Implementation of the 2030 sustainable development goals - affordable and clean energy in the European Union

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Abstract. One of the most important goals of the European Union is to provide citizens of the Member States security and stability in fuel and electricity sectors. The United Nations has defined 17 goals and 169 actions to achieve sustainable development of the world. The goals were to improve the quality of life, reduce the level of poverty, inequalities in the world and sustainable development in terms of climate and environmental protection. The article presents an analysis of the implementation of one of the assumed goals, i.e., sustainable development in the field of Affordable and clean Energy in the European Union. This goal is to ensure that every citizen has access to stable, sustainable, and modern energy at an affordable price. Among others, indicators such as energy import dependency, energy productivity, share of renewable energy in gross final energy consumption, final energy consumption in households per capita were analysed. The authors analysed the trends of the above-mentioned indicators in the European Union, with particular emphasis on Poland. In order to be able to predict how the analysed phenomena will develop until 2030, the authors built forecasts. For this purpose, among others, ARIMA models were used. The authors created several dozen models, from among which model with the smallest ex post errors and the lowest value of information criteria were selected. The models allowed to determine the degree of achievement of the set goals. They also allowed the designation of scenarios for the potential development of the analysed indicators.

1. Introduction

The term sustainable development, which appears in the treaties of the European Union, means a combination of economic, political and environmental protection activities aimed at meeting the needs of the citizens of the Union currently and in the future. Sustainable development can be achieved through the appropriate management of the available resources in such a way as to meet the social and economic requirements of the society without adversely affecting the natural environment. As energy generation usually has a negative impact on the state of the environment, it is this issue, among others, that was discussed in The 2030 Agenda for Sustainable Development.

It consists of 17 goals. The goals included in Agenda for Sustainable Development are:

- No poverty
- No hunger
- Good health and well-being
- Quality education
- Gender equality
The European Union places great emphasis on carrying out activities for sustainable development. Therefore, it undertakes a number of activities to ensure this sustainable development. First of all, the goals of sustainable development have been included in the policy and vision of the European Union until 2030 [2]. For the seventh goal, the EU takes measures mainly to increase economic productivity, reduce greenhouse gas emissions, reduce the level of energy consumed, as well as increase the share of renewable energy sources in the energy mixes of the member states. This is reflected in the indicators that Eurostat has adopted to track and monitor the progress of the activities carried out.

This article focuses on the analysis of the seventh of the 17 goals, Affordable and clean Energy in relation to the entire European Union (EU-27). The case of Poland was also discussed in comparison to the EU-27 countries.

For this purpose, the indicators proposed by Eurostat were used. They include:

- **Primary energy consumption** - The indicator measures the total energy needs of a country, excluding any non-energy use of energy carriers. It includes energy consumption by end-users such as industry, transport, households, services and agriculture, plus energy consumption by the energy sector itself for producing and converting energy, losses in energy conversion.

- **Final energy consumption** - the indicator measures energy consumption in Poland excluding all non-energy use of energy carriers. Includes energy used by end-users such as industry, transport, households, services and agriculture; excludes energy consumption by the energy sector itself and losses occurring during energy conversion and distribution.

- **Final energy consumption in households per capita** - it indicates how much electricity and heat is consumed by each inhabitant of the house, excluding energy used for transport. As the indicator refers to final energy consumption, it does not take into account the consumption of the energy sector.

- **Energy productivity** - the indicator measures the amount of economic product that is produced per unit of gross available energy and can cover the entire demand of entities in a given geographical area.

- **Share of renewable energy in gross final energy consumption** - The indicator shows the share of renewable energy consumption in gross final energy consumption. Gross final energy consumption is the energy consumed by end-users as well as grid losses and own consumption of power plants.

- **Energy import dependency** - measures the share of imports in the total energy needs of the country.
• Population unable to keep home adequately warm by poverty status - indicator shows the percentage of the population that is unable to adequately heat their households. Data on this indicator are self-reported by citizens.

• Greenhouse gas emissions intensity of energy consumption (source: EEA and Eurostat) - The indicator is the ratio of energy-related greenhouse gas emissions to gross inland energy consumption. It expresses how many tonnes of CO2 equivalents of greenhouse gases related to energy production are emitted per unit of consumed energy [3].

2. Analysis of the selected indicators

For each of the above-mentioned indicators, a time series analysis has been carried out since 2000. Dependence on energy imports means that the European Union is unable to meet its energy needs on its own. It is therefore necessary to use energy sources from outside the Union. This applies to fossil fuels, i.e. both coal, oil and natural gas. As the economy of the Member States is characterized by too high energy consumption in relation to the possibilities of domestic energy sources, the missing energy is obtained through import. Depending on the energy carrier, the level of addiction varies. In the case of natural gas in the years 2000-2020 for the EU-27 countries, this dependence increased by 24% and in 2020 it amounted to 90%. Norway is the largest gas producer in the EU, and most of the EU’s domestic production comes from its deposits [4, 5]. In Poland, the level of dependence on gas is also increasing, in the analysed period it increased by 17%, and in 2020 it reached 83%. In case of coal, dependence on imports is much lower, but it is also slowly increasing. In 2020, for the EU-27, the dependence on imports was 44% for coal, and 6% in Poland (Figure 1). Although Poland’s dependence on coal imports is seven times lower, at the beginning of the 20th century, Poland was an exporter of this fuel and the ratio was 29% in 2000. In case of crude oil, import is the primary source of this fuel. In the years 2000-2020, there were no significant changes in the level of dependence on oil, it still fluctuates around 100%, both in case of the EU-27 and Poland. The European Union obtains fossil fuels mainly from Russia, and to a lesser extent from other politically unstable countries.

![Figure 1. Energy import dependency own study based on [3]](image)

Increasing energy productivity makes it possible to produce at least the same amount of goods with a lower amount used to produce them energy. Additionally, in case of productivity, organizational changes, such as changing the fuel supplier, are also taken into account. The European Union has set a target related to energy productivity, namely a 30% decrease in energy intensity by 2030. Figure 2 presents energy productivity in the EU-27 countries since 2000. During this time, it increased by 34%.
Annual growth averaged 2%, so if this pace is maintained, the target may be achieved. Although this goal is very ambitious, the EU countries are still motivated to achieve it. It will also enable the reduction of air pollutant emissions, as well as obtaining financial savings. In Poland, compared to the EU-27, energy productivity leaves much to be desired. Despite the upward trend since 2000, it is on average 51% lower than the EU average.

![Figure 2](image.png)

**Figure 2.** Energy productivity own study based on [3]

Renewable energy in the European Union has been developed for many years as shown in Figure 3 [6]. In case of households, renewable energy sources have already made a similar contribution to the production of electricity and heat as fossil fuels. Renewable energy sources are very often used by prosumers, which eliminates the need to create extensive technical infrastructure. These types of installations will facilitate the achievement of the main objectives of the European Union in the field of environmental protection, ensuring access to energy in the right amount and price, and increasing energy productivity [7]. The demand for energy is increasing, and therefore the demand for renewable energy will also increase [8]. Therefore, EU member states must develop the potential of renewable energy sources to meet the needs of citizens. In Poland, the share of renewable energy in gross final energy consumption is lower than the EU-27 average. In the years 2004-2019, this share was lower by an average of 40%. The intensive development of renewable energy in Poland was observed only after Poland joined the EU, while other Member States were already highly involved in this matter.
85% of the energy supplied to households in the European Union is used for the production of heat and water heating. What is left is of course energy used for lighting buildings and powering household appliances. Therefore, the EU puts emphasis on increasing the level of energy efficiency, mainly through thermal modernization of buildings or the use of energy-saving technologies. As shown in Figure 4, in the years 2000-2019 the level of final energy consumption did not change significantly, both in the EU-27 (-5%) and in Poland. (-3%).

Figure 4. Final energy consumption in households per capita own study based on [3]

Figure 5 shows greenhouse gas emissions intensity of energy consumption. Changes in emissions are presented in relation to the base year as 2000. In 2018, there was a decrease by 25% and 22% in emissions for EU-27 and Poland, respectively. The decrease was achieved mainly due to the reduction in the share of hard coal in electricity production, an increase in the share of gas-fired power plants.
and the use of renewable energy sources. In comparison to other EU countries, Poland produces much more greenhouse gases. The main sources of their creation are power engineering and transport.

![Figure 5](image1)

**Figure 5.** Greenhouse gas emissions intensity of energy consumption own study based on [3]

Final energy in the European Union is used primarily for heating buildings, industry and transport. Energy consumption, despite the development of industry, the growing number of machines and devices requiring power, remained at a constant level in the years 2000-2019 as shown in Figure 6 [9]. This was possible mainly due to the increase in energy efficiency. The decrease in energy consumption was also recorded in connection with the economic crisis in 2007-2009. In Poland, energy consumption continues to grow and increased by 30% during the analysed period.

![Figure 6](image2)

**Figure 6.** Final energy consumption own study based on [3]
3. Results and discussions

The ratios presented above were used to determine the Compound Annual Growth Rate (CAGR):

\[
CAGR = \left( \frac{y_t}{y_{t_0}} \right)^{\frac{1}{t-t_0}} - 1
\]

where:

\( t \) – most recent year,

\( y_t \) – value of the analysed variable in base year,

\( y_{t_0} \) – value of the analysed variable in most recent year,

\( t_0 \) – base year.

The indicator was calculated according to the Eurostat methodology for the EU-27 countries. The results are presented in Table 1. The result is also marked with a graphic symbol (an arrow). The last column additionally specifies the nature of the indicator for each of the variables. It has been taken into account whether the indicator is a stimulant or a destimulant. The CAGR indicator determined by the authors is a long-term indicator, because 2005 was adopted as the base year. The indicator determines the rate at which the examined variable will grow in a given period each year. For energy productivity and share of renewable energy in gross final energy consumption, the CAGR is above 1%. Both factors act as stimulants, which means that their increase is a positive phenomenon. Energy import dependency is also increasing, but at a slower pace.

However, the increase in this indicator is negative. Indicators for final energy consumption in households per capita, final energy consumption and greenhouse gas emissions intensity of energy consumption are less than 0. Due to the fact that these variables are a destimulant, their decrease is a positive phenomenon. In the last column of the table 1, the nature of the variable was defined and scores were assigned on a scale from -2 to 2. The maximum Ch can reach the value of 12, in the analysed example it is 6, i.e. 50%. A similar analysis was also carried out for Poland. It should be noted that the CAGR index for Poland takes very similar values for energy productivity. Final energy consumption in households per capita, Share of renewable energy in gross final energy consumption, Greenhouse gas emissions intensity of energy consumption. The most significant difference appears in the case of the CAGR indicator for Energy import dependency. For Poland, it is 20 times greater. This is, of course, a disadvantage. Also in the case of Final energy consumption for Poland and the EU-27 countries, the indicators differ significantly. For Poland, the CAGR is 1.39, which means that energy consumption increases annually by less than 1.5%. The Ch index also reaches the value of 50%, as in the case of the EU-27 countries.

| Indicator                        | CAGR (%) | Symbol | Charakter (Ch) |
|----------------------------------|----------|--------|----------------|
| Energy import dependency         | 0.35     | 📈     | - (-1)         |
| Energy productivity              | 2        | 📈     | ++ (+2)        |
| Final energy consumption in      | -0.78    | 📈     | + (+1)         |
| households per capita            |          |        |                |

Table 1. CAGR values for EU-27
The only factor that characterizes the negative value of the Ch indicator is the energy import dependency. Therefore, it is for this indicator that the forecast until 2030 was made. The forecast horizon is distant, but this is the year in which the goals of The 2030 Agenda For Sustainable Development are to be achieved. In order to make the forecast, the ARIMA model (0,2,1) as shown in Figure 7 was used [10, 11, 12]. The ex post model error (MAPE) is only 1.78% and can therefore be considered highly accurate. The forecast shows an upward trend. Compared to 2019, the energy import dependency is expected to increase by 25% in 2030. If no measures are taken to change the trend of import dependence, this situation may seriously threaten the energy security of the European Union. It is similar in Poland, but the increase in dependence is even faster. In the same period, according to the forecast made, it will increase by 47%. The determined confidence interval determines the scenarios of the possible development of the phenomenon in the future. This means that with 95% probability the level of dependence on energy imports may move within the range determined by the confidence interval.

![Figure 7. Forecast of EU-27 dependence on energy imports by 2030](image)

4. Conclusions

Sustainable development in the field of clean and affordable energy means, above all, the development of tools enabling the citizens of the European Union to receive energy in the required quantity, time and price. These tools, however, must meet additional criteria, that is, energy generation must not have a negative impact on the natural environment.

In order to achieve this goal, the policy of the European Union takes into account the need to modify the energy mix, increasing the share of renewable energy sources. It will also help to reduce greenhouse gas emissions. The introduction of these changes will also have a positive impact on the
development of the society of the Member States. In order to measure the progress in achieving the set goals, indicators enabling their verification were adopted. The study analyses the indicators selected by Eurostat for the purpose of producing clean and available energy. The authors analysed the condition of the Compound Annual Growth Rate (CAGR) for the EU-27 countries, with particular emphasis on Poland. The conducted analysis allowed for the following conclusions:

- The main problem that adversely affects the implementation of the seventh goal is the growing dependence on energy imports. The EU's dependence on coal, oil and gas from third countries is increasing.
- The achievement of this goal is positively influenced by the increase in energy productivity, which, first of all, allows to reduce the demand for energy carriers even with constant demand for it, and also allows to reduce the negative impact of energy on the environment.
- The upward trend in the share of renewable energy sources in the energy mix is also beneficial. This energy is generated in the territory of the EU, which makes it possible to increase the level of energy security in the EU.
- The CAGR indicator therefore showed that the European Union should, above all, take specific measures to find alternative energy sources that could take a significant position in the energy bowl. The solution would also be to develop effective and economical methods of generating energy based on coal, whose significant resources are located in the geographical area of the EU, for example in Poland or Spain. As a result, the Member States would become independent in terms of energy from the import of carriers, mainly Russia. It is also necessary to continue increasing the level of diversification of energy sources and increasing the potential of renewable energy sources.

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