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THE POLISH ENERGY SECTOR CHARACTERISTICS IN COMPARISON TO EUROPEAN UNION COUNTRIES IN TERMS OF SUSTAINABLE DEVELOPMENT

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ABSTRACT

In every country, the energy sector plays a very important role - from its efficient operation electricity and heat supplies depend on. Moreover, its level of efficiency can measurably affect the condition of the natural and the social environment. Therefore, the purpose of this article was to examine to what extent the Polish energy sector fulfills the framework of sustainable development conception. In order to achieve the adopted objective, comparative analyzes have been carried out among all European Union countries. It allowed to identify areas in which the Polish energy sector fully implements the principles and objectives of this concept, as well as areas where still there is a lot need to be dome. The analyzes concerned several key issues: the level of energy generated from renewable energy sources (RES), the structure of sources of raw materials for energy production, the values of regulatory indicators for sustainable energy, level of greenhouse gas and pollutants emissions by energy sector, environmental taxes paid by energy sector, environmental protection expenditure of energy sector, environmental investments and wastewater management and, last but not least, innovations expenditures of energy sector. Examining these issues makes it possible to determine the so-called “level of sustainability" or the sustainability in energy sector degree’s determination for Poland.

Keywords: energy sector, sustainable energy, emissions, pollutants, innovation, expenditures

INTRODUCTION

In addition to the first phase in abstract – from energy sector’s efficient operation, proper functioning of the remaining economy’s branches or even the life of the people, depend on as well. Any breakdowns that result in power interruptions may bring a measurable negative effect - such as lack of information transfer, cessation of life support devices, or even may lead to a catastrophe. Each such a break also generates very high costs associated with potential "losses" (e.g. caused by not delivering goods via rail transport electricity powered), that must be incurred.

Countries’ economic development depends on access to energy. It is forecasted that by 2040, the world economy will be growing at an average rate of 2.9% per year. Taking into account the predicted constant increase in energy efficiency, the growth of the global energy sector will be 1.3% per year. It is also predicted that the importance of conventional sources (coal and oil - expected 0.8% growth per year) will be reduced, while the share of renewable energy sources (solar, wind and geothermal - an 11.1% increase per year). And the development of renewable energy industry should contribute to achieving its share of about 20% in total energy production in 2014 (*Energy…,* 2016). Thus energy is critical to economic and social development but, depending on the way it is produced, transported and used, it can contribute to both local environmental degradation, such as air pollution, and global environmental problems, principally climate change (Spalding-Fecher, 2003). For many years, the main raw material for the energy production had been hard coal and brown coal, whose rich deposits provided continued supply of these raw materials to the power stations, thus enabling constant energy production. However, the use of this raw material has had negative effects on the natural environment and on humans as well. First of all, burning coal produces many pollutants emitted to the atmosphere, thus worsening the condition of the air and affecting the human health. It produces ashes as well, which was released into the environment causing its degradation. In addition, the natural environment was negatively impacted by coal mines - in the form of cleared forests or contaminated sites. All this also caused the deterioration in people living conditions. Moreover, coal as a raw material is a non-renewable resource, which leads to the fact that over a time, the source of this raw material will be depleted. This fact, as well as the continuous technology development together with the growing people awareness in the field of environmental protection, have caused that, at present, not only coal as a raw material is being used for energy production. Because for many years, raw materials from the

renewable energy sources (RES) in the form of wind, water, sun, geothermal or biomass have been used. Increasing share of this kind of energy sources in the energy production, causes that the whole energy sector becomes to be more "sustainable". But one should not be forgotten, that the "sustainability " of the energy sector is being also influenced by other issues.

SUSTAINABLE DEVELOPMENT IN ENERGY SECTOR

Sustainable development concept was mentioned at first during the Conference in Paris in 1968. A group of economic experts, called the Club of Rome, led by D. Meadows, mentioned the need for sustainable utilization of natural resources in the document *The Limits of the Growth* (Fidlerova, Jurik, Sakal, 2016). The concept of sustainable development in the simplest sense, implies striving for a balance between its three main pillars: the society, the environment and the economy, on which the modern world based. All these pillars are closely linked to each other and changes occurring in one of them, also cause changes in the others. But the concept of sustainable development also speaks about the use of the Earth's resources in that way how the present generation does, and the future generation could benefit from it at the same scale (Starostka-Patyk, 2016). This perception mainly refers to the use of non-renewable resources - in such a way that future generations can equally use them. The universality of the sustainable development concept means that references to its principles and objectives can be found practically in all sectors or branches of the economy, but the energy sector can be considered as the foundation of this concept. Because coal, next to wood, was the second largest use raw material in the Industrial Revolution. This over-exploitation of this raw material caused that W.S. Jevons and others, predicted that the coal seams would be exhausted within the next hundred years. Thus, unlimited consumption of coal should be reduced, and therefore it becomes necessary to search for new sources of energy, that would be able to replace coal as the primary raw material for its production (Jevons, 1866).

Energy is perceived as an essential factor for sustainable development and poverty eradication. In the year 2015 more than 1.1 billion people had no access to electricity and more than 2.8 billion had no access to modern energy services. In addition, around 4.3 million people died or have been sick due to pollution resulting from cooking and heating with unsustainable fuels. According to Ban Ki-moon, UN Secretary-General, energy is "*the golden thread that connects economic growth, increased social equity, and an environment that allows the world to thrive. Development is not possible without energy, and sustainable development is not possible without sustainable energy*" (Ki-moon, 2016). Sustainable energy has a major impact on people's lives and is an engine for poverty alleviation, social progress, equity, economic growth and environmental sustainability. Energy has helped transform economies and societies by spurring industrialization and raising living standards. Furthermore, energy is indispensable for meeting basic human needs, including warmth, lights or even nutrition. Has a direct impact on people, communities and nations. It also helps to keep and realize human rights, such as right to work, education and better health (*Delivering…,* 2016). But currently, despite these visible benefits, there are many challenges facing countries all around the world (fig. 1).

Fig. 1. Energy and sustainable development challenges
Source: (Delivering…, 2016).

Social impact – as was mentioned above, in the year 2015 more than 1.1 billion people had no access to electricity and more than 2.8 billion had no access to modern energy services. In addition, around 4.3 million people died or have been sick due to pollution resulting from cooking and heating with unsustainable fuels. Furthermore it mainly women and girls spend time for energy gathering for cooking and heating. While, according to study conducted in Nicaragua, access to electricity improves women's economic situation (Kammila, Kappen, Rysankowa, Hyseni, Putti, 2014). That is why the elimination in disparities in access to energy is so important.

Economic impact – here the key challenge for developing countries is meet rising energy demand in a cost-effectively and sustainable way. Rising costs and energy price fluctuations mostly hit the poorest part of the society, also, for SME's (small and medium-sized enterprises) the access to reliable, affordable energy services is vital for its profitable and efficient operations (*Accelerating…,* 2015). Not to mention that SME's make up more than 90% of global businesses and also are the main source for the jobs for the poor. So, enabling the access to appropriate energy sources would have positive impact not only on the company itself but their surroundings as well.

Environmental impact – more than 2/3 of global greenhouse gas emissions come from the energy sector, causing that energy sector is a key sector for mitigating global warming (*Energy and…,* 2015). Carbon dioxide emissions higher by 40% in comparison to 1997, have a significant impact on climate change, thus resulting in extreme weather events, such as droughts, storms or coastal flooding, which affect not only people's life but also have negative impact on energy production and supply. In additions, increasing level of pollutions affect crop yields as well. That is why the improvements in resource management is essential (*World Energy…,* 2015).

From the above is clearly visible that there is still a necessity to undertake actions leading to cause energy sector more sustainable. This necessity and demand for modern and sustainable energy caused that sustainable energy issue have been a subject of many discussions, meetings and documents issued over the years: Agenda 21, during the 9th session of the Commission on Sustainable Development, Johannesburg Plan of Implementation, Strategy Note on Sustainable Energy, Sustainable Energy for All initiative, Rio+20 Conference documents and Sustainable Development Goals.

Agenda 21 highlights that current level of energy consumption and production are not sustainable, thus proposes the following activities in order to encourage greater efficiency in its use. So governments and industry should intensify efforts to use energy in a more economically efficient and environmentally sound manner. This can be achieved by encouraging the dissemination of current environmentally sound technologies, use of new and renewable sources of energy, sustainable use of renewable natural resources, promoting environmentally sound technologies' research and development and to assist developing countries to use these technologies in a greater extent (*Agenda 21,* 1992). During the 9th session of the Commission on Sustainable Development, all participants agreed that there is a need to put a stronger emphasis on development, implementation and transfer of cleaner energy and more efficient energy technologies. Thus the urgent action in order to further development and expansion of alternative energy source is needed (*Report…,* 2001). Johannesburg Plan of Implementation as a result of World Summit on Sustainable Development in 2002, calls for actions leading to (Brzeziński, 2016):

- better access to energy services which are reliable, affordable, economically viable, socially acceptable and environmentally friendly,
- recognition that energy services have positive impacts not only on improvement of standards of living but also on poverty eradication,
- developing and disseminating alternative energy technologies together with increasing the share of renewable energy sources,
- diversification of energy supply by more efficient and cost-effective energy technologies' further development,
- further combination of energy technologies in order to meet the growing need for energy services,
- development's acceleration of cleaner energy efficiency and energy conservation technologies,

Strategy Note on Sustainable Energy was a response to a 2002 Worlds Summit on Sustainable Development's call and highlighted the need for more coordinated and coherent programs on energy activities (*Delivering…,* 2016). Sustainable Energy for All initiative includes three major objectives

which should be completed by the 2030: energy access to modern energy service for all, doubling the rate, in a global dimension, in energy efficiency and also, doubling the share of renewable energy sources in a global energy use (*See4all,* 2017). Rio+20 Conference documents highlight the following statements: recognition of the critical role that energy plays in development process, improving the energy efficiency, bigger share of renewable energy sources and cleaner and energy-efficient technologies and the need to address the challenge of access to sustainable modern energy services available for everyone are crucial for sustainable development (*Future…,* 2012). And last but not least, in a set of Sustainable Development Goals, proposed by UN General Assembly, dedicated and stand-alone goal on energy - ensure access to affordable, reliable, sustainable and modern energy for all (*The Sustainable…,* 2016). Not only documents and notes issued by organizations reflect the important role of energy sector in sustainable development. But this issue or the need to act in order to cause energy sector more sustainable is important among the regular people. For example, based on the research conducted by Accenture in 2011 among the 1000 CEO's from energy sector, allowed to conclude the following (*Towards…,* 2011):

- 94% of them believe that sustainability issues will be critical to the future success of their business,
- 96% of them believe that sustainability issues should be fully integrated into the strategy and operations of a company,
- 70% of them cite 'brand, trust and reputation' as one of the top three factors driving them to take action on sustainability issues,
- 92% of them see 'accurate valuation by investors' of sustainability as important to reaching a tipping point in sustainability,
- 81% of them see climate change as the global development issue most critical to address for the future success of their business,
- 94% of them believe that companies should integrate sustainability through their supply chain, however only 57% believe that their company has,
- 91% of them report that their company will employ new technologies to address sustainability issues over the next five years.

Thus, is it clearly visible that energy sector is one of the major issue of sustainable development.

The characteristics of Polish energy sector

The structure of energy production by sources

Poland is one of the largest primary energy producers in the European Union with the share at the level of 8.7% in 2014). Among the EU Member States, only United Kingdom (14,0%), France (17,6%) and Germany (15,6%) are bigger energy producers (*Gospodarka…,* 2015). Primary energy production in Poland is based on fossil fuels primarily. Coal (hard and lignite) is on the first place, accounting for 56% of the demand. The share of crude oil is also significant - 25% (*Sektor…,* 2012). Traditionally, the Polish energy sector is based on fossil fuels, whose large deposits are located in Poland - these are the 9 largest deposits all over the world. In the structure of electricity production, two main fuels - coal and lignite, play a key role, responsible for nearly 90% of electricity production in Poland (figure 2) (*Sprawozdanie…,* 2015).

However, according to the forecast of the demand for fuels and energy by 2050, prepared by the National Agency for Energy Conservation ordered by the Ministry of Economy, Polish power industry in the middle of the XXI century will significantly differ from the current one, which is based on 90% coal almost. According to KAPE analysts, the share of hard coal in electricity production will fall from around 48% to 33% in 2050. While the amount of energy produced from this fuel (about 73 TWh per year) is not going to change. However, the share and production energy from lignite will significantly decrease. The forecast does not imply the launch of new lignite mines, which is not socially acceptable in any part of Poland. Hence, the share of energy from this fuel is expected to decrease from nearly 40% to 5% only (*Prognoza…,* 2017).

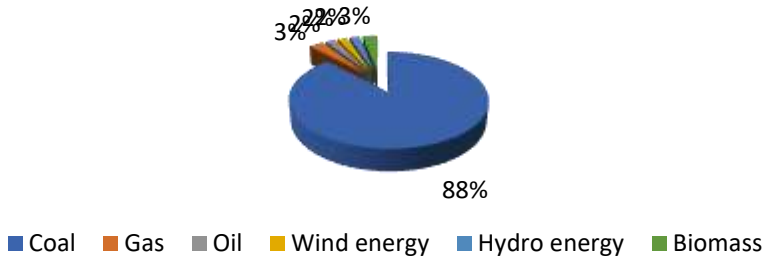

Fig. 2. The structure of sources used by Polish energy sector
Source: authors' work based on (Gospodarka…, 2016).

In 2014, gross domestic electricity consumption amounted to 158 734 GWh and was higher about 0.5% than in 2013. Domestic electricity consumption did not fundamentally change, in comparison to the previous year, despite rising GDP growth in 2014, which was 3.3%. Meanwhile, the volume of gross domestic electricity production in 2014 was at 156 567 GWh and was lower by 3.7% than the volume for the previous year (*Sektor…,* 2012).

Table 1. Energy production and consumption structure in the years 2013–2014.

	2013	2014	Dynamic
Coal power plant	84 566	80 284	-5,06
Lignite power plant	56 959	54 212	-4,82
Gas power plant	3 149	3 274	3,98
Industrial power plant	9 171	9 020	-1,64
Hydro power plant	2 762	2 520	-8,76
Wind sources	5 823	7 184	23,38
Other renewable sources	72	73	0,18
Total energy production	162 501	156 567	-3,65
Domestic energy consumption	157 980	158 734	0,49

Source: authors' work.

Still the vast majority of energy production is based on conventional fuels, ie hard coal and lignite. But the share of wind and other renewable energy sources continues to increase. The difference between these figures was balanced by the import of electricity, whose surplus over exports was 2 167 GWh in 2014 (*Sektor…,* 2012).

Renewable energy sources

In Poland, renewable energy sources are being also intensively developed. The share of electricity from RES in the final gross energy consumption has steadily grown since 2004, and reached a level of 12.4% in 2014. The record growth was noted in 2012 at a level of 10.68% vs. 8.16% in 2011, thanks to the rapid development of wind power, which at the same time constitute the most rapidly developing technology (Schnell, 2016).

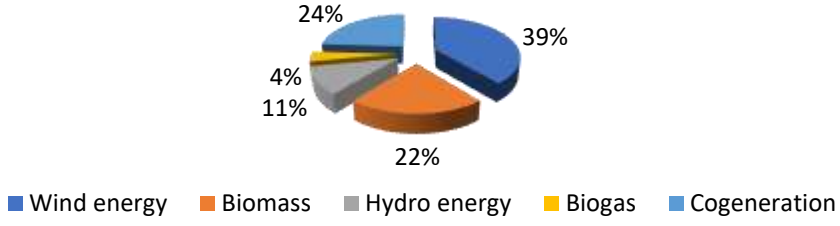

Fig. 3. The share of renewable sources of energy in energy production
Source: authors' work based on (Sektor…, 2012).

Wind power is one of the leading renewable energy source. According to the Energy Regulatory Office, at the end of September 2012, there were 663 wind farms in Poland with a total capacity of 2,341 MW. According to industry data, the record was 2015, when noted the highest power increase installed in wind turbines, reaching a total of around 5500 MW at the end of April 2016. Wind energy currently accounts for 57.6% of all renewable energy sources. Water power increased from 177.4 ktoe to 204 ktoe in the years 2004-2014, but since 2010 there have been no significant changes. The share of photovoltaics in RES consumption in the power sector almost does not exist, as the minimum growth was recorded in 2012 (0.1 ktoe), ending in 2014 at 0.6 ktoe. The share of biomass co-incineration in power plants and dedicated installations in renewable energy used in the power sector, steadily increased until 2012, when reached the highest level of 819.3 ktoe, followed by a sharp drop in 2013 to 682 ktoe. In 2014, the biomass sector again saw a visible increase in share of RES energy consumption (Schnell, 2016).

Despite the fact that in 2014, the share of renewable electricity generated from RES in final energy consumption has steadily risen to 12.4% in 2014, taking into account the conditionality and conservative approach of the current government to the power sector, can be assumed that by 2020, the share of RES in total gross energy consumption will not increase to a mandatory level of 15% (Lis, Bajdor, 2013). Market and legal conditions do not allow for the assumption that the share of RES in electricity and heat engineering and refrigeration will increase in the next years, it is better to expect stagnation in the development of these areas. As a consequence, Poland will be faced with a choice to make a statistical transfer of RES energy from Member States with a surplus of "green energy", which can cost about 8 billion PLN (Schnell, 2016).

The number and structure of energy recipients

There are final customers on the demand side of the retail electricity market. There are about 16.9 million of them, of which 90.2% (over 15 million) are recipients of G tariff group, including the overwhelming majority of household customers (over 14 million) who purchase energy for consumption in the household. The remaining group of final customers are recipients belonging to A, B and C tariff groups. A and B groups are recipients supplied from high and medium voltage networks and they are so called. industrial customers, while group C comprises consumers connected to a low-voltage grid, collecting electricity for the purposes of conducting business activity, so-called. business receivers (*Sprawozdanie…,* 2015).

Electricity consumers are entitled to receive electricity continuously and reliably from the selected electricity supplier. Between 2004 and 2014, the share of final energy consumption in the transport and services sectors and the share of industry, households, and agriculture decreased. Transportation share increased from 20 to 26%, and services from 12 to 13%. Industry share declined from 27 to 24% and agriculture from 8 to 6% (Figure 4).

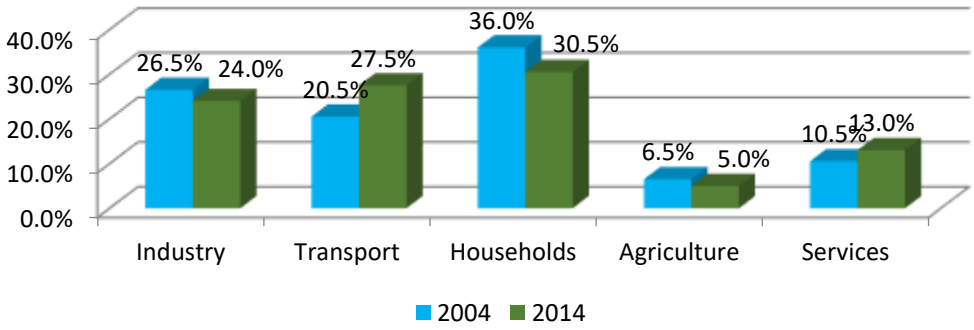

Fig. 4. The structure of final energy consumption in Poland by sectors
Source: authors' work based on (Sprawozdanie…, 2015).

The biggest change has taken place in the transport sector, whose growing significance is linked to the growing role of freight as well as private passenger transport.

THE RESEARCH METHODOLOGY

The main objective of this article is to examine to what extent the Polish energy sector fulfills the principles of sustainable development concept, against the rest of the EU countries. Despite the fact that the Polish energy sector is primarily based on coal as the main raw material for energy production, taking into account aspects such as:

- greenhouse gas emissions, pollution and waste generated by the energy sector,
- the amount of environmental taxes, the level of expenditures on environmental and the level of expenditure on innovations paid by the energy sector,

becomes possible to determine to which extent Polish energy sector is sustainable.

The first stage of the conducted research is to review the level of energy produced, final energy consumption (in total and in chosen sectors), energy productivity in all EU countries. Next, based on the chosen volumes, in addition to the indicators mentioned above, final energy consumption per population, energy productivity per population and the overall score for energy access, energy efficiency and renewable energy will be calculated as well.

The research results

General data

The first stage of the analysis was to present the basic figures characterizing the energy sector of all EU countries such as: the level of generated energy (including RES), share of renewable energy in gross final energy consumption, final energy consumption and energy productivity.

Table 2. The main volumes of EU energy sector.

Primary production of energy (in 1000 toe)				Primary production of renewable energy (in 1000 toe)			
Country	**2015**	**Country**	**2015**	**Country**	**2015**	**Country**	**2015**
France	136 698,8	Hungary	10 166,0	Germany	38 886,1	Belgium	2 958,6
Germany	119 769,6	Greece	8 408,0	Italy	23 563,9	Greece	2 640,7
United Kingdom	118 274,2	Slovakia	6 320,1	France	21 416,9	Latvia	2 337,2
Poland	67 346,6	Estonia	5 553,5	Sweden	18 374,9	Croatia	2 227,6
Netherlands	47 586,4	Portugal	5 303,6	Spain	16 873,5	Hungary	2 217,9
Italy	36 133,9	Iceland	4 938,3	United Kingdom	11 834,7	Bulgaria	2 032,6
Sweden	33 643,7	Croatia	4393,0	Finland	10 394,4	Slovakia	1 591,6
Spain	33 440,6	Slovenia	3 390,6	Austria	9 303,3	Lithuania	1 466,1
Czech Republic	28 756,0	Latvia	2 345,3	Poland	8 635,2	Estonia	1 286,3
Romania	26 656,4	Ireland	1 911,7	Romania	5 935,0	Slovenia	1 025,6
Finland	17 537,8	Lithuania	1 585,1	Portugal	5 182,1	Ireland	980,7
Denmark	15 708,6	Luxembourg	146,9	Iceland	4 938,3	Cyprus	118,0
Bulgaria	11 986,3	Cyprus	121,2	Netherlands	4 810,4	Luxembourg	113,0
Austria	11 932,1	Malta	14,8	Czech Republic	4 279,3	Malta	14,8
Belgium	10 366,7			Denmark	3 528,4		

Source: authors' work.

How the above table presents, in case of primary production energy, Poland is on the 4th place, right after France, Germany and United Kingdom. However a significant disproportion can be noticed between United Kingdom and Poland – primary production energy in Poland is almost twice less than

in United Kingdom. France's first place comes from the fact that this country has a highly developed nuclear power and more than ¾ of primary production energy comes from nuclear. France derives about 75% of its electricity from nuclear energy, due to a long-standing policy based on energy security but this share may be reduced to 50% by 2025. This caused that France, also is the world's largest net exporter of electricity what brings more than 3 bln euro of profit. It is also worth to notice that 17% of France's electricity comes from recycled nuclear fuel. Thus, France has been very active in developing nuclear technology. In Germany, having the second place in primary production energy, nuclear power is used as well, but to a lesser extent than in France, it accounts for 12% of the total energy generated by the 17 installed reactors, while almost ¾ of the primary production energy is produced from combustion of coal, crude oil and natural gas. In case of Germany it also worth to note that this country has the lowest wholesale electricity prices in Europe but the highest retail prices, due to its energy policies. United Kingdom has 15 reactors generating about 21% of its electricity, but it is planned to retire half of this capacity by 2025. And most of the UK's electricity is produced by burning fossil fuels,

mainly natural gas (30%) and coal (22%). A very small amount is produced from oil (under 1%). In case of Poland – there are plans to have nuclear power as part of a diverse energy portfolio, but at the moment, Poland does not produce electricity from nuclear. And this may be the cause why, Poland on the 4th place in the case of primary energy production, is almost twice less in comparison to United Kingdom.

In the case of primary production of renewable production Poland is on 8th place, after the Germany, Italy, France, Sweden, Spain, United Kingdom, Finland and Austria. Again Germany are on the 1st place, with primary production of renewable production at the level of 38 886 thousand toe, while in Poland primary production of renewable production have reached the level of 8 365 thousand toe, so only 1/5 of Germany's production. Here, it is also worth to highlight the overall structure of renewable sources used in the mentioned countries (figure 5).

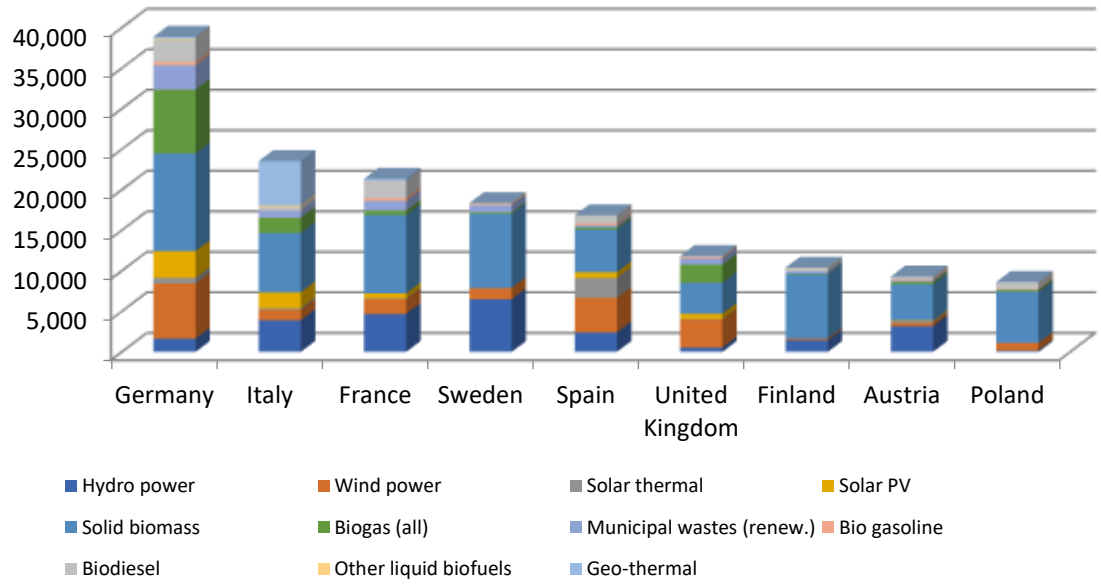

Fig. 5. The structure of RES used in the selected countries

Source: authors' work.

As it is visible the main renewable source for all these countries is solid biomass. While in Germany almost every kind of renewable source is being used for energy production, in Finland, Austria and Poland, next to solid biomass, hydropower biodiesel, biogas and municipal waste are being used as well. But from the above we can assume, that the more renewable sources country uses for energy production the bigger value of energy produces from these kind of sources.

Table 3. The main volumes of EU energy sector – continued

Share of renewable energy in gross final energy consumption (in %)				Energy productivity (in KGOE)			
Country	**2015**	**Country**	**2015**	**Country**	**2015**	**Country**	**2015**
Iceland	70,2	Greece	15,4	Ireland	16,1	Portugal	7,5
Sweden	53,9	France	15,2	Denmark	15,4	Belgium	7,1
Finland	39,3	Czech Republic	15,1	Luxembourg	11	Slovenia	5,6
Latvia	37,6	Germany	14,6	Malta	11	Finland	5,6
Austria	33	Hungary	14,5	United Kingdom	10,6	Croatia	5,2
Denmark	30,8	Slovakia	12,9	Italy	10	Lithuania	4,9
Croatia	29	Poland	11,8	Austria	9,3	Latvia	4,8
Estonia	28,6	Cyprus	9,4	Sweden	9	Slovakia	4,6
Portugal	28	Ireland	9,2	Germany	8,9	Hungary	4,5
Lithuania	25,8	United Kingdom	8,2	Spain	8,8	Poland	4,4
Romania	24,8	Belgium	7,9	Netherlands	8,5	Romania	4,4
Slovenia	22	Netherlands	5,8	France	8,3	Czech Republic	4
Bulgaria	18,2	Luxembourg	5	Cyprus	7,8	Estonia	2,8
Italy	17,5	Malta	45,8	Greece	7,6	Bulgaria	2,2
Spain	16,2						

Source: authors' work.

As it is visible from the table above, for both issues, Poland is located on the further places. In the case of share of renewable energy sources in gross final energy consumption – this sources accounted for 11,8% only in the overall structure of energy acquisition. Wherein, as mentioned earlier, taking account the current government politics in regards to energy sector, only slight increase or even a stagnation of this share can be expected. In this ranking, Iceland is the leader, with more than 70% of renewable resources, mainly hydro energy and geothermal. Sweden is on the second place, as half of its primary energy production comes from renewable sources. The first is a solid biomass but hydro and wind energy are on the second place. In case of Finland, where the share of renewable sources in primary energy production is almost 40%, the solid biomass and hydro energy are also in the first place. Poland is on much further place, in case of energy productivity - this indicator results the division of the gross domestic products by the gross inland consumption of energy, it simple measures the productivity of energy consumption. In this ranking Poland is on the 5th place from the end. Which means that energy efficiency is on a very low level and underlines the high energy intensity of all economy sectors and branches. Ireland and Denmark, with indicators of 16.1 and 15.4, are the undisputed leaders in this ranking. Improving energy efficiency and rational use of existing energy resources, in the perspective of increasing energy demand, are areas where Poland attaches a great importance. The Energy Efficiency Act, presented in May last year, which came into effect on 1 October 2016, defines (*Legal Act…,* 2016):

- rules for drawing up a national energy efficiency action plan, including, in particular, energy efficiency targets;
- tasks of public sector entities in the scope of energy efficiency;
- rules for achieving the obligation to achieve energy savings (white certificates system);
- rules for carrying out an enterprise's energy audit.

The implementation of these measures would lead to this indicator's further increase. And the first effects of this law should already be visible in the 2017 statements.

Detailed data

In order to determine to what extent the Polish energy sector implements the principles and goals of the concept of sustainable development, the following measures have been compared: Regulatory Indicators for Sustainable Energy for chosen countries, greenhouse, emission and waste generated by energy sector, solar collectors surfaces per household, environmental taxes, environmental protection expenditure, environmental investments and wastewater management and innovations expenditures incurred by energy sector.

Regulatory Indicators for Sustainable Energy

According to Regulatory Indicators for Sustainable Energy, Poland got 78 points of overall score. This indicator consists three sub-indicators: energy access, energy efficiency and renewable energy. And each of them consists a number of sub-indicators, which in total, give the overall picture of sustainable energy for the selected country.

Table 4. Regulatory Indicators for Sustainable Energy

Energy access	Energy efficiency	Renewable energy
Existence and monitoring of officially approved electrification plan	National energy efficiency planning	Legal framework for renewable energy
Scope of officially approved electrification plan	Energy efficiency entities	Planning for renewable energy expansion
Framework for grid electrification	Information provided to consumers about electricity usage	Incentives and regulatory support for renewable energy
Framework for minigrids	EE incentives from electricity rate structures	Attributes of financial and regulatory incentives
Framework for stand-alone systems	Incentives & mandates: large consumers	Network connection and pricing
Consumer affordability of electricity	Incentives & mandates: public sector	Counterparty risk
Utility Transparency and Monitoring	Incentives & mandates: utilities	Carbon pricing and monitoring
Utility Creditworthiness	Financing mechanisms for energy efficiency	
	Minimum energy efficiency performance standards	
	Energy labeling systems	
	Building energy codes	
	Carbon Pricing	

Source: authors' works based on http://rise.esmap.org/scores, access data 2-03-2017.

Unfortunately not for all EU countries, these indicators have been calculated, the table below lists the countries, which through the share of the relevant information, are listed in the table below.

Table 5. The values of Regulatory Indicators for Sustainable energy

Country	Energy access	Energy efficiency	Renewable energy	Overall score
Denmark	100	86	95	94
Netherlands	100	76	92	90
Germany	100	77	91	89
United Kingdom	100	77	89	89
Romania	100	86	74	87
Czech Republic	100	70	87	86
France	100	76	81	86
Italy	100	72	85	86
Belgium	100	77	76	84
Austria	100	73	74	82
Finland	100	63	84	82
Spain	100	68	79	82
Sweden	100	62	84	82
Greece	100	57	84	80
Poland	100	57	78	78

Source: authors' work.

According to the presented table, Poland is on the last position with the lowest value of 78 points among listed 15 countries. It is also evident that the first indicator, energy access for all countries, has the maximum value. It follows that all these countries have:
- officially approved national electrification plan,
- achieved targets included in the plan,
- government has a dedicated funding line or budget for electrification,
- minigrids are legally allowed to operated in the country,
- national programs which aim to develop stand-alone systems or support the development of those,
- available to publicity financial statements of the largest generation, distribution and retail electricity sales companies,

The different results can be noted for the other two indicators, energy efficiency and renewable energy, which translates into different overall results to determine the extent to which the national energy industry is sustainable. Poland has the lowest value for energy efficiency, which was caused by the following reasons:
- Lack of governmental and/or independent bodies dedicated to regulating EE activities of energy suppliers and energy consumers,
- lack of bills and reports which compare them to other users in the same region in case of residential, commercial and industrial customers,
- lack of bills and reports that show their energy usage compared to previous bills or reports over time in case of residential, commercial and industrial customers,
- lack of financial incentives for large consumers to invest in energy efficiency,
- lack of tax incentives for large consumers to invest in energy efficiency,
- lack of program to publicly recognize large-scale users that have achieved significant energy savings measures,
- lack of program which offers assistance (from a government or independent entity) to large-scale users to identify energy savings investments opportunities,
- lack of utility energy efficiency regulation program,
- lack of minimum energy performance standards and energy efficiency labeling schemes for selected sectors.

In case of renewable energy indicator, Poland got 78 points, but countries such as Austria, Belgia and Roman got even less. But still, this value is one of the lowest values presented in the table.

It can be concluded then that Poland still need to work on many issues, which fulfillment, cause that polish energy sector would be more sustainable.

The level of greenhouse gas and pollutants emissions generated by energy sector

Looking at the table below, it is clear that both, in the case of greenhouse gas emissions as well as pollutant emissions by the energy sector, Poland is located among the first five countries. In case of greenhouse gas emission, Poland is on the 5th place with the amount of 308 848 thousand tons, which is half less than energy sector in Germany generates. United Kingdom, Italy and France are on the further places. Such great values result, among other things, from the fact that these countries are also in the forefront of primary energy production. Also, taking account the level of greenhouse gas emission per household, Poland is on the 3rd place with the value of 0,02 thousand tons per one household. But what is worth to notice, on the first two places are Luxembourg and Estonia. While its primary energy production was far behind the primary energy production in Poland. It can be therefore presumed that while high levels of greenhouse gases generated by the energy sector in Poland was caused by large quantities of primary energy produced, such a high level for Luxembourg and Estonia may be caused by insufficient or inadequate measures to eliminate or reduce greenhouse gas emissions .

Table 6. Pollutants and greenhouse emissions generated by energy sectors

Greenhouse gas emission (in th tons)		Greenhouse gas emission (in th tons/household)		Pollutants emissions (in tons)		Pollutants emissions (in tons/household)	
Country	**2015**	**Country**	**2015**	**Country**	**2015**	**Country**	**2015**
Germany	762 338,40	Luxembourg	0,04	Poland	767 048	Estonia	0,089
United Kingdom	425 368,96	Estonia	0,03	Germany	613 054	Cyprus	0,080
Italy	339 798,04	Poland	0,02	United Kingdom	608 594	Bulgaria	0,065
France	319 636,23	Cyprus	0,02	Spain	389 662	Poland	0,054
Poland	308 848,16	Czech Republic	0,02	Greece	230 129	Greece	0,053
Spain	238 091,85	Ireland	0,02	Romania	222 032	Malta	0,053
Netherlands	153 789,70	Netherlands	0,02	Bulgaria	191 616	Czech Republic	0,035
Czech Republic	95 026,02	Germany	0,02	Italy	164 245	Romania	0,030
Belgium	82 290,58	Belgium	0,02	Czech Republic	161 222	Slovakia	0,026
Romania	76 723,69	Greece	0,02	France	143 841	Finland	0,025
Greece	75 206,62	Finland	0,02	Finland	65 786	United Kingdom	0,022
Austria	51 418,39	Malta	0,02	Netherlands	65 194	Spain	0,021
Finland	44 385,62	Denmark	0,02	Estonia	51 152	Lithuania	0,021
Portugal	43 978,69	United Kingdom	0,02	Slovakia	48 904	Slovenia	0,016
Bulgaria	43 148,73	Slovenia	0,02	Portugal	46 186	Croatia	0,015
Hungary	40 279,59	Bulgaria	0,01	Sweden	40 935	Germany	0,015
Sweden	39 285,29	Slovakia	0,01	Belgium	33 262	Denmark	0,013
Denmark	36 784,56	Austria	0,01	Hungary	32 024	Ireland	0,012

Ireland	35 000,11	Italy	0,01	Denmark	31 500	Portugal	0,011
Slovakia	27 029,14	Spain	0,01	Lithuania	27 587	Latvia	0,010
Estonia	18 697,85	France	0,01	Croatia	23 078	Luxembourg	0,010
Croatia	16 241,44	Croatia	0,01	Cyprus	23 060	Netherlands	0,009
Slovenia	13 254,13	Portugal	0,01	Ireland	20 816	Sweden	0,008
Lithuania	10 915,56	Romania	0,01	Austria	17 793	Hungary	0,008
Luxembourg	9 403,04	Hungary	0,01	Slovenia	13 838	Belgium	0,007
Latvia	6 952,97	Latvia	0,01	Latvia	8 491	Italy	0,006
Cyprus	5 959,49	Lithuania	0,01	Malta	7 944	France	0,005
Malta	2 498,86	Sweden	0,01	Luxembourg	2223	Austria	0,005

Source: authors' work.

In the case of pollutant emissions, as shown in the table above, Poland is on the first place with 767 048 tons, followed by Germany, United Kingdom and Spain. While for such countries, such high levels of emissions are due to high levels of primary energy production, in Poland, such high levels of pollution are due to the use of outdated technologies and insufficient power plants installed in power plants. The amount of pollutant emissions certainly is also affected by the use of hard coal as the main raw material used to produce energy. On the other hand, in the case of the amount of pollutants emitted by the energy sector per household, Poland is also at the top of the list, with the fourth place with 0.054 tons. In this ranking Estonia, Cyprus and Bulgaria are the first three countries where primary energy production does not exceed 12 thousand toe. annually. It can be assumed here also, that while high levels of greenhouse gases generated by the energy sector in Poland are due to large quantities of primary energy produced, for the first three countries it can provide for example the lack or inadequate use of emission reduction or emission reduction solutions. The Polish energy sector also has the first place in terms of generated waste. Every year the Polish energy sector generates over 21 million tons of waste, Greece, on the second place, generates half of that amount. On the one hand, it is possible to translate such a high level of generated waste by high level of primary energy production, but looking at the comparison of how much waste is generated per unit of primary energy produced - Poland is on the 22nd place among all 27 countries. Thus, this can be attributed to the high quality of the used coal, which generated quite small amount of waste, as well as the use of modern combustion and co-incineration technologies that reduce waste generation as well.

Table 7. Waste generation level and solar collectors surface for all EU countries

Waste generation (tons)		Waste generation (tons/household)		Waste generation (tons/toe)		Solar collectors surface (sq met/household)	
Country	**2015**	**Country**	**2015**	**Country**	**2015**	**Country**	**2015**
Poland	21 892 195	Estonia	12,438	Hungary	1,295	Cyprus	3,479
Greece	10 887 688	Bulgaria	3,097	Estonia	1,280	Austria	1,326
Germany	9 975 200	Greece	2,488	Bulgaria	0,760	Greece	1,003
Bulgaria	9 105 116	Poland	1,551	Portugal	0,325	Germany	0,463
Estonia	7 109 650	Romania	0,949	Lithuania	0,310	Denmark	0,403
Romania	7 091 832	Latvia	0,873	Slovakia	0,266	Malta	0,337
Spain	5 271 536	Slovenia	0,717	Netherlands	0,264	Portugal	0,275
Italy	3 195 277	Finland	0,558	Ireland	0,227	Slovenia	0,271
United Kingdom	3 140 120	Hungary	0,557	Spain	0,187	Luxembourg	0,244
Hungary	2 311 832	Denmark	0,456	Italy	0,168	Spain	0,195
Sweden	1 895 399	Sweden	0,372	France	0,158	Ireland	0,187
Netherlands	1 671 432	Slovakia	0,291	Belgium	0,131	Belgium	0,141
France	1 587 553	Belgium	0,290	Latvia	0,088	Italy	0,144
Finland	1 464 124	Spain	0,287	Slovenia	0,085	Poland	0,135
Belgium	1 360 938	Germany	0,248	Finland	0,083	Bulgaria	0,117
Denmark	1 081 977	Netherlands	0,219	Greece	0,083	Czech Republic	0,116

Czech Republic	1 012 205	Czech Republic	0,218	Denmark	0,069	Croatia	0,122
Latvia	727 167	Ireland	0,188	Luxembourg	0,064	Slovakia	0,093
Slovenia	633 319	Austria	0,139	Sweden	0,056	Sweden	0,094
Slovakia	536 670	Italy	0,124	Austria	0,045	France	0,075
Austria	531 191	United Kingdom	0,111	Czech Republic	0,035	Netherlands	0,085
Ireland	321 019	Croatia	0,080	Poland	0,035	Hungary	0,067
Portugal	177 493	Lithuania	0,076	Romania	0,033	United Kingdom	0,049
Croatia	119 603	France	0,055	Croatia	0,027	Finland	0,019
Lithuania	100 987	Portugal	0,043	United Kingdom	0,027		
Malta	3 914	Malta	0,026	Malta	0,021		
Luxembourg	3 149	Luxembourg	0,014	Germany	0,012		

Source: authors' work.

In the case of a comparison of waste generated per farm, Poland ranks fourth in terms of volume generated by the energy sector. The first three places have Estonia, Bulgaria and Greece. In turn, the latest summary of solar panels surface per household, Poland is in the middle, on the 14th place among the 24 mentioned countries, with 0.13 m2 of panels per household. Cyprus is a big surprise, with more than 3 m2 of solar panels per household. However, this can be explained by the location of the island having a lot of sun during the whole year. Germany, in turn, with the opinion of the country where solar panels are widely used, occupies fourth place - there is less than 0.5 m2 of solar panels per household. On the last place is Finland - but this fact can also be explained by the location of this country and the weather conditions.

The level environmental taxes, environmental protection expenditure, environmental investments and wastewater management held by energy sector

Once again, Poland is on the first place, in case of environmental protection expenditure in energy sector with the volume of almost 2000 mln euro. Rumunia, having the second place, has more than half less amount of environmental protection expenditures. It is therefore clear that the Polish energy sector allocates very large amounts of money to the natural environment. Taking into account the size of these expenditures per inhabitant, Poland is right after the Czech Republic. But in the Czech Republic, these costs are 58 euro and in Poland – 52 euro, however it should be borne in mind, that the Czech population is four times smaller than the Polish population.

Table 8. Environmental protection and investment expenditure and wastewater management in all EU countries.

Environmental protection expenditure in energy sector (in mln euro)		Environmental protection expenditure in energy sector (in euro per inhabitant)		Total environmental investments (in mln euro)		Wastewater management (in mln euro)	
Country	**2015**	**Country**	**2015**	**Country**	**2015**	**Country**	**2015**
Poland	1 992,87	Czech Republic	58,79	Poland	726,87	Poland	947,63
Romania	798,59	Poland	52,36	Romania	479,31	Romania	399,85
Czech Republic	618,21	Romania	39,89	Czech Republic	320,65	Czech Republic	251,79
Sweden	325,48	Sweden	34,06	Sweden	202,02	Sweden	120,73
Slovakia	151,19	Croatia	28,99	Croatia	72,73	Slovakia	109,44
Croatia	123,57	Slovakia	27,94	Slovakia	70,58	Croatia	65,41
Bulgaria	108,31	Latvia	17,55	Bulgaria	31,17	Bulgaria	14,39
Portugal	65,84	Bulgaria	14,87	Latvia	27,24	Latvia	8,04
Latvia	35,52	Portugal	6,28	Portugal	22,00	Lithuania	4,13
Lithuania	16,08	Lithuania	5,41	Lithuania	8,76	Portugal	1,77

Source: authors' work.

In the case of environmental investments implemented by the energy sector, again Poland ranks first with the level of 726 million euro. Romania, the 2nd in terms of investment, with 479 million euro allocated to environmental investments in 2015. Czech Republic and Sweden are located next. Croatia, which ranks fifth in this ranking, has almost 3 times less the level of investment in environmental investments in comparison to Sweden. Lithuania is on the last place, whose energy sector in 2015 allocated only a little over 8 million euro for environmental investments. Poland also ranks first among countries in which the energy sector spends the most on wastewater management, with 647 million euro spent in 2015. Romania was 2nd again with less than 400 million euros allocated to wastewater management in 2015. Portugal was on the last place with an amount not exceeding 2 million euro on wastewater management.

Innovations expenditures covered by energy sector

In the case of the overall level of expenditures on innovations borne by the energy sector, Poland is in the first half of the list, occupying 12th place among 28 countries. In 2015, the expenditures on innovations incurred by the Polish energy sector amounted to a little over 2,010 million euro. Compared to Germany, whose energy sector allocated nearly 60,000 million euro in 2015, this amount is only a fraction. Moreover as presents the table below, Germany is an undisputed leader, because in France, on the second place, the energy sector has spent less than 32,000 million euros for innovation in 2015, half of the German energy sector's expenditure. On the next places are United Kingdom, Italy and Sweden. In turn, Cyprus was in the last place, because in this country the energy sector allocated 13 million euros for the innovation in 2015.

Table 9. Innovations expenditures incurred by energy sectors from all EU countries

Innovations expenditure in energy sector (in mln euro)		Innovations expenditure in energy sector (euro/inhabitant)	
Country	**2015**	**Country**	**2015**
Germany	59 058,0	Sweden	1 040
France	31 668,2	Denmark	879,0
United Kingdom	28 839,3	Austria	862,5
Italy	12 105,7	Finland	739,7
Sweden	10 137,1	Germany	727,3
Netherlands	7 574,0	Iceland	651,4
Austria	7 396,6	Belgium	643,7
Belgium	7 247,1	Luxembourg	608,2
Spain	6 920,0	France	476,8
Denmark	4 974,9	Netherlands	448,1
Finland	4 047,3	United Kingdom	444,5
Poland	2 010,3	Slovenia	315,4
Czech Republic	1 765,0	Italy	199,1
Hungary	1 109,6	Czech Republic	167,5
Portugal	1 078,6	Spain	149,0
Slovenia	650,6	Hungary	112,6
Greece	561,4	Estonia	106,1
Romania	344,1	Portugal	104,0
Luxembourg	342,4	Malta	76,4
Bulgaria	317,4	Poland	52,9
Slovakia	259,2	Greece	51,7
Iceland	214,4	Slovakia	47,8
Croatia	192,0	Croatia	45,4

Estonia	139,4	Bulgaria	44,1
Lithuania	104,1	Lithuania	35,6
Latvia	37,7	Latvia	19,0
Malta	32,8	Romania	17,3
Cyprus	13,3	Cyprus	15,7

Source: Own work.

While analyzing the amount of innovation expenditure incurred by the energy sector per inhabitant, Poland is ranked 20 out of 28 countries, spending 52.9 euro per capita. Sweden is one of the first countries where the amount of innovation expenditures per capita was higher than 1,000 euro. Germany, with expenditures of 727 euro, can be explained by the size of the population - over 80 million inhabitants. In turn, Cyprus is again on the last place - in this country the amount of innovation spending in 2015 per capita was slightly higher than 15 euro.

CONCLUSIONS

On the basis of the conducted analyzes it can be stated that the Polish energy sector may not fully implement the assumptions of the concept of sustainable development, but it is taking many steps in this direction and achieving tangible results. The actions that the Polish energy sector can identify as sustainable, are reflected in the following effects:

- The Polish energy sector uses renewable energy sources for energy production, primarily wind energy. While their share in the overall structure of raw materials used for energy production is increasing year by year, it still does not exceed 15%;
- As far as the size of the waste generated by the energy sector, Poland ranks first, from a comparison of these figures to the volume of energy produced Poland has one of the latest places. This can be attributed to the high quality of the coal used, which results in a little amount of waste as well as the use of modern incineration and co-incineration technologies that reduce waste as well;
- In the rankings on the amount of expenditure incurred by the energy sector for: environmental expenditure, environmental investments and wastewater management, Poland ranks first in all three cases. As a result, the Polish energy sector demonstrates its responsibility for the natural and social environment;
- In the case of the overall level of expenditures on innovations borne by the energy sector, Poland is in the first half of the list, occupying 12th place out of 28 countries. Thus, it can be stated that the energy sector allocates a quite high volumes of its financial resources for innovation, but it is also seen that this part could be much higher;

On the contrary, the following issues cause that the Polish energy sector is not yet fully sustainable:

- In terms of raw materials used for energy production, coal is still the main raw material in Poland and so far it is unlikely that in the near future it will change. In turn, renewable energy sources represent less than 12% of the total structure of all raw materials. Also coal power plants are the largest energy producers in Poland;
- For regulatory indicators for sustainable energy, Poland ranks last with the lowest points value of 78 points. It can be concluded then that Poland still needs to work on many issues, which fulfillment, cause that Polish energy sector would be more sustainable;
- Analyzing the levels of pollutants and greenhouse gases emissions into the atmosphere, it is clear that Poland is at the forefront of countries with the highest values;
- Also in the case of the amount of waste generated by the energy sector, Poland is very high, occupying the first place;
- in the rankings of surface of solar panels mounted per household, Poland is in the middle, having the 14th place among the 24 listed countries, with an area of 0.13 m2 of panels per household. Such low popularity of solar panels is dictated on one hand by polish weather conditions, as well as insufficient financial incentives offered by the government to encourage people to buy and use solar panels.

To sum up, it can be stated that the Polish energy sector is a sustainable in “half way” only - there are areas where much has been done, but there are still many issues which need to be solved. There is only a hope the activities of the Polish energy sector will continue in the right direction.

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