0.0	1.0	0.0	0.0
Ireland	7.6	3.0	0.5	4.0	0.1	0.0
Greece	11.3	5.4	2.1	1.6	2.2	0.0
Spain	13.7	5.6	2.0	3.5	2.6	0.0
France	8.6	5.7	1.9	0.7	0.3	0.1
Croatia	23.0	15.5	6.4	0.8	0.2	0.1
Italy	16.8	8.6	2.5	0.8	1.4	3.5
Cyprus	5.5	2.1	0.0	0.8	3.5	0.1
Latvia	35.1	31.2	3.7	0.3	0.0	0.0
Lithuania	20.5	19.0	0.4	1.0	0.1	0.0
Luxembourg	4.9	4.2	0.2	0.2	0.3	0.0
Hungary	12.0	11.1	0.1	0.2	0.1	0.4
Malta	2.6	1.0	0.0	0.0	1.6	0.0
Netherlands	4.7	3.6	0.0	0.8	0.2	0.1
Austria	29.0	17.3	9.6	1.3	0.8	0.1
Poland	9.4	8.2	0.2	1.0	0.1	0.0
Portugal	21.5	12.6	3.2	4.3	0.6	0.8
Romania	18.4	11.5	4.4	1.9	0.5	0.1
Slovenia	16.1	9.9	5.0	0.0	0.5	0.7
Slovakia	9.6	7.2	2.0	0.0	0.3	0.0
Finland	31.6	26.7	4.3	0,6	0.0	0.0
Sweden	42.2	24.8	14.2	3.1	0.0	0.0
United Kingdom	7.7	5.3	0.3	1,8	0.4	0.0

Source: own elaboration on the basis of renewable energy statistics.

The authors of the paper analysed the changes in share of electricity from renewable sources in gross electricity consumption. It is worth mentioning that Cyprus and Malta had no share of electricity from renewable sources in gross electricity consumption in 2004, but by 2015 these countries reached the levels respectively of 8.4% and 4.2%. The highest increase in share of electricity from renewable sources in gross electricity consumption in the years 2004-2015 was in Estonia (2416.7%), Belgium (805.9%) and the United Kingdom (540%). The lowest increase in share of electricity from renewable sources in gross electricity consumption in the years 2004-2015 was observed in Slovenia (11.6%), Austria (13.8%) and Latvia (14.1%).

The highest increase in share of renewable energy sources in heating and cooling in 2004-2015 was observed in Malta (1,181.1%), the United Kingdom (685.8%) and Luxembourg (283.3%). The lowest increase in share of renewable energy sources in heating and cooling was observed in 2004-2015 in Portugal (2.8%), Latvia (21.9%) and Croatia (31.3%).

Finally, we analysed the share of renewable energy sources in transport. Malta, Cyprus and Ireland did not use renewable energy sources in transport. The biggest increase in share of renewable energy sources in transport in 2004-2015 was found in Luxembourg (6,400%), Finland (2,100%) and Denmark (1,575%). The lowest increase of share of renewable energy sources was found 2004-2015 in Spain (70%), Latvia (85.7%) and Estonia (100%).

Table 2. Changes in renewable energy in 2004-2015 (%)

Country	Share of electricity from renewable sources in gross electricity consumption			Share of renewable energy sources in heating and cooling			Share of renewable energy sources in transport		
	2004	2015	change	2004	2015	change	2004	2015	change
EU-28	14.3	28.8	97.2	10.2	18.6	82.4	1.4	6.7	378.6
Belgium	1.7	15.4	805.9	2.9	7.6	162.1	0.5	3.8	660.0
Bulgaria	9.1	19.1	109.9	14.1	28.6	102.8	0.9	6.5	622.2
Czech Republic	3.6	14.1	291.7	9.9	19.8	100.0	1.5	6.5	333.3
Denmark	23.8	51.3	115.5	20.6	39.5	91.7	0.4	6.7	1575.0
Germany	9.4	30.7	226.6	6.3	12.9	104.8	2.2	6.8	1600.0
Estonia	0.6	15.1	2416.7	33.2	49.6	49.4	0.2	0.4	100.0
Ireland	6.0	25.2	320.0	2.9	6.4	120.7	0.0	6.5	650.0
Greece	7.8	22.1	183.3	12.8	25.9	100.8	0.1	1.4	1300.0

Country	Share of electricity from renewable sources in gross electricity consumption			Share of renewable energy sources in heating and cooling			Share of renewable energy sources in transport		
	2004	2015	change	2004	2015	change	2004	2015	change
Spain	19.0	36.9	94.2	9.5	16.8	76.8	1.0	1.7	70.0
France	13.8	18.8	36.2	12.3	19.8	61.0	1.5	8.5	466.7
Croatia	35.5	45.4	27.9	29.4	38.6	31.3	1.0	3.5	250.0
Italy	16.1	33.5	108.1	5.7	19.2	236.8	1.2	6.4	433.3
Cyprus	0.0	8.4	-	9.3	22.5	141.9	0.0	2.5	250.0
Latvia	46.0	52.2	14.1	42.5	51.8	21.9	2.1	3.9	85.7
Lithuania	3.6	15.5	330.6	30.4	46.1	51.6	0.4	4.6	1050.0
Luxembourg	2.8	6.2	121.4	1.8	6.9	283.3	0.1	6.5	6400.0
Hungary	2.2	7.3	231.8	6.5	21.3	227.7	0.9	6.2	588.9
Malta	0.0	4.2	-	1.1	14.1	1181.8	0.0	4.7	470.0
Netherlands	4.4	11.1	152.3	2.2	5.5	150.0	0.5	5.3	960.0
Austria	61.8	70.3	13.8	20.1	32.0	59.2	4.5	11.4	153.3
Poland	2.2	13.4	509.1	10.2	14.3	40.2	1.4	6.4	357.1
Portugal	27.5	52.6	91.3	32.5	33.4	2.8	0.4	7.4	1750.0
Romania	25.0	43.2	72.8	17.6	25.9	47.2	1.5	5.5	266.7
Slovenia	29.3	32.7	11.6	18.4	34.1	85.3	0.9	2.2	144.4
Slovakia	15.4	22.7	47.7	5.1	10.8	111.8	1.4	8.5	507.1
Finland	26.7	32.5	21.7	39.5	52.8	33.7	1.0	22.0	2100.0
Sweden	51.2	65.8	28.5	46.7	68.6	46.9	5.3	24.0	352.8
United Kingdom	3.5	22.4	540.0	0.7	5.5	685.8	0.3	4.4	1366.7

Source: own elaboration on the basis of renewable energy statistics.

Solar PV technology

Currently, there are two popular ways of converting solar energy: photovoltaics (PV) and concentrated solar power. But photovoltaic technology has much wider use in the field, for several reasons.

Solar photovoltaic power is the most common source of electricity in the world by number of installations [Gielen et al., 2016, p. 19]. As a result of the decline in the cost of

PV panels and rising efficiency in solar cells [Honrubia-Escibano et al., 2015, p. 467], solar PV accounted for 20% of all new power generation capacity in 2015 [Gielen et al., 2016, p. 25].

Of course, PV generation is at a maximum in the daytime. One of the promising areas for the development of PV is the creation of self-contained photovoltaic installations with a capacity of 2 to 3 kW with an area of 20-30 m^2, located on the roofs and facades of private houses, and generating approximately 3,000 kWh per year.

Now, the most important task of PV is to achieve costs where photovoltaic electricity is equal in value, or even cheaper, than energy obtained through a conventional electrically conductive network from power plants [Teregulov, Abdrashitov, 2017, p. 21].

Photovoltaic cells are made of semiconductor materials. When sunlight enters the cells, it knocks electrons out from their atoms. The electrons generate electricity when they pass through the cell.

The structure of the material has two energy bands, separated by a forbidden zone, known as an energy or band gap: the valence band and the conduction band. The valence band of a semiconductor material, for example silicon, is filled with electrons, and its conducting band is empty. On the contrary, the conduction band in a conductor material is partly filled. A certain amount of energy must be reached before the electron is transferred from the valence band to the conduction band, which is equal to the band gap energy and depends on the type of material. Consequently, based on the material used, PV technology is subdivided into crystalline, thin film, compound semiconductor and nanotechnology [Horubia-Escribano, et al., 2017, p. 470].

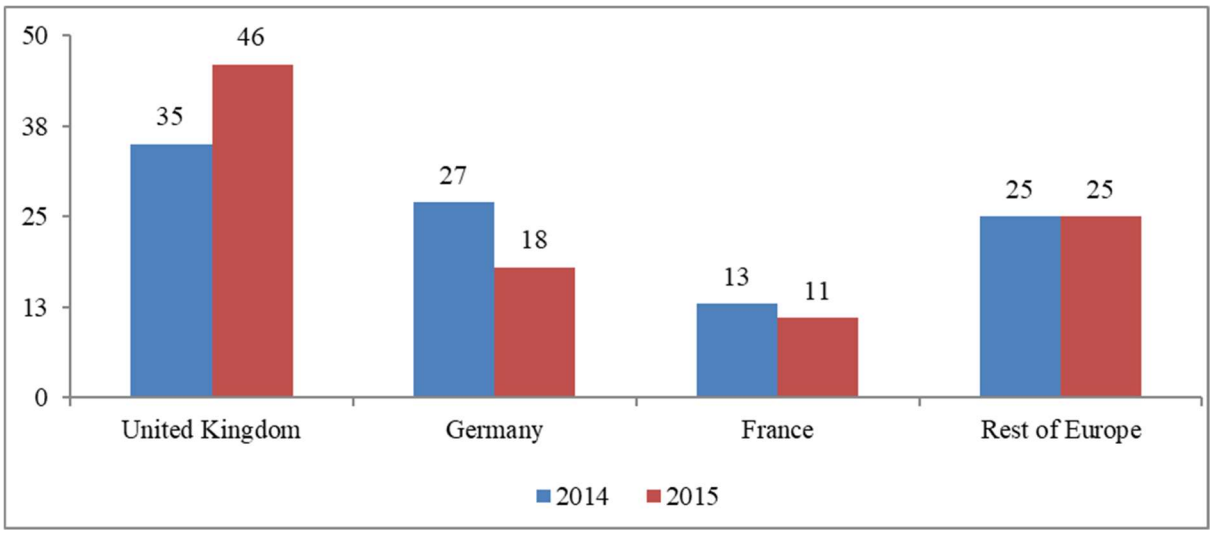
The most solarised continent is Europe. In Europe, an average of about 4% of electricity demand comes from solar power, and, in the most advanced solar markets, is around 8%. No other region can boast such high solar shares [Solar Market Report & Membership Directory, 2016, p. 11].

In 2015 the European solar market saw significant growth. Demand grew by 15% compared to the previous year. In Europe, the base for the demand for solar power consists mainly of three countries – UK, Germany and France. Their markets produce 75% of the solar energy, which equals 6 GW, in 2014 it was also 75%, but 5.3 GW (figure1) [Solar Market Report & Membership Directory, 2016, p. 17].

Italy was previously a European leader. It installed about 300 MW, that's almost 100 MW less than in 2014. In 2008, Spain was the world market leader. But the Spanish Government is blocking the emergence of the self-consumption market with a solar tax and

high penalties for non-declared prosumers [Solar Market Report & Membership Directory, 2016, p. 25].

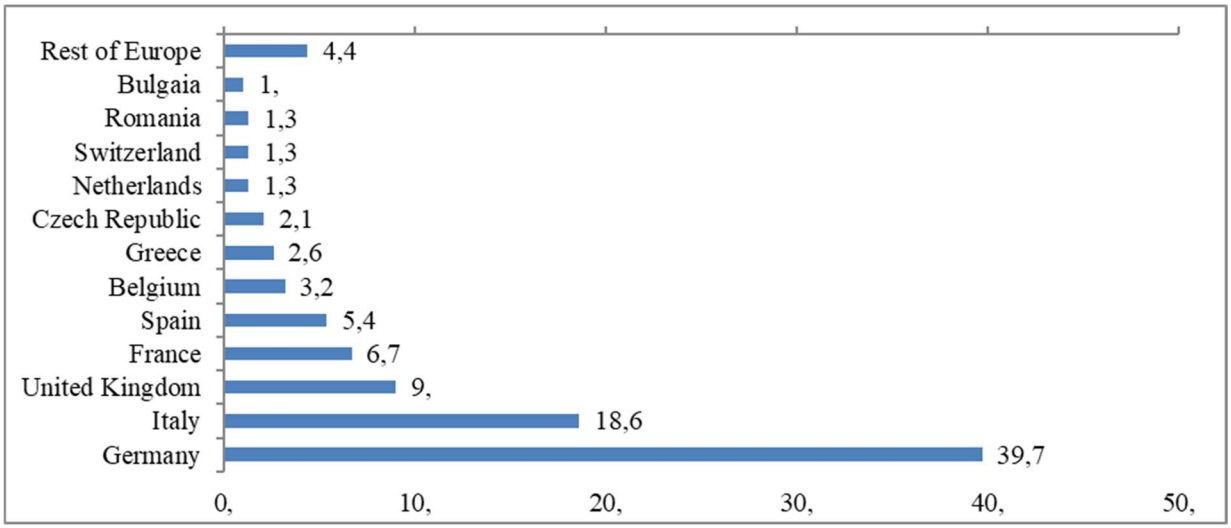
Fig. 1. Capacity additions and shares of main 3 European solar markets in 2014 and 2015 (%/MW)



Source: Solar Market Report & Membership Directory, 2016.

Twelve countries in Europe have installed solar power capacities exceeding 1 GW (figure 2). The total European on-grid capacity is 92 GW. Germany's PV capacity remains the largest in Europe, at about 40 GW. Italy's capacity is half that at almost 19 GW.

Fig. 2. European countries with total solar PV capacities larger than 1 GW



Source: Solar Market Report & Membership Directory, 2016.

But in the UK, the amount of solar power installed in 2016 decreased by about half compared with the previous year, when there was record growth. The fall occurred when the government severely cut incentives for householders to fit solar panels and closed subsidies for

large-scale "solar farms" [Worldwide solar power growth leaps by 50% thanks to US and China, 2017, p. 16].

For today, there are several different policy schemes for divided solar generation in Europe. The Netherlands is using net-metering for residential buildings. For example, in Germany and Austria self-consumption schemes are applied to residential and commercial solar systems. Other countries have introduced net-billing schemes, such as Italy and Portugal, but still have limited success [Solar Market Report &Membership Directory, 2016, p. 22].

Tax stimulating for alternative energy in Europe

Global investment trends indicate a possible change in the structure of the entire global energy system in the coming decades towards the use of renewable energy sources. The study of the experience of the leading countries in the development of alternative energy makes it possible to identify and adapt the most effective mechanisms when developing investment programmes of federal and regional importance for improving energy efficiency. In various tax systems of European countries, incentive measures for investments in alternative energy take special forms and sizes, but are aimed at achieving the same effect – to make high-risk and long-term investments in energy objects more profitable.

According to experts from the US's Oak Ridge National Laboratory, a ten-year, federal, industrial tax credit of 1.5 cents per kWh can reduce the average life cycle cost of solar energy by about 25%. Some European countries are currently using this type of tax incentive. In some European countries a property tax reduction is used to stimulate the development of solar energy. This that can eliminate up to 100% of the tax on property, land and fixed assets used to produce solar energy [Clement et al., 2005]. Therefore, reducing property tax can help create a tax parity between alternative energy and traditional technologies. Investment tax incentives are also often applied to small, client-oriented or service companies that are not producers, but consumers of energy and energy-saving technologies. It should be noted that some European countries abolished the practice of granting production tax credits because it requires constant monitoring of the production activities of companies and leads to high administrative costs.

Reductions in excise duties allow consumers to avoid up to 100% of the sales tax when buying energy from renewable sources, equipment or fuel. Thus, the reduction of excise taxes stimulates the demand for "green" energy. Some European countries impose a tax on sales of conventional electricity, but do not tax the sale of energy produced from alternative sources. Others reduce excise duties on the sale of equipment for the production of alternative energy. A rarer case is the return of a portion of the excise duty. The consumer can file an application

for the return of all or part of the tax paid at the time of equipment purchase. Tax benefits for consumers of energy-efficient technologies used in Europe are shown in Table 1.

Table 3. Measures of tax incentives for the development of alternative consumer-oriented energy technologies used in some European countries

Country	**Austria**	**Greece**	**Spain**	**Portugal**	**France**	**Czech Republic**
Sector	Residential	Residential, commercial	Residential, commercial	Residential	Residential	Residential, commercial
Type of tax incentive	Tax cuts	Credit	Credit	Credit	Credit	Tax cuts
Rate, %	Up to 25	Up to 75	10	Up to 30	15	Up to 100
Technologies that are subject to the stimulus	Solar energy, biomass energy	Solar energy	Solar energy, biomass energy	All	All	All

Source: Tax incentives for alternative energy in Europe, 2012.

As a result of the integrated use of tax incentives for alternative energy, as well as a number of other measures of state support (guaranteed tariffs for the supply of energy to the grid), European countries have achieved very impressive results in the development of solar energy [Ratner, 2011, p. 43].

Despite the fact that tax incentive measures for alternative energy have produced very significant results in a number of countries, other states prefer to use other incentive measures. Thus, in Germany, the main instruments of state support for alternative energy are guaranteed tariffs for the supply of electricity from alternative sources to the grid. Depending on the location and some technical conditions, the governmental programme Reneschabel Energy Sources Act guarantees a 20-year sponsorship tariff from 9.20 to 5.02 euro cents per kWh for generators installed earlier than 01.01.2010 [Ayodele et al., 2016, p. 15]. Based on the legislative level, guarantees to provide a bonus tariff for 20 years and mandatory connection to the grid allow investors of offshore projects to reduce risks and plan their activities for years to come.

Investing in renewable sources of energy

In 2014, the share of electricity received from renewable energy sources was 22.6%, which is 3.5% higher than in 2013 [Renewables, 2015, p. 136]. Such a steep rise was created thanks to world trends and government benefits for its production. Today, the largest corporations and financial institutions, in addition to profitability, should also pay attention

to environmental sustainability, as the world community is increasingly worried about the state of the planet. Such technologies include photovoltaic, i.e. CSP panels. In monetary terms, this is almost $ 150 billion, with a total investment of $ 270 billion alone in 2014 [Renewables, 2015, p. 136]. The leader in the production of electricity today is Germany (photovoltaic and CSP). There is a "green tariff", which allows any business to produce electricity, where the state is legally obliged to buy each kilowatt of energy produced. The availability of additional tender programmes and a system of pure measurement allows you to attract foreign capital. In Europe, the leaders in the production of electricity from renewable energy sources are Germany, Italy and Spain. To a greater extent, they are financed by such financial institutions as the European Investment Bank (EIB). These investments are innovative due to their novelty and pursued goals, namely: promoting environmental sustainability, the efficiency of production of electrical technologies, and promoting competitiveness with producers of "traditional" electricity. The EIB offers more than 15 subsidy options, including loans, partnerships, investments, various funds, initiatives, and research support. There are several programmes to be highlighted, namely:

- GEEREF (Global Energy Efficiency and Renewable Energy Fund) – this fund is investing in projects that introduce alternative energy sources to developing countries.
- JEREMIE (Joint European Resources for Micro to Medium Enterprises) is a fund dedicated to financing renewable energy projects in Europe for small and medium-sised businesses. During the existence of the fund, 1.2 billion euros were placed in 10 countries to provide guarantees, financial instruments, as well as borrowed funds. At the time of the last report, the EIB provided loans of more than 3,2 billion euros for alternative energy, most of which were directed to photovoltaic and CSP panels [Novikov, 2016, p. 315].

Conclusions

The paper has analysed changes in renewable energy, particular biofuels and renewable wastes, hydropower, wind, solar and geothermal in 2015. Then, renewable energy sources and their use in the EU in 2004-2015 were presented. Latvia (31.2%), Finland (26.7%) and Sweden (24.8%) are the countries with the biggest share of biofuels and renewable waste in 2015. The smallest share of biofuels and renewable waste in the EU in 2015 was observed in Malta (1.0%), Cyprus (2.1%) and Ireland (3.0%).

The analysis conducted showed that the highest increase of share of electricity from renewable sources in gross electricity consumption in the years 2004-2015 was in Estonia (2,416.7%), Belgium (805.9%) and the United Kingdom (540%). Slovenia (11.6%), Austria (13.8%) and Latvia (14.1%) were the countries with the lowest increase in share of electricity from renewable sources in gross electricity consumption in the years 2004-2015.

Solar energy is the most promising alternative energy based on environmental, economic and safety criteria. The main problem of solar energy is the cost of saving solar energy generated in the daytime, storing it for evening peak consumption. Battery systems, which have a service life of three to six years, are several times more expensive than the solar cells themselves. The cost of solar generation, which is "unregulated", is not comparable to the cost of generating electricity in conventional power plants that can freely generate it at any time, if necessary. Currently, the use of solar energy and expensive solar battery systems is economically justified only for those regions and facilities where there is no other possibility of connecting to the electricity grid.

Some European countries impose a tax on sales of conventional electricity, but do not tax the sale of energy produced from alternative sources, and some of them are reducing excise duties on the sale of equipment for the production of alternative energy. For this reason, the reduction of excise taxes stimulates the demand for "green" energy.

However, we should not forget the following important factors that encourage the consideration of solar energy:

1. The cost of fossil fuels is steadily increasing as their reserves decrease.
2. Reasonable state policy makes the use of solar power plants more profitable.
3. Progress does not stand still. The efficiency of solar power plants is increasing, new technologies are being developed in the generation and accumulation of electricity.

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