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Analysis of energy efficiency in Poland in 2008-2018 in the context of sustainable development

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Abstract: analysing the Polish energy sector, changes in the market can be seen as a consequence of growing role of EU regulations, which increasingly affect the functionality of national and local markets. As a general rule, the basis of regulation is set out in the adopted strategy papers, indicating developmental desires within the energy market. The energy policies that are taken, which define the implementation measures, should guarantee the security of investment in the long term. The increase in energy efficiency generates significant financial savings while generating benefits for the environment, industry, transport or households. As part of monitoring the level of energy efficiency, the ODYSSEE-MURE programme has developed the ODEX indicator. The aim of the study was to analyze the level of efficiency in Poland in general and with an indication of three main sectors, as well as the level of Polish energy savings in the years 2008-2018. The research showed that the increase in energy efficiency of the Polish economy in the period under consideration is systematically increasing. Overall, between 2008 and 2018, the average rate of energy efficiency improvement was 1. 7% per year. On the other hand, savings achieved in 2018 within the indicated sectors amounted to 0.10 Mtoe.

Key words: energy efficiency, ODEX index, energy management, energy production

1.0. Instruduction

As the economic development of regional integration in Europe progressed, activities between countries were initiated as part of the development of a collective energy policy and, consequently, further climate and energy policy measures. Due to the increasing changes, mainly in the external environment of the European Union, climate protection issues have increasingly been addressed by policy makers. At present, despite the advanced specialisation, the implementation of energy policy objectives requires that climate policy objectives be taken into account at the same time. Given the considerable number of overlapping aspects of these policies, it is understood that they are implemented jointly as part of the European Union's climate and energy policy. The priorities in the field of energy management in the territory of the European Union include: security of energy supply to the internal market, liberalisation of the electricity and gas markets, change in the generic structure of energy carriers used in terms of their impact on the environment, as well as development of modern energy technologies and research.

In the international and European sphere, significant changes are being made to the legislation, which emphasises the importance of energy efficiency in terms of reducing energy consumption and CO2 emissions. The sustainable development objectives for 2016-2020 announced by the SBOs in 2015 indicate, inter alia, an improvement in energy efficiency of 27% (with reference to 1990).

As part of the implementation of the new energy policy, it is crucial to adequately select tools for monitoring the undertaken projects. To this end, the use of indicators aimed at assessing the extent to which the objectives have been met and at producing internationally comparable statistics is justified.A dedicated meter is the ODEX energy efficiency index for monitoring targets. The ODEX index was developed in the framework of the ODYSSEE-MURE programme, in which 28 countries from the EU and Norway cooperate. The main objective of the programme is to regularly monitor changes in energy consumption through two complementary databases: ODYSSEE related to energy efficiency and CO2 emissions, and the MURE database indicating actions taken to reduce energy consumption.

The aim of the study is to analyse the ODEX index and energy savings in Poland, taking into account the main economic sectors in the context of sustainable development. The analysis period adopted covers the period 2008-2018.

Energy efficiency – the EU regulatory framework

Both the Member States and the EU institutions are responsible for shaping and implementing climate and energy policy in the European Union. Projects carried out in the wider energy sector have been initiated since the beginning of the European Communities. However, it was only with the Lisbon Treaty that Title XXI - Energy - was included in the Treaty on the Functioning of the European Union (Treaty on the Functioning of the European Union, Article 194. which has contributed to formalising the competences and responsibilities in this area, which have been shared between the Member States and the European Union, and formally strengthening EU climate and energy policy.

The objectives indicated for climate and energy policy should include ensuring the operation of the energy market, and should be implemented in accordance with an approach of solidarity between Member States. In addition, they contribute to energy saving and the promotion of energy efficiency, to the development of new and renewable forms of energy, to the interconnection of energy networks, and to the security of energy supply in the EU (Treaty on the Functioning of the European Union, Article 194).

The priority objectives of the EU climate and energy policy have been specified within the so-called Climate and Energy Package, which is a set of six acts that were adopted by the European Commission in 2007 and 2008 (European Commission 2007). The first strategy was the 2007 European Energy Policy, which set targets (Paska, Surma 2013: 8):

- to reduce greenhouse gas emissions by at least 20% by 2020 with reference to 1990 (base year) and, in case a global agreement on greenhouse gas reduction is reached, to reduce greenhouse gas emissions by 30% by 2020 in the EU,
- to increase the share of energy from renewable sources in the context of final energy consumption to 20% by 2020, including a 10% share of biofuels in total fuel consumption,
- to increase energy efficiency by 20% by 2020 with reference to the forecast for energy and fuel demand.

The indicated objectives of the climate and energy policy have been specified and included in the strategies drawn up by the European Commission, as well as in the actions implemented. Among the most important solutions for improving energy efficiency, the EU economy's Europe 2020 strategy for smart, sustainable and inclusive growth (European Commission

2010), based on increasing competitiveness, stands out, as well as the long-term strategy for developing a competitive low-carbon economy by 2050 contained in the Roadmap for moving to a competitive low-carbon economy (European Commission 2011a). Subsequently, the climate and energy policy objectives have been taken into account in the Committee of the Regions' Opinion on 'The climate and energy policy framework for 2020-2030' (European Commission 2014b), which sets out the EU policy objectives and targets for the period 2021-2030, and these objectives have been included in the European Energy Security Strategy (European Commission, 2014a).

Energy efficiency is one of the most important economic issues alongside productivity, efficiency, effectiveness and quality (Czerwińska, Pacana 2019: 3-4). The concepts presented are closely linked by a complex series of relationships that require a deepening of certain definitions and aspects.

When considering the concept of energy efficiency, the first step should be to understand its essence. In the narrow definition, economic efficiency should be understood as the relationship between the effect and the effort (Roszek 2008: 125-133; Pionek 2001: 32-33; Paterson 1996: 377-390). On the other hand, in the context of referring the achieved effect to the amount of energy consumed (for example, in the production process, in the implementation of its individual stages or in the consumption of individual machines and equipment), it is possible to apply the concept of energy efficiency and define it as the ratio of the obtained results, goods, services or energy to the input of energy (Skoczkowski, Bielecki 2016: 173-184; Michalski 2010: 33-34). Economic efficiency is not only linked to technological processes in a qualitative sense, but also means efficient energy consumption. Therefore, energy efficiency is a measure of the use of energy in economic activity and is a fundamental factor in improving competitiveness, expected environmental effects, as well as energy security of the country. Its improvement reduces the energy and material intensity of the economy and creates a relative supply surplus (Mastelarska 2011: 281-296).

Energy efficiency in the context of sustainable development

Improving the level of energy efficiency is one of the key issues in terms of implementing the idea of sustainable development. According to the concept of this idea, there is a compromise solution between the economy, society and environmental resources, i. e. between progressing economic development and leaving the natural environment in the best possible condition for future generations to use it (Mazur-Wierzbicka 2006: 317-320; Tester, Drake, et all 2005: 19; Pacana, Czerwińska, et all 2020: 151-153). Energy efficiency measures are directly linked to the sustainable development objectives set out in the UN Agenda for Sustainable Development 2030. (United Nations 2015):

- Target seven: 'Ensure an affordable, reliable, sustainable and modern energy supply for all'
- Target thirteen: 'Take urgent action to mitigate climate change and its effects".

The aim of EU energy policy and legislation relating to the energy sector is to implement actions consistent with the rationale of sustainable development, mainly through the evolution of technologies using renewable energy resources and the development of cogeneration of electricity and heat (Skoczkowski 2002: 2-10). The Green Paper presented on 8 March 2006 was a kind of attempt to direct the EU strategy towards sustainable development in the field of energy (European Commission 2006).

Energy policy is a key level of sustainable energy development. Sustainable energy can be defined as the conversion of primary energy into heat and electricity, together with its supply to the final consumer in such a way as to meet the needs of both current and future generations, taking into account social, economic and environmental considerations of the development of the social unit. Issues relating to the concept of sustainable energy consumption are to be considered as part of energy policy, not energy itself (Prandecki 2014: 247).

The concept of sustainability also exists in energy systems. It is emphasised that a sustainable energy system should be based on: 'a combination of renewable energy technologies, renewable fuel transport, renewable heat, demand reduction, efficiency of use, as well as co-generation of energy production' (Mitchell 2010: 121-124). The features of this type of energy system include (Wach 2008):

- increasing use of renewable energy sources,
- emphasis on achieving long-term economic and environmental goals,
- functioning in competitive markets,
- growing interest in and penetration of new technologies,
- emphasis on taking into account external costs,
- functioning in international markets with identical competition rules.

A special role in balancing development processes in the energy aspect is attributed to renewable energy sources. However, it was often pointed out that it is difficult to indicate a situation in which the energy obtained was generated only from RES. The main barriers were: significant costs, limited electricity storage capacity or lack of capacity to produce mass-scale installations. However, the lack of political will was indicated as the most significant barrier (Malko 2006: 190; Graczyk 2017:56). Currently, sustainable energy is a different and broader concept than renewable energy, because all energy sources with a simultaneous relatively long life cycle and low environmental impact should be classified as such energy. (Pradecki 2014: 243).

An interesting definition of sustainable energy has been developed by the LG Action organisation, which brings together local authorities taking actions contributing to sustainable development. According to the representatives of the organisation, sustainable energy is not only a problem in terms of sustainability, but also in terms of allowing the use of energy sources that cause relatively little harm to humans and the environment. This is important because in practice there is no energy source that does not generate environmental damage. Therefore, all the theories indicating the possibility of harmless energy production are utopian in nature (Prandecki 2014: 239-240).

ODEX energy efficiency index methodology

The ODEX index is an aggregated indicator of energy efficiency. Among aggergated indicators of Energy efficiency, ODEX is presently one of the most complete for monitoring the implementation of the indicative target, within the framework of energy end-use efficiency indicated in Directive 2006/32/EC (Directive of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services) (Arcipowska, Tomaszewska 2012: 7). The ODEX index provides a measure of progress on energy efficiency in relation to three strategic sectors: transport, industry and households, as well as the country's economy as a whole. The methodology used allows to calculate the index in several stages with different levels of aggregation (Weber 2009: 1563-1564). ODEX is a weighted average of the indices of unit consumption of particular sub-sectors, where the weights assigned indicate the share of a particular sub-sector in total energy consumption. The subsystem indicators are calculated based on observed changes in specific energy consumption. These changes are expressed in physical units (for example, square metres of housing). Some sectors are not included in the ODEX calculation, such as construction and mining. This is due to the difficulty of obtaining data, and it is assumed that all sub-sectors have energy efficiency gains equal to the sector average (Enerdata 2016).

The ODEX indicator is obtained by aggregating the changes in specific energy consumption observed over time at specific end-use levels. It is calculated for each year as the quotient of the actual energy consumption in a given year and the theoretical energy consumption not taking into account the effect of the unit consumption, i. e. assuming the existing energy intensity of the production processes of the products concerned. A 3-year moving average is calculated to reduce accidental variations. A decrease in the value of the indicator means an increase in energy efficiency. The ODEX indicator does not show the current level of energy intensity, but progress from the base year 1990 (Zając 2010: 2453-2454).

The ODEX is calculated using the following formula:

$$\frac{I_t}{I_{t-1}} = \frac{\sum_i EC_{i,t}}{\sum_i A_{i,t} \cdot UC_{i,t-1}} \qquad (1)$$

where:

$EC_{i,t}$ – energy consumption in the *i* sector in year *t*,
$A_{i,t}$ – variable activity of sector *i* in year *t*,
$UC_{i,t}$ – unit consumption of sector *i* in year *t.*

In the formula It is the index value for year t, so the ratio It/It-1 indicates the level of energy consumption in year t divided by the energy consumption that would have occurred in year t, where the specific consumption was the same as in year t-1 (Enerdata 2016).

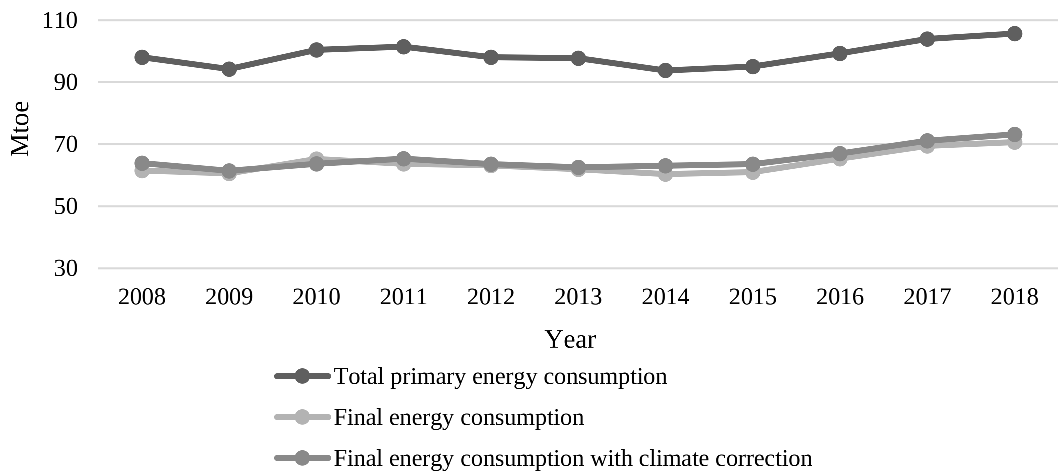
This indicator is not focused on absolute values as it illustrates the change that has occurred in relation to the energy efficiency level of the reference year. A shortcoming of this approach is that the result of the ODEX index is significantly influenced by the situation in the base year. Reading the value of ODEX, it should be noted that its value at the level of 99 indicates an improvement of 1%, so a decrease in the value of the indicator indicates an increase in energy efficiency (Lapillonne, Pollier 2011; Kicki, Jezierowska 2015:31).

In industry, for example, the overall effect of unit consumption will be obtained by aggregating the effects of unit consumption within individual departments. The ODEX indicator is calculated for each year by dividing actual energy consumption by theoretical energy consumption without taking into account the effect of unit consumption (i. e. without saving the energy obtained by reducing the unit energy consumption as part of energy efficiency improvement measures for the production process of the product). If the energy efficiency index was 85 in 2000, this means an improvement in energy efficiency of 15% compared to energy technologies and practices in 1990 (Zając 2010: 2453-2454).

Energy efficiency and energy savings 2008-2018

The analysis of energy efficiency and energy savings is based on an analysis of the level of energy consumption (Figure 1). In the period under consideration, total primary energy consumption increased by 7. 6 Mtoe - from 98. 1 Mtoe to 105. 7 Mtoe, which meant an increase of 0. 8%/year. The highest consumption took place in 2018 (105. 7 Mtoe) and was 1. 7 points higher than in 2017. The lowest energy consumption, after a three-year decline, was recorded in 2014 - 93. 8 Mtoe. The dynamics of growth of energy consumption is connected with significant economic growth that took place in the last three bars of the examined district. With regard to the final increase in energy consumption, an average annual blunt increase of 1. 4% was observed. In 2009 and the years 2011 - 2014 a decrease in consumption was recorded, reaching 60. 6 Mtoe, followed by 63. 7 Mtoe, 63. 2 Mtoe, 62. 0 Mtoe and finally 61. 0 Mtoe.

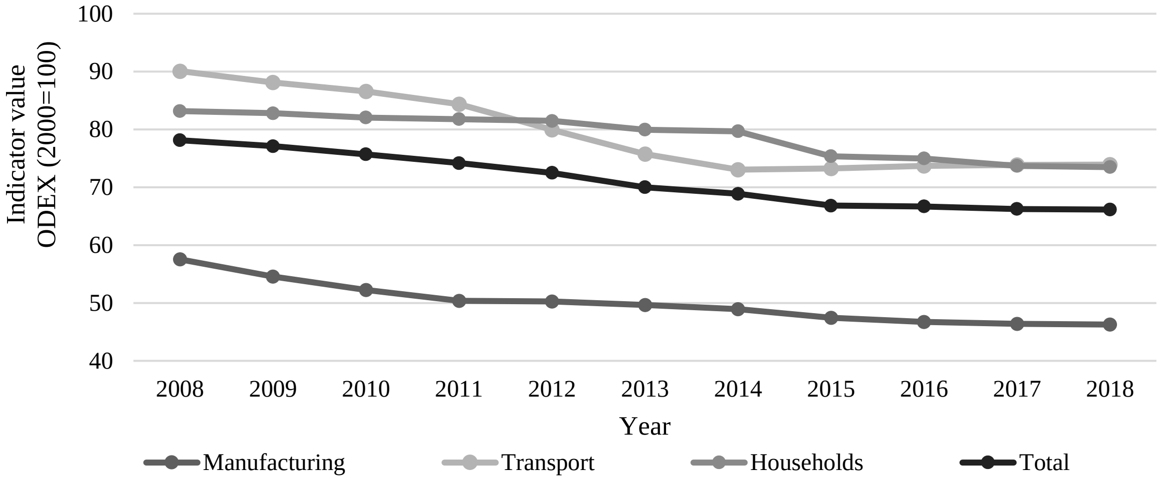
Fig. 1. Energy consumption 2008 – 2018 in Poland



Source: www.stat.gov.pl (access: 11.11.2020)

The ODEX index in the study is calculated to the base 2000=100. Overall, in the years 2008-2018 the value of the index decreased from 78. 1 to 66. 2 points. The average rate of energy efficiency improvement was 1. 7% per year. The slowest rate of improvement was observed in the household sector - the annual improvement in the period 2009-2018 reached 1. 2% (down from 83. 2 to 73. 5 points). In the transport sector, the average rate of improvement was 2. 0%, and the value of the 2018 index was normalized at 73. 9 points. On the other hand, the fastest rate of improvement (2. 2% annually) was recorded in the processing industry, for which the value of the indicator amounted to 46. 3 points. in 2018. The indicated data are presented in Figure 2 concerning the value of ODEX in the years 2008 - 2018 in Poland.

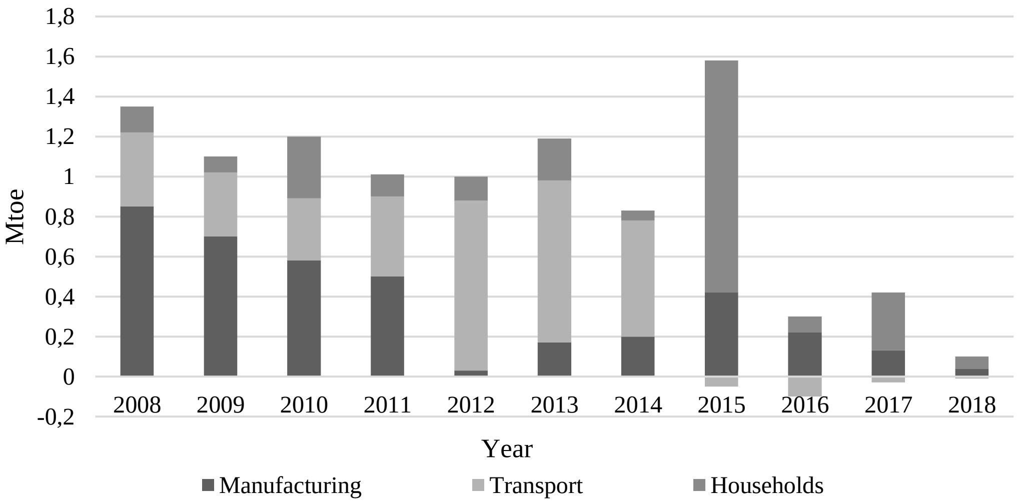
Fig. 2. ODEX values from 2008 - 2018 in Poland



Source: www.stat.gov.pl (access: 11.11.2020)

Energy savings in the most important sectors (processing industry, transport and households) have been achieved for almost the entire period under study. An exception was made for the period 2015-2018 in the transport sector. Savings achieved in 2018 within the indicated sectors amounted to 0. 10 Mtoe (million tonnes of oil equivalent). This figure was made up of savings made in the processing industry and in households, as well as a slight decrease in energy efficiency in transport. The level of savings within the key sectors is shown in Figure 3.

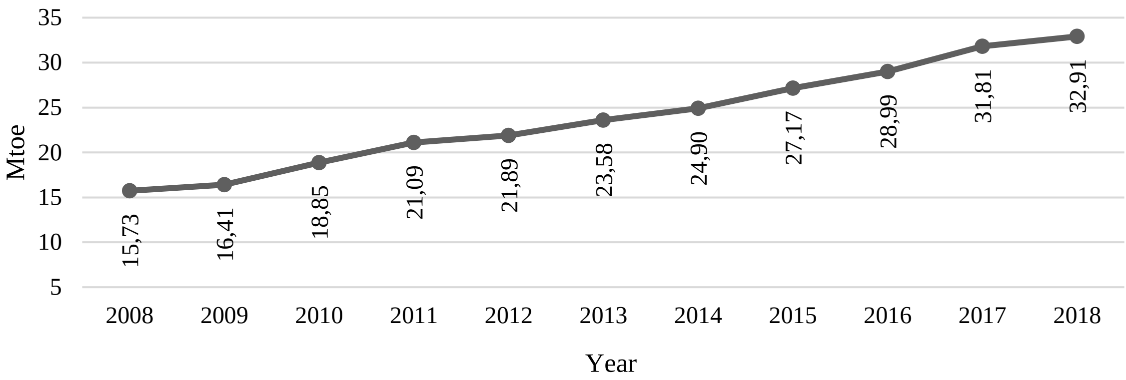
Fig. 3. Level of savings in the most important sectors between 2008 and 2018 in Poland



Source: www.stat.gov.pl (access: 11.11.2020)

The cumulative energy savings since 2000 (shown in Figure 4) illustrates how much energy consumption would have been higher in that year if energy efficiency improvements had not been implemented after 2000. The figures in the chart also take into account the savings made by sectors that are covered by the European Emissions Trading Scheme (EU ETS) (e. g. energy-intensive industry, including oil refineries, ironworks and aluminium production, metals, lime, glass, cement, ceramics, paper, cellulose, cardboard, organic chemicals and bulk acids). The data contained in Figure 4 has been calculated according to the assumption that the initial ODEX value for 2000 is equal to 100).

Fig. 4. Level of energy savings from 2000 in 2008 - 2018 in Poland

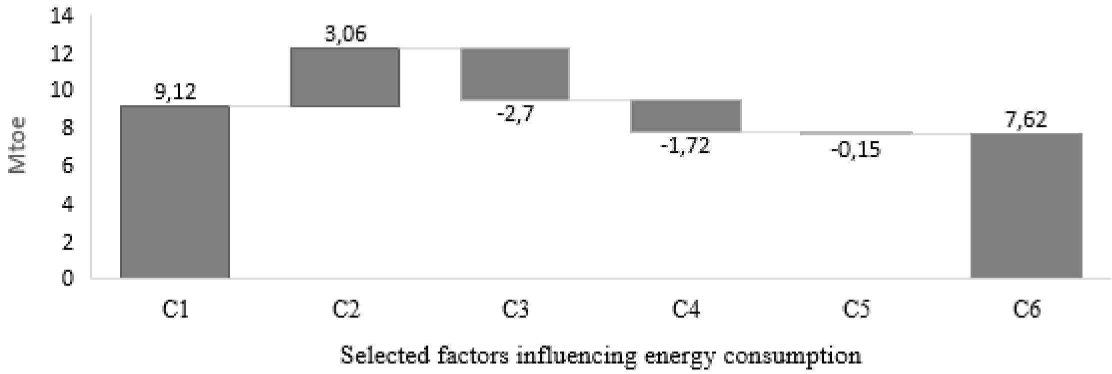


Source: www.stat.gov.pl (access: 11.11.2020)

In 2008, energy savings amounted to 15.73 Mtoe, and in 2018 it reached 32.9 Mtoe.

An important issue in analysing energy efficiency and energy savings is to determine the impact of individual factors on the level of energy consumption. In Figure 5 showing the decomposition of changes in primary energy consumption, the following are indicated: C1: change in consumption - final energy; C2: prevalence of energy; C3: efficiency of the combined heat and power plant; C4: energy mix; C5: other factors; C6: change in consumption - primary energy.

Fig. 5. Factors influencing energy consumption between 2008 - 2018 in Poland



Source: www.stat.gov.pl (access: 11.11.2020)

Between 2008 and 2018, total primary energy consumption increased by 7. 62 Mtoe. According to Figure 5, the increase in energy consumption was influenced by the increase in final energy consumption (9. 12 Mtoe), as well as the increase in the scale of electricity distribution (increase in electricity generation), which contributed to the escalation of demand for primary energy (3. 06 Mtoe).. On the other hand, the decrease in demand for primary energy was influenced by the appropriate efficiency of the heat and power plant (- 2. 7 Mtoe) and the increased use of energy from renewable sources (- 1. 72 Mtoe), which was also influenced by other factors - a decrease of 0. 2 Mtoe.

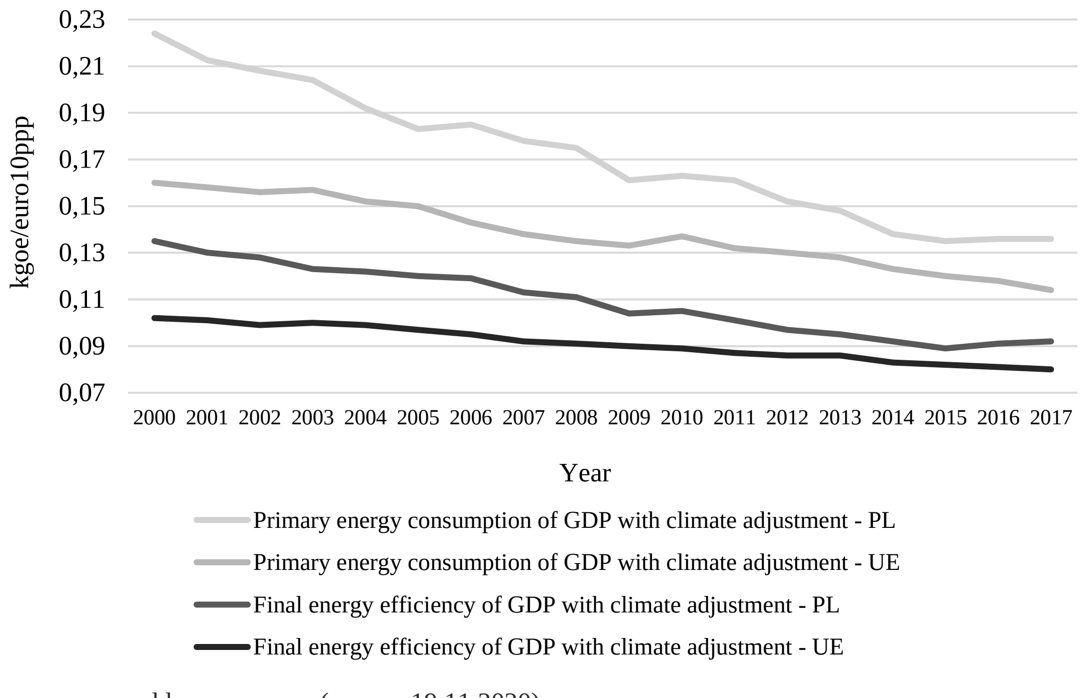
Poland in relation to the European Union 2000-2018

In making international comparisons, an important issue is to eliminate the impact of price differences between services and goods on the level of economic indicators, which can be achieved by taking purchasing power parity into account.In the situation of the analysis of a country with a significantly lower level of services and prices of goods than the area under consideration (e. g. Poland in relation to the European Union), the elimination of the differences identified contributes to the reduction of the level of the energy intensity indicator, thus indicating more clearly the actual difference in energy efficiency.

The primary energy intensity of Poland's Gross Domestic Product (GDP) including climate change, expressed in constant 2010 prices, taking into account purchasing power parity in 2017, reached 0. 137 kgoe/euro10ppp (kilogram of oil equivalent/euro expressed in the market rate in 2010 including purchasing power parity) and was 16. 6% higher than the European average (0. 118). The indicated difference was reduced by 24. 9 percentage points in relation to 2000, when the value of energy intensity of Poland's primary GDP including the climate correction reached 0. 221 kgoe/euro10pppp, while for the European Union it reached 0. 156 kgoe/euro10pp. It is noteworthy that the rate of improvement in energy intensity in our country (2. 8%/year) was in the years 2000-2017 almost twice as high as the EU average (1. 7%/year). The presented changes in primary energy intensity of GDP with climate change are shown in Figure 5.

As regards the final energy intensity of GDP, the gap is slightly smaller. In 2017 it was 14. 9% between Poland and the EU average. Also, the difference in the rate of efficiency improvement in the period 2000-2017 was lower and amounted to 2. 2%/year for our country, compared to the European average, which reached 1. 4%/year. Information on energy intensity of final GDP (including climate change) for Poland and the EU is presented in Figure 6.

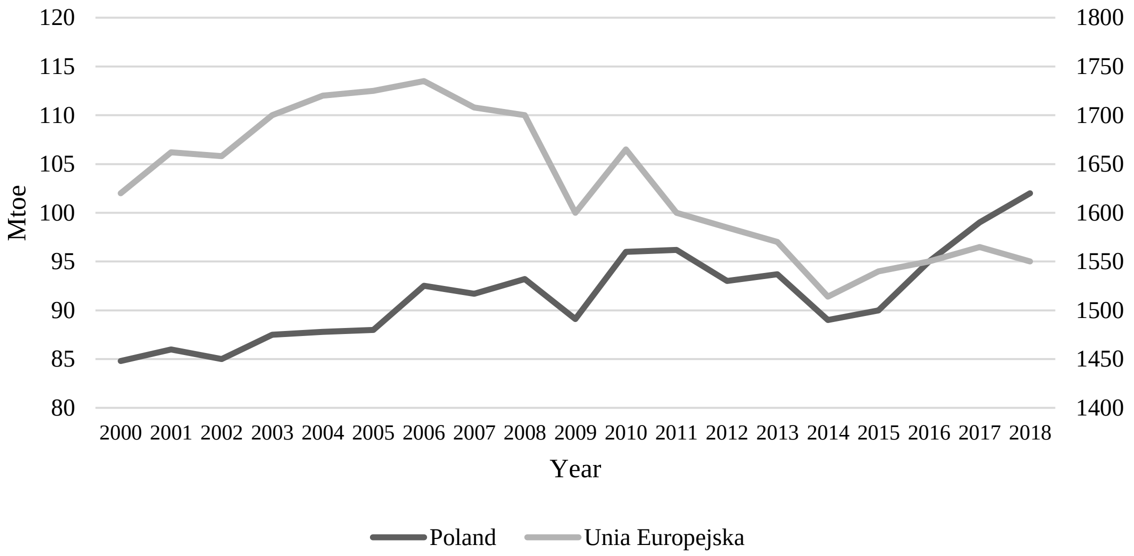
Fig. 6. Primary energy consumption of GDP with climate adjustment and final energy consumption of GDP with climate adjustment 2000-2017



Source: www.oddysse-mure.eu (access: 19.11.2020)

To supervise the implementation of the Europe 2020 Strategy, the indicator "primary energy consumption" is used, calculated as gross inland energy consumption excluding non-energy consumption (Directive 2012/27/EU). The primary energy consumption indicator values are shown in Figure 7.

Fig. 7. Primary energy consumption 2000 - 2018



Source: ec.europa.eu/eurostat (access: 19.11.2020)

The primary energy consumption index for Poland in 2018 reached 101. 1 Mteo and is above the target adopted for 2020. (96,4 Mteo).

Energy efficiency of Poland after 2020

Poland's energy policy is governed by strategic framework documents, including the Polish Energy Policy. The obligation to draw up this document is imposed on the minister in charge of energy, which is regulated by the Energy Law Act, which in Articles 13-15a specifies the content, objectives and shape of the document (Energy Law Act Dz. U. of 2020 pos. 833). The overarching objectives of Poland's energy policy are to ensure energy security, increase energy efficiency and competitiveness of the economy and environmental protection.

In accordance with the obligation imposed by the provisions of the Regulation of the European Parliament and the Council on the Member States of the European Union, a National Energy and Climate Plan for 2021-2030 has been drawn up. This document was submitted on 30 December 2019 to the European Commission, by which it was adopted on 18 December 2019. The National Energy and Climate Plan 2021-2030 indicates Poland's objectives, policies and actions to implement the five dimensions of the energy union, which include:

- energy security,
- decarbonisation,
- internal energy market,
- energy efficiency,
- research, innovation and competitiveness.

This document was prepared on the basis of national development strategies approved at the government level (including on the basis of the State Environmental Policy 2030, the Strategy for Sustainable Development of Transport to 2030 and the Strategy for Sustainable Development of Rural Areas, Agriculture and Fisheries 2030), as well as taking into account the draft Energy Policy of Poland to 2040 (www. gov. pl), with the development of the Plan resulting from the Regulation on the management of the Energy Union (Regulation (EU)

2018/1999 of the European Parliament and of the Council of 11 December 2018 on the management of the Energy Union and Climate Action).

The National Energy and Climate Plan for 2021-2030 indicates the 2030 climate and energy targets for:

- 7% reduction of greenhouse gas emissions in sectors not covered by the ETS compared to 2005 levels,
- 21-23% share of RES in gross final energy consumption (the 23% target will be achievable if Poland is granted additional EU funds, including those for a fair transformation), taking into account:
  - 14% share of RES in transport,
  - annual increase of RES share in heating and cooling by 1. 1 points. percent. On average.
- increase in energy efficiency by 23% as compared to PRIMES2007 forecasts,
- reduction to 56-60% of the share of coal in electricity production.

Projections for the National Energy and Climate Plan 2021-2030 indicate that the level of primary energy consumption in 2030 will be around 91. 3 Mtoe. Expressing in natural values, this objective will translate into a reduction in primary energy consumption of about 27. 3 Mteo in relation to PRIMES 2007 forecasts which simulate a market balance solution for energy supply and demand (Energy - Economics - Environment Modelling Laboratory Research and Policy Analysis National Technical University of Athens, 2009). PRIMES 2007 forecasts indicate primary energy consumption this year at the level of approx. 118. 6 Mtoe. The final energy consumption by 2030 is also expected to be around 67 Mteo, which indicates that the actions indicated in the National Plan will contribute to a reduction in final energy consumption of around 18. 4 Mtre in relation to PRIMES 2007 forecasts. By contrast, the projected total cumulative final energy savings, calculated on the basis of the guidelines of the revised Energy Efficiency Directive using data from forecasts of average annual final energy consumption for the period 2016-2018, will be 30 635 Mtoe (Energy Efficiency 2008-2018, 2020: 38).

Summary

Energy efficiency as the optimal instrument to increase security of energy supply and at the same time reduce greenhouse gas emissions and is a central part of the EU's strategy for sustainable development. Energy efficiency in the context of EU regulations and programme arrangements is becoming an important additional source of energy, indicating the level of energy saved. It has been reflected in the process of shaping the European Union's energy efficiency policy in the form of an energy and climate policy, the long-term economic development strategy "Europe 2020", as well as in the attempt to build a European low-carbon economy by 2015.

The European Commission, through its strategies and action programs, defines guidelines for actions and reforms that should be implemented by the EU Member States, in the regional and local scope. Besides, the Commission uses several instruments delineating the desired areas of change as well as supporting states in their actions. The Commission uses financial and tax instruments which play an important role in reducing economic barriers. The indicated instruments may indirectly increase the importance of activities aimed at increasing the level of energy efficiency.

It is worth noting the increase in energy efficiency of the Polish economy, which, during the period considered, is steadily increasing - both concerning the entire economy and the three analyzed sectors in the period from 2008 to 2018. Overall, in 2008-2018, the average rate of improvement in energy efficiency was 1, 7% annually. The fastest rate of improvement (2.2% annually) was recorded in the processing industry. The savings achieved in 2018 in the indicated sectors amounted to 0.10 Mtoe (million tonnes of oil equivalent). Within the most important sectors (processing industry, transport and households), energy savings have been achieved during almost the entire period under review. To further increase the level of energy efficiency and the level of savings, increasing knowledge and reducing the lack of information in this regard still play an important role.

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