



EU Energy and Climate Policies: Challenges and Opportunities for Poland

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ABSTRACT

Along with the observed in the second half of the 20th century progressing climate change and accelerating greenhouse gas emissions levels (GHG-*greenhouse gases*), the European Commission (EC) actively started to act, both internally and globally, against these adverse changes. This paper presents the current energy and climate policy of the European Union resulting from the long-term strategy based on developing low-carbon economy, and analyses its influence on energy transformation of the Polish economy. It contains results of analyses and assessments of the implementation process of energy and climate policy in the economy of Poland as an EU member, economic restructuring and it indicates challenges connected with the practical aspects of EU energy policy objectives implementation in the near future. The analysis is based on literature of the subject, EU strategic programming documents relating to the strategy of developing low-carbon economy in the EU, those relating to energy and climate policies, legal acts, reports and industry publications as well as Polish background documents and regulations. The analysis concerns the period between 2004 and 2017 and contains actual data obtained from EUROSTAT and GUS (Statistics Poland).

Keywords: Energy Policy, Climate Policy, The European Union, Poland, Clean Energy

JEL Classifications: Q48, Q58, F53

1. INTRODUCTION

Climate change is one of the greatest challenges of our time, and its adverse impacts undermine the ability of all countries to achieve sustainable development, as survival of many societies and ecosystems has become endangered (UN, 2015. p. 5). The principles of sustainable development have constituted one of the fundamental rules governing processes of European economic integration. Sustainable development, as outlined in Treaties, is understood as economic development taking account of environmental protection, social justice, wellbeing of citizens, higher standard of living for present and future generations.

Along with the observed in the second half of the 20th century progressing climate change and accelerating greenhouse gas

emissions levels (GHG-*greenhouse gases*)¹, the European Commission (UE-EC) actively started to act, both internally and globally, against these adverse changes.

The energy sector releases substantial amounts of CO₂ to the atmosphere, hence significantly contributing to the emergence of the greenhouse effect. Growing energy consumption, domination of its conventional sources in the energy mix in member states, increasing dependence of the EU on oil and gas imports create a fundamental challenge for the growth of the EU economy and natural environment, including climate. Simultaneously transformation of the energy sector towards replacement of conventional energy sources with renewable energy (RE) with the use of modern energy technologies has not only become central

¹ Greenhouse gases comprise of i.e. steam, CO₂, CH₄, N₂O, freon, halon

to climate change mitigation, but it also creates new opportunities for the economic development of the whole region. Therefore, the European Union has been making intensive efforts to combat climate change and wishes to develop zero-carbon economy in the future.

This paper presents the current energy and climate policy of the European Union resulting from the long term strategy of developing low-carbon economy and analyses its impact on energy transformation the Polish economy. It contains conclusions of an analysis and assessment of the implementation process of energy and climate policy in the Polish economy (as an EU member), economic restructuring and it indicates development challenges connected with the practical side of implementing the Union's energy policy objectives in the near future.

The analysis is based on literature of the subject, EU strategic programming documents relating to the strategy of developing low-carbon economy in the EU, those relating to energy and climate policies, legal acts, reports and industry publications as well as Polish background documents and regulations. The analysis concerns the period between 2004 and 2017 and contains actual data obtained from EUROSTAT and GUS (Statistics Poland).

2. EU ENERGY AND CLIMATE STRATEGY – TOWARDS CLIMATE-NEUTRAL EUROPEAN ECONOMY 2050

The idea of sustainable development is a crucial element of economic integration within the European Union and its dimensions: economic, social, environmental are confirmed by EU Treaties. The preamble to the Treaty on European Union (TEU) states that member states are "(...) determined to promote economic and social progress for their peoples, taking into account the principle of sustainable development and within the context of the accomplishment of the internal market and of reinforced cohesion and environmental protection, and to implement policies ensuring that advances in economic integration are accompanied by parallel progress in other fields (...)" Further provisions of the Treaty (Art. 3 Section 3) stipulate that "(...) The Union shall establish an internal market. It shall work for the sustainable development of Europe based on balanced economic growth and price stability, a highly competitive social market economy, aiming at full employment and social progress, and a high level of protection and improvement of the quality of the environment. It shall promote scientific and technological advance. It shall combat social exclusion and discrimination, and shall promote social justice and protection, equality between women and men, solidarity between generations and protection of the rights of the child. It shall promote economic, social and territorial cohesion, and solidarity among Member States. It shall respect its rich cultural and linguistic diversity, and shall ensure that Europe's cultural heritage is safeguarded and enhanced (...)" (European Union, 2010).

Moreover, as reinforced by the provisions in Article 21 of the Treaty, the European Union defines and pursues common policies

and actions, and wishes to work for a high degree of cooperation in all fields of international relations, including actions aimed to solve global economic, social and environmental problems. Based on these provisions, as well as those more detailed ones regarding energy policy (Art. 194 of the Treaty on the Functioning of the European Union – TFEU) and environmental protection policy (Art. 192 TFEU), industry policy (Art. 173 TFEU), energy infrastructures (Art. 170 TFEU), research and technological development (Art. 179 TFEU) and other, the European Union creates its own development strategies and action plans concerning energy use². Simultaneously, member states are obliged to implement EU regulations in their own internal legal systems (*acquis communautaire*).

The division of competences between EU institutions and EU member states is made according to the principle of subsidiarity, which means that „ (...) in areas which do not fall within its exclusive competence, the Union shall act only if and in so far as the objectives of the proposed action cannot be sufficiently achieved by the Member States, either at central level or at regional and local level, but can rather, by reason of the scale or effects of the proposed action, be better achieved at Union level.” (Art. 5 Section 3 TEU).

Energy cooperation in Europe began in the 1950s and it was sealed by signature of the agreement on creation of the European Coal and Steel Community (ECSC) and the European Atomic Energy Community (EURATOM)³. At the beginning of 2000 a new chapter regarding energy policy was added to the Treaty provisions (Art. 194 TFEU). It was a pivotal point, particularly important due to introduction of dynamic changes concerning European energy transformation with regard to natural environment and climate change conditions.

In the context of the establishment and functioning of the internal market and with regard for the need to preserve and improve the environment, Union policy on energy aims, in a spirit of solidarity between Member States to ensure the functioning of the energy market, ensure security of energy supply in the Union, promote energy efficiency and energy saving and the development of new and renewable forms of energy and promote the interconnection of energy networks (Art. 194 Section 1 TFEU). They are by and large compatible with the Union policy on the environment contributing to pursuit of such objectives as: Preserving, protecting and improving the quality of the environment, protecting human health, prudent and rational utilisation of natural resources, promoting measures at international level to deal with regional or worldwide environmental problems, and in particular combating climate change (Art. 191 Section 1 TFEU). Therefore climate change is considered to be one of the crucial long term factors requiring consistent actions between many EU policies and globally. As a result, in the EU energy policy along with liberalisation of the energy

2 The competences are shared between the EU and the member states as regards energy and the environment, whereas when it comes to, for instance, industry the Union coordinates actions and supports or complements member states.

3 ESCS ceased to exist 50 years after its establishment and its functions were embraced by the European Union.

market and actions aimed at ensuring energy security there have appeared objectives connected with climate. These actions include, i.e., a shift away from fossil fuel towards renewable energy sources, operations boosting energy efficiency, research and development, and broader application of clean energy technologies⁴. In the new millennium key EU development strategies include issues related to the transition of the energy sector towards creation of zero-carbon economy as the ultimate goal.

The main goal of the EU sustainable development strategy as regards energy and climate is to provide affordable, reliable and sustainable modern (clean) energy for consumers. In the light of EU strategies it could be possible thanks to providing widespread access to energy, boosting energy efficiency and maximizing the use of renewable energy sources. At the same time it is believed that this transition is feasible by accelerating research into innovative energy technologies, investments in energy efficiency and energy infrastructures (Eurostat, 2018, p.131-147; p.237-253). The above mentioned actions are meant to contribute significantly to implementation of commitments arising from adoption of the UN Framework Convention on climate change and provisions of the Paris agreement of 2015.

The basis for the transformation process of European economy, according to energy and climate policy goals, is formed by the current laws of the EU and its member states, development programmes and strategies, as well as regulatory, administrative, economic and social impact instruments (Table 1).

4 More on stages of EU energy policy development (Wojtkowska-Lodej et al., 2016, p. 11-41).

A vital initial stage of implementing ambitious targets of energy and climate policy as outlined in the EU energy strategy (European Commission, 2007), and those subsequently included in Europe 2020 strategy are those goals which refer to energy management and climate, defined in the so-called climate and energy package and constituting a significant element of the EU policy for two decades (European Commission, 2010) (Table 2). They refer to reduction of greenhouse gas emissions, increase in the use of renewable energy sources and reduction of energy consumption due to increase in energy efficiency. They have been defined in the form of increasing quantitative indicators until 2020 and then – 2030.

By 2020, according to the Europe 2020 strategy the EU has committed itself to reducing CO₂ emissions at least by 20%, increasing the use of RES in final energy consumption to 20%, including 10% share of biofuels in the EU's energy mix (compared to the base year 1990), boosting energy efficiency by 20% in comparison to the demand estimate for fuel and energy. A further progress in meeting the climate targets set to be achieved by 2030 is to be boosted by subsequent strenuous actions reflected in the higher levels of the given indicators amounting to 55%, 32% and 32.5% respectively (the 40% greenhouse gas emissions reduction target has been updated). The achievement of energy and climate objectives is also supposed to be aided by further progress in developing the internal energy market through expanding interconnections (including cross-border electricity networks) accounting for 10% in 2020 and 15% in 2030, as well as greater EU-funded financial support.

The strategy of transformation of the EU economy into competitive and low-carbon economy by 2050 is supposed to mean reducing

Table 1: Selected management tools regarding energy and climate policy in the EU

Type of instrument	Examples of regulations
Legal regulations	<ul style="list-style-type: none"> • European Union law (Art. 194. TFEU, Art. 191. TFEU and other) • National regulations of EU member states (legal acts)
Programmes and strategies for energy development	<p>EU strategies:</p> <ul style="list-style-type: none"> • An energy policy for Europe [COM (2007) 1] • EU strategy for smart, sustainable and inclusive growth <i>Europe 2020</i> [COM (2010) 2020] • A Roadmap for moving to a competitive low carbon economy in 2050 [COM (2011) 112] • A policy framework for climate and energy in the period from 2020 to 2030 [COM (2014) 15] • A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy [COM (2015) 80] • Closing the loop - An EU action plan for the Circular Economy [COM (2015) 614] • A Clean Planet for all A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy [COM (2018) 773] • The European Green Deal [COM(2019)640 Final] <p>EU member states' policies:</p> <ul style="list-style-type: none"> • National energy policies • National environment protection policies • Industrial, R&D and other policies
Legal and administrative instruments (incl. instruments voluntary in member states within legal nicety)	<ul style="list-style-type: none"> • Prohibitions • Obligations • Permits/licences
Economic instruments	<ul style="list-style-type: none"> • EU Emission Trading Scheme (EU ETS) • Fees • Taxes • Collateral/Warranties
Social impact instruments	<ul style="list-style-type: none"> • Education • Lobbying

Source: Author's own elaboration based on (Poskrobko and Poskrobko, 2012, p. 260-274)

Table 2: 2020 and 2030 framework for climate and energy – agreed targets

Year	Greenhouse gas emissions	Share of renewable energy	Energy efficiency improvement	Interconnection	Climate in EU funded programmes	CO ₂ from:
2020	-20%	20%	20%	10%	2014-2020	
2030	≤-40%	≥ 32%	≥ 32,5%	15%	2021-2027	cars -37.5% vans 31% lorries 30%
2030*	≤-55%	≥ 32%	≥ 32,5%			
2050	→developing climate neutral European economy towards 2050					

*Upwards revision clause by 2030. Source: (European Commission, 2019a, p. 12; European Commission, 2019b, p. 5)

national emissions by 80% compared to the level in 1990 and concerns changes in the whole economy, with a particular regard to energy-intensive and carbon-intensive sectors, that is: energy, construction, services, transportation, agriculture. For each of the sectors the EC document defines greenhouse gas emission indicators on the assumption that it will be a gradual process. For the energy sector it was assumed that CO₂ emissions reductions by 2005 should account for -7%, by 2030: between -54 and 68%, and by 2050: Between -93 and -99%, compared to 1990 (European Commission, 2011). These figures indicate that ultimately virtually all CO₂ emissions are to be completely eliminated in electricity generation. It is estimated that the share of low-carbon technologies among all technologies used will be increasing gradually from the current level of 45% to approximately 60% in 2020, 75-80% in 2030 and will be nearing 100% in 2050⁵. This will mean scattered electricity and heat generation and transition towards a more efficient and sustainable energy system in Europe. The EU greenhouse gas emission permit trading, along with other instruments of economic policy, such as energy taxation or technical support, as well as demand-side actions creating incentives for the desired changes will greatly contribute to the invention of various low-carbon technologies. It is visible in the Energy Union strategy, which assumes that the Union is to serve as a platform for enhanced regional cooperation between EU member states (European Commission, 2015).

Achievement of the above mentioned EU energy and climate policy objectives will depend on the member states, their potential and determination in transforming their economies towards the low-carbon economy.

For many countries, mostly those situated in the Central and Eastern Europe (CEE) region, due to particular internal factors (owing to i.e. access to natural energy resources, economic structure, electricity generation structure etc.), the objectives set by the European Union are a difficult challenge to face (Wojtkowska-Łodej and Nyga-Łukaszewska, 2018, p. 295-315). Nevertheless, these countries address those challenges and create their own, tailor-made development strategies, consistent with the Union's objectives and strategies. For fifteen years so far the CEE countries have been implementing a model, which assumes balancing economic, social and environmental development thanks

5 The idea, therefore, is to build a climate neutral economy, which means such emission levels that could be absorbed by the natural environment.

to financial support within the consistency policy as well as many other programmes.

The way in which national energy and climate policy for Poland as an EU member state is implemented will be dealt with below.

3. POLAND AS AN EU MEMBER STATE; INTERNAL FACTORS AND REGULATIONS CONCERNING ENERGY AND CLIMATE

3.1. Processes of System Transformation and Adaptation to EU Membership; Starting Conditions and Regulations

2019 marks 30th anniversary of the beginning of system transformation processes in the Polish economy: from centrally-planned to market economy. Processes of demonopolisation, restructuring, deregulation and privatisation since the early 90s of the 20th century have been accompanied by changes connected with the EU accession process and EU membership (since 2004).

Poland is the sixth largest EU member state by land area (covering 312,7 thousand sq. m) with the population of 37 m and economy developing dynamically at a pace of 4,7% in 2007 and GDP per person of 12 100 Euros (Statistics Poland, 2018, p.7). When joining the European Union Poland transposed the Union's legal system into its national law, including energy and the environment. The energy sector has a fundamental significance for the functioning of the Polish economy, constituting approx. 4% of total value added and 1.1% of all people employed (in 2015).

Poland is one of these member countries, which possess their own conventional energy sources, i.e., coal and lignite. It is these resources and their utilization which have cemented carbon dependent economic structure with high share of coal in the primary energy structure, final energy consumption and electricity generation. It puts the Polish economy in a particularly difficult position in light of the measures introduced by the EU in effort to reduce pollution and long term retreat from conventional energy sources in favour of extensive use of renewables and transformation of member states' economies into low carbon economies. Poland is the sixth largest EU country by primary energy generation and the second largest by coal and lignite mining (Statistics Poland, 2019). Coal has the largest share in the structure of primary energy generation and it amounted to 76.87% in 2017 compared to 16.44% in the UE (Table 3).

Poland also extracts natural gas, the share of which in the national balance accounts for 5.5%, as well as renewables with the share of 14.14% in 2017. These figures point to the change made in the Polish economy in the last 15 years, expressed in the reducing coal mining in favour of renewables and natural gas.

The obvious consequence of having access to hard coal and its mining is coal dominance in the structure of electricity generation (Table 4). The share of coal in this structure accounted for 76.9% in 2017, whereas other energy carriers accounted for 23.03%, including RES – 14.44% and natural gas – 7.22%. This situation is dramatically different in Poland than in EU28 and the only noticeable similarities concern changes in time expressed through increase in significance of RES and subsequent growing natural gas use in electricity generation.

Between 2004, when Poland became the member of the EU, and 2017 Polish economy recorded dynamic growth of 3 to 6% per year. This dynamics was accompanied by a slightly slower growth in primary and final energy consumption (Figure 1). It was connected with changes in the economic structure expressed in a shift away from heavy and energy intensive industry dominance and boost in energy efficiency of the Polish economy.

Since joining the EU solid fuels consumption has followed closely the use of renewables. Nevertheless, both growth dynamics of RES in primary energy consumption (TPES – total primary energy supply) in Poland and decline dynamics of solid fuels consumption have been slower than in the EU (Figure 2).

As a result of trends observed in conventional energy consumption and RSE greenhouse gas emissions, including carbon dioxide, have been changing. In 2017 greenhouse gas emissions per CO₂ amounted to 339,05 mio tons CO₂, compared to 324,44 mio tons CO₂ (EU Commission, 2019).⁶ It was connected with the structure of Polish economy, its transformation processes and dynamic economic growth between 1990 and 2019.

6 A detailed examination of these issues is to be found in the latter part of the analysis.

Table 3: Production of primary energy in Poland and EU

Primary energy sources	2004		2017	
	Mtoe	%	Mtoe	%
Poland	78.57	100.00	64.37	100.00
Solid fuels	69.22	88.10	49.84	76.87
Petroleum and products	0.98	1.24	1.05	1.63
Natural gas	3.93	5.00	3.51	5.45
Nuclear	0.00	-	0.00	-
Renewables and biofuels	4.32	5.50	9.10	14.14
Wastes non-RES	0.13	0.16	0.87	0.91
UE*28	937.26	100.00	759.84	100.00
Solid fuels	198.05	21.13	124.93	16.44
Petroleum and products	147.88	15.78	74.55	9.81
Natural gas	204.78	21.85	103.09	13.57
Nuclear	260.60	28.35	210.72	27.73
Renewables and biofuels	113.61	12.12	226.59	29.82
Wastes non-RES	7.20	0.77	14.20	2.63

Source: Author's own elaboration based on (EU Commission, 2019)

Due to having access to coal and changes in energy consumption structure subsequent changes in trade of energy carriers has occurred. Poland is far less dependent on import than EU countries on average. However, over the last years, it has become net importer of fossil fuels and electricity, and import dependence dynamics, particularly in terms of conventional sources is greater than in EU28. In 2015 Poland imported approximately 70% natural gas and crude oil in total and it also became coal importer (Figure 3).

Polish main trade partners in this respect are Russian Federation, Iraq, Australia and the United States of America. Due to high geographical concentration of natural gas and crude oil supply Poland has made an immense investment effort in order to seize new opportunities and create new transit routes for these resources. Since then a terminal based in Świnoujście, providing liquefied gas to Poland was opened and a pipeline supplying gas from Norway is being built. In addition, Poland signed an agreement with the USA concerning gas supplies to Poland and the first deliveries took place in 2017. With a view to actions aimed at boosting domestic gas extraction and the observed diversification of supplies to Poland the situation related to energy security has been ameliorating (Wojtkowska-Łodej et al., 2018, p.39-42).

3.2. Polish Energy Policy as Regards Energy and Climate

Internal factors, sectoral demand for energy in the economy, social and environmental conditions and EU membership requirements as well as obligations connected with commitments concerning international agreements all form a basis for the implemented energy policy. Polish energy policy objectives include energy efficiency improvement, increase in fuel and energy supply security, diversification of electricity generation through implementation of nuclear energy, enhanced use of RES, development of competitive fuel and energy markets and reduction of the impact of power generation on the environment (Ministry of Economics, 2009).⁷

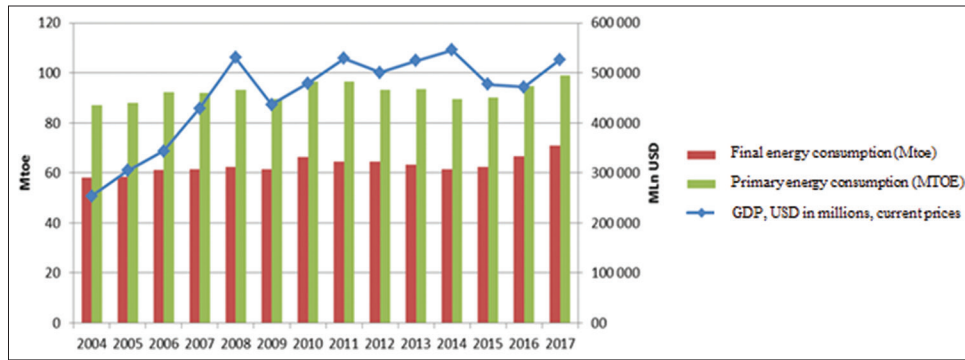
7 Member states may determine the conditions for exploiting energy resources, their choice between different energy sources and the general structure of their energy supply (Art.194 TFEU section2).

Table 4: The structure of electricity generation in Poland and the European Union

Energy carriers	2004		2017	
	TWh	%	TWh	%
Poland (total)	153.89	100.00	170.40	100.00
Solid fossil fuels	141.12	91.70	131.16	76.97
Oil and petroleum products	2.91	1.89	2.02	1.19
Gases	5.00	3.25	12.31	7.22
Nuclear	0.00	-	0.00	-
Renewables and biofuels	4.82	3.13	24.60	14.44
Wastes non-RES	3.69	0.03	0.31	0.18
UE28 (Total)	3295.82	100.00	3294.31	100.00
Solid fossil fuels	985.43	29.90	677.02	20.55
Oil and petroleum products	148.49	4.51	60.66	1.84
Gases	652.41	19.80	695.92	21.12
Nuclear	1008.44	30.60	829.72	25.07
Renewables and biofuels	488.36	14.82	1005.61	30.53
Wastes non-RES	12.70	0.37	25.38	0.89

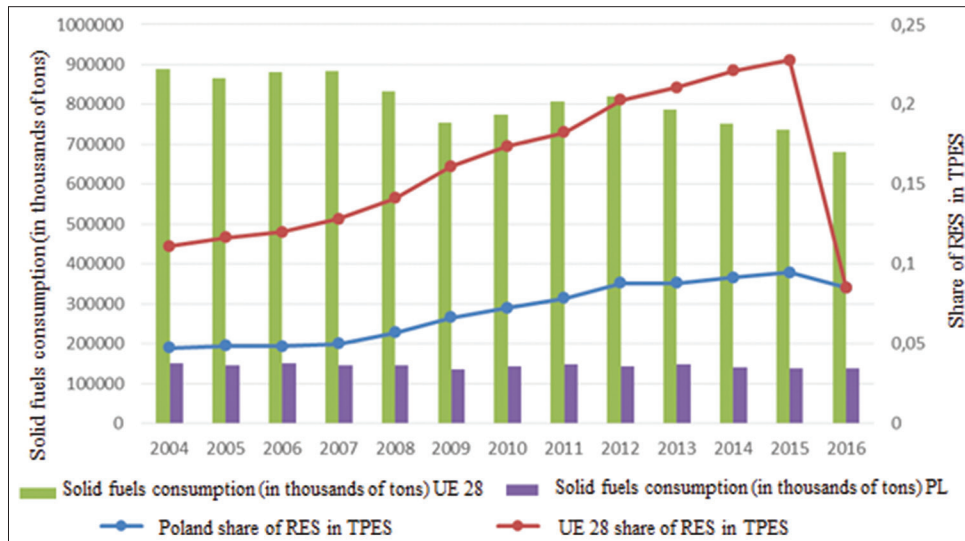
Source: Author's own elaboration based on (EU Commission, 2019)

Figure 1: Primary and final energy consumption and GDP development in Poland



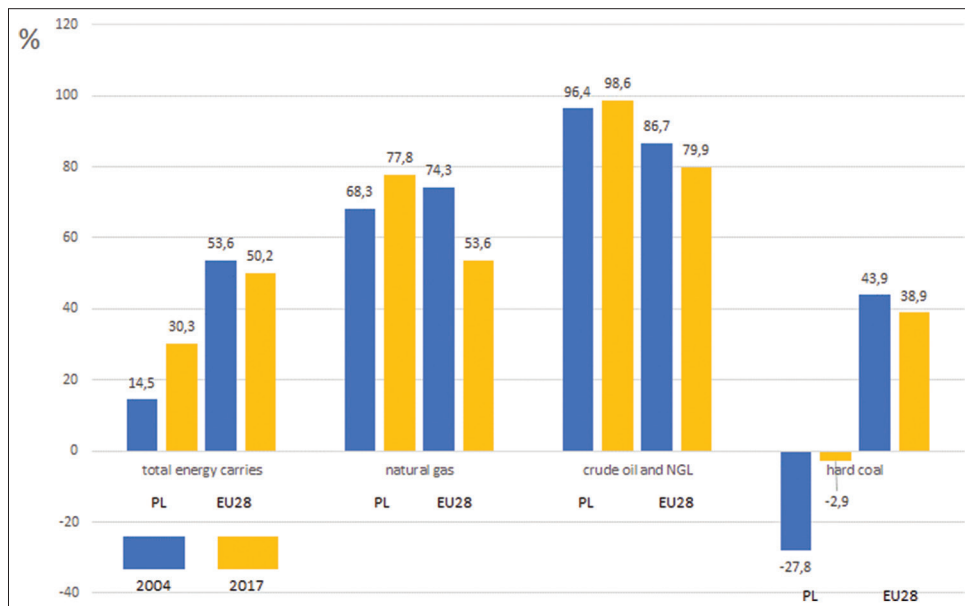
Source: Author's own elaboration based on (Eurostat, 2019).

Figure 2: Solid fuels consumption and RES in Poland and EU



Source: Author's own elaboration based on (Eurostat, 2019).

Figure 3: Dependence on energy import in Poland and EU28



Source: Author's own elaboration based on (Eurostat, 2019).

The current one, *Energy policy of Poland until 2040*⁸ (PEP2040) drafted by the Ministry of Energy is one of the sectoral strategies resulting from the *Sustainable Development Strategy*. Its aim is "(...) to provide energy security while ensuring competitiveness of the economy, energy efficiency and reduction of the impact the energy sector has on the environment. All this is to be achieved by optimal use of domestic energy resources" (Ministry of Energy, 2019). In order to deliver the agreed energy policy objectives, which include energy security, competitiveness and energy efficiency, as well as reduced environmental impact, there have been outlined strategic directions and actions, comprising the full energy supply chain from energy sources, through energy generation and supply distribution to the ways energy is used. They comprise of:

- Optimal use of domestic energy resources
- Development of the power capacity and transmission infrastructure
- Diversification of natural gas and oil supply and network infrastructure development
- Development of energy markets
- Launch of nuclear energy
- Development of renewable energy sources
- Development of heating and cogeneration
- Improving energy efficiency.

The objectives of both the current and the planned policy (PEP2040) are in line with the energy policy established in TFEU and are expected to ensure sustainable development of the whole economy. As far as energy and climate are concerned, they include actions aimed at reducing greenhouse gas emissions, conventional energy carriers consumption and the growing use of RSE and nuclear energy as well as boosting energy efficiency (Wohlgenuth and Wojtkowska-Łodej, 2003, p.111-121). The key energy and climate policy document in Poland parallel to the EU timetable for action concerning implementing energy union measures is the integrated energy and climate plan (*National Energy and Climate Plan*, NECP) for the years 2021-2030 (Ministry of Energy, 2019). This plan concerns Polish input into meeting energy and climate objectives.

The Polish NECP draft was published and presented for public consultations on January 15, 2019. According to projections made in NECP greenhouse gas emissions in Poland will drop from 37,2 m tons in 2010 to 366,5 m ton in 2030. NECP presents nuclear energy implementation as a crucial factor for decarbonising the economy and the first nuclear power unit is to be launched in 2033. The declared target for the share of energy from RES in the final consumption of renewables for 2030 was set at 21% (27% in the electricity sector). Apart from biomass, offshore wind farms and photovoltaics are expected to be of particular significance. In terms of energy efficiency Poland declares 23% savings in primary energy compared to 2007 projections. NECP projects a 60% share of coal in electricity generation (compared to the current 77%) (CEE Bankwatch Network, 2019, p. 13).

8 Following the public consultation procedure the document is awaiting adoption by Parliament.

Thus, despite different conditions for energy sector development in Poland than in many other EU countries, thanks to economic policy adopted in Poland, involving energy and climate, the country participates in actions aimed at energy restructuring of its economy, as well as the EU economy, towards low carbon solutions. Polish membership in the EU offers and opportunity of benefiting from financial support of the system transformation processes and transformations in the energy sector within regional development, cohesion and R&D policies. In terms of investments financed by public funds, member states were mostly focused on programmes connected with creation of intelligent, integrated energy systems (*Integrated Strategic Energy Technology Plan- SET-Plan*), new initiatives undertaken as part of public-private partnerships (PPP), and cooperation of industrial research facilities with universities (e.g., European Institute of Technology - EIT, Knowledge and Innovation Communities - KICs). There appeared a need for developing new skills at European and national levels, as well as new professions training for the evolving job market resulting from energy sector transformation (Wojtkowska-Łodej et al., 2018, p. 20-23). EU financial aid was a crucial factor enabling Poland to proceed with many of its strategic investments in the national gas supply system: LNG gas terminal in Świnoujście, gas transmission network, underground storage tank systems (UST), electricity and heat networks, and it amounted to over 17,5 bn PLN (Wiśniewski and Cylwik, 2019, p. 178).

Within the last fifteen years Poland has undertaken the effort not only to build market economy but also one friendly for both the environment and climate (Table 5).

Due to a high average annual GDP growth, ranging from about 3% to 6% in the last three decades, Polish economy underwent economic structural changes and, as result, national gross energy consumption per unit of GDP, which amounted to 0.23 kgoe/Euro in 2017 compared to 0.46 kgoe/Euro in the years 2000-2005) has been falling. These processes have been accompanied by the lowering CO₂ emissions, which is evidenced by the CO₂ emissions intensity index. Positive changes have also been observed in recycling of municipal waste. On the other hand, high energy intensity is recorded in transport, which additionally is a substantial CO₂ producer.

Throughout the analysed period aggregate Herfindahl-Hirschmann index (HHI) has slightly improved for main energy products in national gross energy consumption and it amounted to 0.33 in 2017 compared to 0.43 in the years 2001-2005. Similarly, HHI regarding concentration of suppliers for net imports of oil, natural gas liquids (NGL), natural gas and coal has picked up, which indicates increased diversification of suppliers and, therefore, lower delivery risk.

During the economic transformation processes there were implemented numerous market-based instruments, such as: environmental taxes, certificates supporting RSE use, cogeneration or energy efficiency in energy generation, EU Emissions Trading Scheme. Additionally, public funding and governmental programmes aimed at R&D in energy and environmental protection have also been extensively applied.

Table 5: Green growth in Poland (selected indicators)

Green growth performance		2001-2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Macroeconomic*														
Energy intensity	kgoe/	0,46	0,43	0,40	0,38	0,36	0,28	0,27	0,25	0,25	0,23	0,23	0,23	0,23
Carbon intensity	€	1,92	1,75	1,63	1,54	1,44	1,30	1,07	1,03	1,01	0,94	0,92	0,91	-
Resource intensity (reciprocal of resource productivity)	kg/€	2,70	2,50	2,60	2,54	2,40	2,08	2,10	1,80	1,68	1,62	1,53	1,55	1,58
Waste intensity	kg/€	-	0,74	0,63	0,54	-	0,51	-	0,42	-	0,44	-	0,42	-
Real unit of energy cost	kg/€ % of added value	-	-	-	-	-	19,5	21,0	21,2	20,1	19,9	20,3	20,8	-
Environmental taxes	% GDP	7,5	8,2	7,7	7,6	8,0	2,6	2,6	2,6	2,4	2,6	2,7	2,7	2,7
Sectoral														
Industry energy intensity	kgoe/€	0,39	0,29	0,27	0,21	0,22	0,18	0,17	0,12	0,12	0,12	0,11	0,11	0,10
Share of energy-intensive industries in the economy	% GDP	12,7	5,9	5,6	5,6	5,9	14,09	14,8	14,1	13,9	13,8	13,9	14,1	-
Electricity prices for medium-sized industrial users	€/kWh	0,05	0,05	0,05	0,08	0,09	0,10	0,10	0,09	0,09	0,08	0,09	0,08	0,09
Gas prices for medium-sized industrial users	€/kWh	-	-	-	-	-	0,03	0,03	0,04	0,04	0,04	0,04	0,03	0,03
Public R&D for energy	% GDP	-	0,00	0,01	0,01	0,01	-	-	0,01	0,01	0,01	0,01	0,00	0,00
Public R&D for environmental protection	% GDP	-	0,00	0,01	0,01	0,01	-21,4	-	0,02	0,02	0,03	0,03	0,03	0,03
Municipal waste recycling rate	%	4,1	6,9	7,7	10,5	17,4	51,7	17,5	12,0	15,1	26,5	32,5	34,8	33,8
Share of GHG emissions covered by ETS**	%	-	52,1	52,3	51,6	50,8	1,43	52,5	51,7	52,4	51,9	52,1	49,9	-
Transport energy intensity	kgoe/€	0,78	0,79	0,80	0,75	0,81	3,87	0,92	0,83	0,76	0,76	0,80	0,88	0,95
Transport carbon intensity	kg/€	2,43	2,20	2,11	2,02	2,17	-	2,51	2,25	2,06	2,06	2,19	2,45	-
Security of energy supply														
Aggregated supplier concentration index	HHI	NDA	NDA	NDA	NDA	29,2	29,5	28,9	29,8	27,0	27,4	27,2	25,7	-
Diversification of energy mix	HHI	0,43	0,42	0,41	0,39	0,38	0,38	0,38	0,36	0,37	0,36	0,35	0,34	0,33
Share of RES in energy mix	%	4,6	4,8	5,0	5,6	6,6	-	-	-	-	-	-	-	-

*All macro intensity indicators are expressed as a ration of a physical quantity to GDP (for years 2001-2009 in 2000 prices, for 2010 in 2005 prices, and for 2011-2017 in 2010 prices).

**Proportion of GHG emissions covered by EU emissions trading system (ETS) (excluding aviation): based on GHG emissions (excl. land use, Land use change and forestry) as reported by Member States to the European Environmental Agency. Source: Author's own elaboration based on: SWD (2019) 1020 final of 27.2.2019, p. 65; SWD (2018) 219 final of 7.3.2018, p. 46; SWD (2017) 86 final of 22.2.2017, P 45; SWD (2013) 371 final of 29.5.2019.; EU Commission (2019)

4. ENERGY TRANSFORMATION OF POLISH ECONOMY; FINANCIAL AND SOCIAL CHALLENGES AND DEVELOPMENT OPPORTUNITIES

The megatrends observed in global and regional energy sectors constitute, on the one hand, a challenge for Europe and member states (connected with RSE development, actions aimed at long term development of carbon neutral economy, technological progress, ongoing digitization, new forms of consumption), on the other, they offer an opportunity to combat climate change more actively and efficiently.

So far, implementation of energy and climate policy objectives in Poland has generated high costs due to the earlier mentioned coal structure of energy generation, as well as structure and energy intensity of the economy. They are connected in particular with costs of CO₂ emission cuts, electricity price rises related to new solutions implemented within the EU ETS, a probable subsequent lower competitiveness of the Polish economy, carbon leakage and likely unemployment rise (Wojtkowska-Lodej et al., 2016, p.48-52). It is

estimated that costs of ensuring energy security of Poland, according to „Energy Policy of Poland until 2040” (EPP40), within the coming 20 years will amount to 400 bn PLN, which means spending 20 m PLN annually for this purpose (Motowidlak, 2019).

This transformation, due to capital requirements and the project execution period, poses a particularly tough challenge for Poland with its carbon-based structure of primary energy balance. We may also expect that independent processes such as: growing coal import, rising emission costs or EU funding may contribute to accelerating the shift towards gradual departure from coal.

Abandoning coal as the basic energy source may trigger substantial social problems. Main reserves of this fossil fuel are located in Upper Silesia, a region with a population of 5,3 m, which stands for approx. 13% of Poles (Kulik, 2019). Most workplaces are closely connected with coal mines present here for decades. The profession of a miner has passed down for generations, and mining tradition shaped the individual character of this region. In February 2019 coal mining employed approx. 83 thousand people, despite decades-

long gradual drop in coal extraction (Derski, 2019).⁹ Therefore, the shift towards carbon neutral economy will mean current jobs losses and new jobs creation as well as necessity of substantial financial assistance aimed at retraining. Such a process requires time and coordinated actions within economic, industrial and social policies. Creation of new jobs in the region, also those connected with green economy and clean energy sources, is possible due to, e.g. well-developed labour market and high level of education resulting from existing universities, including technical ones.

However, in the light of immense financial and social factors, delaying energy transformation may also bring negative effects for the whole Polish economy. It may occur that the speed of transition towards new energy sources in Poland will be slower than the dynamic growth of RSE generation capacity on the EU market, which, in turn, will pose risk for the Polish electricity system. As a result, higher national price of electricity will lower competitiveness of Polish goods and Polish economy as a whole.

Thus, the already initiated changes in the Polish energy sector should be continued. In the nearest years we might expect that coal will remain important fuel for electricity generation. According to the energy policy (EPP40), the first nuclear power plant should start operating in 2033. Meanwhile, we can observe a boom on the photovoltaic installations market. Construction of large offshore wind farms and investments in biomass and biogas are also planned. A further step in the way energy market will be functioning will involve developing energy storage systems. Boosting the changes will be enhanced by developing electromobility, scheduled in the *Sustainable Development Strategy*. These phenomena will contribute to the further process of energy sector transformation in Poland and already at present, as indicated in this analysis, it is coherent with EU trends. Poland opts for continuation of its climate policy, as illustrated by amendments made to energy and climate targets.

Due to internal factors, capital requirements and the project execution period, changes in the energy sector constitute a particularly difficult challenge for Poland with its carbon-based primary energy balance structure. A significant increase in its dynamics may be in conflict with important social objectives and limited economic resources. What might impact further progress in accomplishing ambitious targets of energy and climate EU policy are new mechanisms creating a level playing field for member states with a dominant carbon structure in their energy mix and giving the opportunity of accelerating transformation in the energy sector (e.g. possibility of EU funding or CO₂ certificates).

5. CONCLUSION

- The EU as a global partner and an important player in the world economy is actively committed to the shift of energy economy of the region towards carbon neutral economy
- Polish membership in the EU has contributed to upgrading the Polish economy and subsequent structural changes, which were mostly correlated with the system transformation process

began in the early 90s. This process also concerned the energy sector and involved demonopolisation, deregulation, privatisation and restructuring, which also led to laying the foundation for market economy. After joining the EU Poland continued the market changes process in the energy sector, which was in line with both national and Union's energy and climate policy

- The initiated energy sector transformation in the long run means, i.e. a more efficient use of energy, necessity of diversifying sources of electricity generation, expressed mostly in departure from carbon-dependent economy, in favour of renewables, implementation of new clean energy technologies, contributing to reducing greenhouse gas emissions, as well as boosting electricity interconnections
- The transformation process in the Polish energy sector over the 15 years of Polish EU membership, coherent both with EU trends and energy and climate policy targets set, can be analysed as positive. Energy transformation may also be an opportunity for further progress of Polish economy by new job creation, innovations etc. Poland identifies with the EU energy and climate policy. However, targets set in strategies for 2030 and 2050 pose a significant challenge for the Polish economy
- Private investments, innovations and internal market cooperation concerning energy generation, transmission, distribution and trading will play an important role in the shift towards carbon neutral economy in EU member states and the EU as a whole.

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⁹ Compare: https://wysokienapiecie.pl/wpcontent/uploads/2019/04/wegiel_gornictwo_wydobycie_praca.png, 15.07.2019.

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