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The Baltic Ring and BEMIP initiatives and their role in the energy security of Baltic states

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Abstract: The following paper treats about the initiatives of Baltic Ring and the Baltic Energy Market Interconnection Plan (BEMIP). Their main purpose is to integrate the electric grid in the states located at the Baltic coast and to eliminate barriers in transmission of electricity between them. This goal is notably difficult to achieve because of three different systems of grid functioning in the Baltic region – the Nordel system connecting Norway, Sweden and Finland, the IPS/UPS system common for all the post-soviet countries including Russia, Belarus, Lithuania, Latvia and Estonia, and the European system used by most countries of European Union. While the Baltic Ring at the moment of its creation was meant to be a plane for cooperation around the coastline of Baltic Sea, its noble objectives did not survive in the XXI century. The new incarnation of Baltic Ring, called Baltic Energy Market Interconnection Plan, does not even declare any will to cooperate with Russia nor Belarus. Its far-reaching goal is to desynchronize the electric grid of Baltic states with the IPS/UPS system and to connect them with the continental Europe. This plan is strongly supported by European Union and criticized by Russia. The main purpose of the following paper is to define the role of the European Union's energy policy in relations between Russia and the Baltic states. The European strategy for limiting Russia's influence is clearly visible in the area of electricity transmission. The Baltic states remain the most sensitive EU countries affected by that kind of influence, so that the BEMIP plan is focused mainly on enhancing their energy security.
Key words: Baltic Ring, energy security of Baltic states

Energy security issues in the context of Baltic states

The definition of energy security is not unanimously accepted by scholars. This situation is caused mostly by differences in defining "security", commonly understood as the freedom from threats. The scientific meaning of security and national security vary between research streams. For realists, the national security is identical to national interest and it may be defined by possessing resources to build a military power of the state, operating in the world of anarchy. Liberalist tradition provides the concept of international society and pays attention to bring the institutional stabilization in order to gain national security. For constructivists, the state's security is based mostly on the intersubjective perception of what the threat is (Degaut 2015).

The energy security concept is a derivative of national security and it also does not have one, commonly accepted meaning. However, most of energy security definitions include the notion of stability, which is the most desirable situation. Energy sector is crucial for the economy of the state as a whole, so that the continuity of energy supply covering the national demand is necessary to achieve, regardless of costs and financial profitability (Månberger, Johansson, Nilsson 2014).

As it was mentioned in the abstract, the Baltic states have their electric grid connected to the post-Soviet IPS/UPS system administered in Russia. This makes their foundations of energy security dependent on decisions made in another country. The state of affairs when a part of European Union's common market is such vulnerable of any external disruption is unacceptable for the EU authorities. The current realisation BEMIP plan is an European response for these uncomfortable circumstances.

Establishing of BALTREL Committee

The Baltic Ring initiative was started in 1998 with special financial support from World Bank and Scandinavian countries, and also the political backing in the European Union. Inauguration was held by 17 big electric companies representing 11 states, becoming members of the new body named BALTREL (full name: The Baltic Ring Electricity Co-operation Committee). The list of founder states includes all the ones with coastline on Baltic Sea – Norway, Sweden, Finland, Russia, Estonia, Latvia, Lithuania, Poland, Germany and Denmark, and also Belarus as an important part of post-soviet grid system in the Baltic area called BRELL (from the first letters of countries: Belarus, Russia, Estonia, Latvia, Lithuania). The most important common interest was to reduce the environmental and financial costs of energy transition and boost regional integration in the spirit of shared responsibility for overall economic good (ABB Review 2001).

At that time all sides were interested in economic cooperation. BALTREL was meant to integrate the electric grid between Russia with post-soviet area and the so-called Western countries. Baltic states were about to turn into a big energy transmission hub between the three systems. Especially Russia was interested to gain new possibilities of electricity exports (Zverev 2013). Moreover, European Union was also interested in diversification of energy supplies.

The BALTREL committee published its main objective in its Position Papers in July 2002. This publication states that the liberalisation of energy market is the key point for the Baltic Ring initiative. Authors criticize the monopolistic nature of electricity sector and see deregulation and competition as a necessity for the further unification. According to the paper, electric grid in all of the member states of Baltic Ring should be totally unbundled from states regulation and independent from any political pressure (Baltrel Position Papers, 2002).

European Commission and its policy towards the Baltic Ring

In the beginning of XXI century, Lithuanian, Latvian and Estonian grid was fully dependent on the stability of the whole IPS/UPS system administered in Moscow. There were basically two types of electric lines – the 330kV and the 750kV networks, forming together a huge ring connecting Moscow, Smolensk (Russia), Belarus, Yantarenergo (Russia), Lithuania, Latvia, Estonia, Pskov (Russia), St Petersburg and again Moscow. Any disturbance in this ring could have caused disconnections in the whole system (Sauhats, Svalovs, Svalova 2003). This state of affairs was inconvenient especially for the Baltic states with modest amount of energy resources.

Nevertheless, geopolitical changes were about to come. In 2004 Lithuania, Latvia and Estonia joined European Union and NATO at the same time, clearly designating the direction of their policy. Also Russia was no longer ruled by the liberal and conciliatory Yeltsin administration, with Vladimir Putin as a new, strong leader with new vision of foreign policy. At that point Lithuania, Latvia and Estonia became a part of the European common market, which is one of the most important principles of EU. At the same time they became an only energy island in the EU, technically dependent on the external system administered by a non-EU power.

European Commission was never under any illusions about the free market of electricity and overall energy. Its publications and official stand shows awareness of the geo-political issues of this sector of economy. The official scientific paper of EC claims that the Baltic states have no need to be interconnected with Russia and Belarus because their dependence on electricity imports from Russia is not very high, however their grid should not operate as an "island" between the Russian and European network. Being dependent from Russia is clearly shown as a dangerous situation that should be changed in becoming decades (JRC Report 2016: 2).

Independence from the IPS/UPS system is believed to be the best projected scenario for the Baltic states in 2050. Estonia with its strong local energy production from fossil fuels is in the best position to gain this result. Also Latvia with advanced renewable energy production would probably be capable of supplying its electricity demand by itself. Lithuania would face the most problematic situation with big growth of energy demand and no nuclear plants nor domestic fossil fuels resources (JRC Report 2016: 14). So that, EC has decided to support the Baltic Ring initiative mostly for the Lithuanian interconnections – LitPol between Lithuania and Poland, and Nordbalt between Lithuania and Sweden. The European Commissioner for Climate Action and Energy, Miguel Arias Cañete, officially declared that there is no place for "energy islands" in European Union and the Baltic states have to be connected with the continental European network (European Commission Energy News 2015).

As it is officially stated by European Commission, the Baltic Ring initiative is not for improving the exchange of electricity between EU and Russia, but rather for the progressive and consequent detachment of the Baltic states from the BRELL area. In case of success, the Baltic states would be dependent on local production of electricity or imports from European Union, with no need to import electricity from Russia or Belarus. In 2021 this goal is still seen as ambitious and long-term project, however it is consequently continued. Nowadays, relations between Russia and European Union are harsh enough to declare it clearly as a project connecting the Baltic states to the Continental European Network. The latest declaration was signed in 2018 by European Commission president and the prime ministers of Poland and three Baltic states (European Commission, 2018).

ENTSO-E and the Baltic Energy Market Interconnection Plan

ENTSO-E (European Network of Transmission System Operators for Electricity) is an European organization established in 2008 by 42 transmission network operators from 35 countries. The main declared goals of ENTSO-E are to make continental Europe the first place of climate-neutral energy production, and also to provide sustainable, well-secured and interconnected system of electricity supply (ENTSO-E Objectives, Official Website). Especially the interconnection is important in the context of Baltic Ring initiative.

The organization of ENTSO-E is not strictly limited to the European Union countries. It has got members also in the other European countries, just like Albania, Bosnia and Herzegovina, Montenegro, North Macedonia, Iceland, Serbia and Switzerland, however actually there is no place for Belarus nor Russia in it, while the three Baltic states are included (ENTSO-E Member List, Official Website). This observation can lead to conclusion that the IPS/UPS system is not expected to become a part of interconnected system of electricity production. Operators of Lithuania, Latvia and Estonia clearly declared their goal by joining the organization of continental European electricity interconnection.

The insight report of ENTSO-E from 2016 indicates that this state of affairs is not accidental. The desynchronization of Baltic states with IPS/UPS system is one of the most important aims of the organization. With support of European Commission and the prime ministers of Baltic States, ENTSO-E created the Baltic Energy Market Interconnection Plan (BEMIP) and finally launched it in 2009. Furthermore, a new declaration from 2015 signed by the governments of Baltic states confirms the objective of desynchronization with BRELL countries, and also expresses their will of implementing the European Energy Security Strategy (ENTSO-E Report from 2016).

The synchronization of European grid is not only a subject of political and business declarations, but is also a part of the Acquis Communautaire. The regulations for cross-border electric network synchronization, named the Network Codes, were mentioned in the Regulation of the European Parliament and of the Council of 13 July 2009. Their main purpose was to create a plane for consultations between European authorities and the transmission system operators associated in ENTSO-E in the joint planning of the legal framework of electricity flows (Regulation (EC) No 714/2009: Article 6). The Regulation of 2009 was replaced in 2019 by the new one, confirming that the cross-border electricity transmission falls within the competence of the European Union, and also that the ENTSO-E is the most important agency in the decision-making process (Regulation (EU) 2019/943: point (42)).

The BEMIP initiative may be recognized as a successor to the Baltic Ring, but without the declared aims of cooperation with Russia and establishing the free energy market. The new plan stands unequivocally against the Russian interests in region, and it arouses enthusiastic reception in the Baltic states. However, the BEMIP goal is very far-reaching and difficult to achieve. Most of the Baltic states, excluding Estonia, have relatively weak domestic energy production sector and they are still very much reliant on the Russian fossil fuels supplies. Especially Lithuanian energy sector is in a poor condition and high level of dependence on electricity produced abroad. Lithuanian publishers are aware of this state of affairs and argue that European Commission should put bigger efforts to support their country in the process of reducing its dependence on Russia. Irma Paceviciute emphasizes that the initiative of BEMIP is nearly fully dependent on external sources of financing. The state of Lithuania has already borne the costs of building the LNG terminal on the Baltic Sea and the short-term financial benefits of this project are less than expected. If Lithuanian taxpayers paid for another far-reaching strategic project with no quick payback, they would probably express their dissatisfaction (Paceviciute 2017).

The most important issue for success of the BEMIP is the Lithuanian atomic energy. The Lithuanian Ministry of Foreign Affairs in its official publication for OSCE (Organization for Security and Cooperation in Europe) stands that there is no possibility to achieve the goals of BEMIP without reactivating of Lithuanian nuclear power plant. What is more, such a project would need a massive investment for adjusting the reactor to nuclear safety requirements, demanding a significant amount of money (Naudužas 2010). Nonetheless, the European Union has already allocated a big financial support for Lithuania in progress of decommissioning the Ignalina power plant, including the dismantling of turbines and support for the personnel. The common objectives of EU and Euratom for Ignalina, Bohunice (Slovakia) and Kozloduy (Bulgaria) nuclear reactors are to liquidate them completely. (European Court of Auditors 2016:

16). Planned budget for this project is at least 5,7 billion euro with possibility to even double this amount (ECA 2016: 72).

The common memorandum of the EU countries from Baltic Sea region, including the BEMIP countries and European Commission, Denmark, Germany, Poland, Finland and Sweden, was signed in 2015. Provisions of this document express the acceptation from European Union to build the new and safe nuclear reactors in the Baltic states and the Baltic Sea region as a whole. On the other hand, the closed reactors just like the Lithuanian Ignalina plant are not planned to operate anymore. The paper includes also a declaration of enhancing the renewable energy sector, nonetheless all the agreements in this area are stated to be voluntary and taking into account the actual capability of electric grid (European Commission Memorandum, 2015). In place of Ignalina old plant, it is planned to build a new reactor in Visaginas. There is a strong support for this idea in Lithuania but creating and implementing the project of financing and sustainable business model appeared to be harder than expected. Visaginas was projected to start operating in 2018-2020 (Grinevičius, Klevinskas, Koraliovas, 2009), however this objective is still far from realization.

The plan of desynchronisation of the Baltic states with the IPS/UPS transmission system is clearly expressed. It also corresponds with the financial and political support for them in providing the energy supply from non-Russian sources, such as the ongoing liquid gas transportation by sea or the planned construction of Lithuanian nuclear power plant. Those initiatives are not foreseen to be profitable. The lack of profits from investments held partially by taxpayers in the Baltic states, especially in the short-term perspective, causes mixed reviews of their policy. Maintaining the current situation of dependence would be much less expensive. However, the undisturbed energy supplies with no concern of external interference are seen as a priority by the Baltic states and the European Union authorities. This observations lead to the conclusion that the economic reasonability is secondary to the main goals of energy security.

Russian perspective of Baltic Ring evolution

The Russian representatives took part in establishing of BALTREL. In the late 90s Russia under Boris Yeltsin rule was suffering from a disastrous economic and socio-political crisis. However, the Russian foreign policy was far more conciliatory than nowadays. The most significant example of this state of affairs was the green light given by Boris Yeltsin for Poland to join NATO in 1993 during his official visit in Warsaw (Milano 1998). The Baltic Ring initiative was expected to bring advantages for everyone at that time.

Since the BALTREL establishment everything changed. The new Russian president, Vladimir Putin, has took up a different strategy in relations with NATO and European Union. Russian relations with Baltic states were very difficult. Until the collapse of Soviet Union, most of the Russian energy transit infrastructure was located in Lithuania, Latvia and Estonia, so that after 1991 Russia was made to pay for exporting energy through its own installations. Putin as a president has put efforts to change this, and the Baltic Ring was seen as an opportunity to do it. In 2001, Russia signed an agreement with Baltic states about using the IPS/UPS grid system administered in Moscow. This agreement improved the Kaliningrad region security because all the connections between central Russia and Kaliningrad were officially linked through Belarus and Lithuania, using the same IPS/UPS system (Korovina 2013: 39).

The European Union's plans were slightly different from that. As mentioned above, European Commission was never interested in a free exchange of electricity with external entities, especially those with dangerous political ambitions. Baltic states are still the main point of interest but their planned role has changed from hub to a kind of buffer zone, isolating the European electricity market from Russian influence. This turn in the Baltic Ring is strongly criticized in Russia where it is seen as a geopolitical game of European Union (Zverev 2013).

Since the collapse of Soviet Union, energy exports were among the most important instruments of Russian foreign policy. Most of the soft-power and hard-power tactics of Russian diplomacy are focused on influencing the energy sector of neighbouring countries. Cutting of the supplies in order to punish a country occurred many times before, e.g. in 2007 for Mažeikiu Nafta (LT) because of signing a deal with Polish company PKN Orlen instead of Russian Lukoil, or the same year in Estonia in response to tearing down the monument memorizing the so-called "liberation" of Estonia by Soviet Union during World War II (Hanson 2013). Harming the continuity of supplies of energy sources is a substantial part of Russian range of tactics. The new incarnation of Baltic Ring, called the BEMIP, is an European response to this state of affairs. The BEMIP is limited to the electric grid operating, however there are more initiatives in the area of Baltic energy security, just like building of LNG sea imports terminal in Klaipeda (Lithuania).

According to the publications of the Russian origin, the evolution from previous ideas od Baltic Ring to the BEMIP is a negative development. I. Zeleneva states that the Baltics have to choose one of two possibilities – to be a buffer zone for the West or to be a bridge between East and West. The original project of Baltic Ring is seen as a constructive idea of integration, while the latest actions of the Baltic states tend to be more anti-Russian. The Russian solution of this dissatisfying state of affairs is turning the Baltics into "energy bridges" with strictly transit role for energy trade between Russia and European Union. Zeleneva mentions also that building the nuclear power plants in the Baltic states in frames of the Baltic Ring is consistent with Russian national interests (Zeleneva 2013). The growing securitization of European energy market is perceived by Russian authorities as one of the biggest threats (Romanova: 136).

Conclusion

The BEMIP is recognized as a far-reaching strategic project with impact on entire European Union's energy security. It may also be found as an anti-Russian initiative. However, the EU policy towards Russia is not that unambiguously hostile in energy sector as a whole. Full implementation of the BEMIP would mean *de facto* detachment of Russian electric grid in the EU but at the same time occurs an opposite process in the fossil fuels sector. The pipelines of Nord Stream and Nord Stream 2 have support from the European Commission, despite of their negative influence on energy security of Baltic states and Poland. The Baltic Ring and BEMIP plans are only a part of the bigger strategy of European Union as a whole. Sustainable and ongoing supplies of Russian natural gas are even more important for the EU than eventual worsening of Baltics energy security. The Russian Gazprom company has got partnership agreements with the biggest gas companies in Europe, just like ENI, Total, EON Ruhrgas and Wintershall (Salaude 2018).

The European energy policy is multi-faceted. The Baltic Ring/BEMIP projects which are beneficial for the Baltic states do not negate the effective Russian-EU cooperation in another branches of energy sector with detriment for the Baltic national interests. Nevertheless, the state of affairs could only get worse without the European Commission support. If EC did not help with financing of the BEMIP and the other projects in energy sector, the Baltic states would be unable to obtain even partial independence from Russian energy and electric grid.

It is hard to project the future of the Baltic Ring/BEMIP initiatives. The SARS-CoV-2 pandemic outbreak and post-pandemic crisis may cause far-reaching changes in political decisions, especially in matter of financing large infrastructural projects. Energy as a whole sector of economy constantly experiences new shocks, mostly caused by the petroleum price fluctuations. Both European Union and Russia will probably suffer negative effects of the pandemic. However, perception of political goals and efforts from both sides to obtain energy security are not likely to change rapidly.

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The distributed energy sector in Poland - current status, challenges, barriers, and the Danish experience

Karol Tałan

Abstract: The article presents the current state of distributed energy in Poland, with particular emphasis on the energy transition plans, analyzing the document Polish Energy Policy until 2040 (PEP2040). Additionally, describes three types of entities: prosumers, energy clusters and energy cooperatives. The author explains their current status, funding sources and barriers. The second part of the publication presents the author's reflections on the problems and challenges related to the development of biogas and wind energy. Additionally, the author focuses on the impact of distributed generation on the power system. Social and local governmental aspects are also presented. In the third part, the author presents the Danish experience in the development of renewable energy sources and distributed generation. The author presents two examples of solutions: a civic foundation in Hvide Sande and a district heating company in Gram. Conclusions of the article includes the proposal of changes to the legislative system that will enable further RES development. In addition, the author draws attention to the impact of the Mój Prąd programme, responsible for the high growth of installed capacity.
Key words: decarbonization, distributed energy, PEP2040

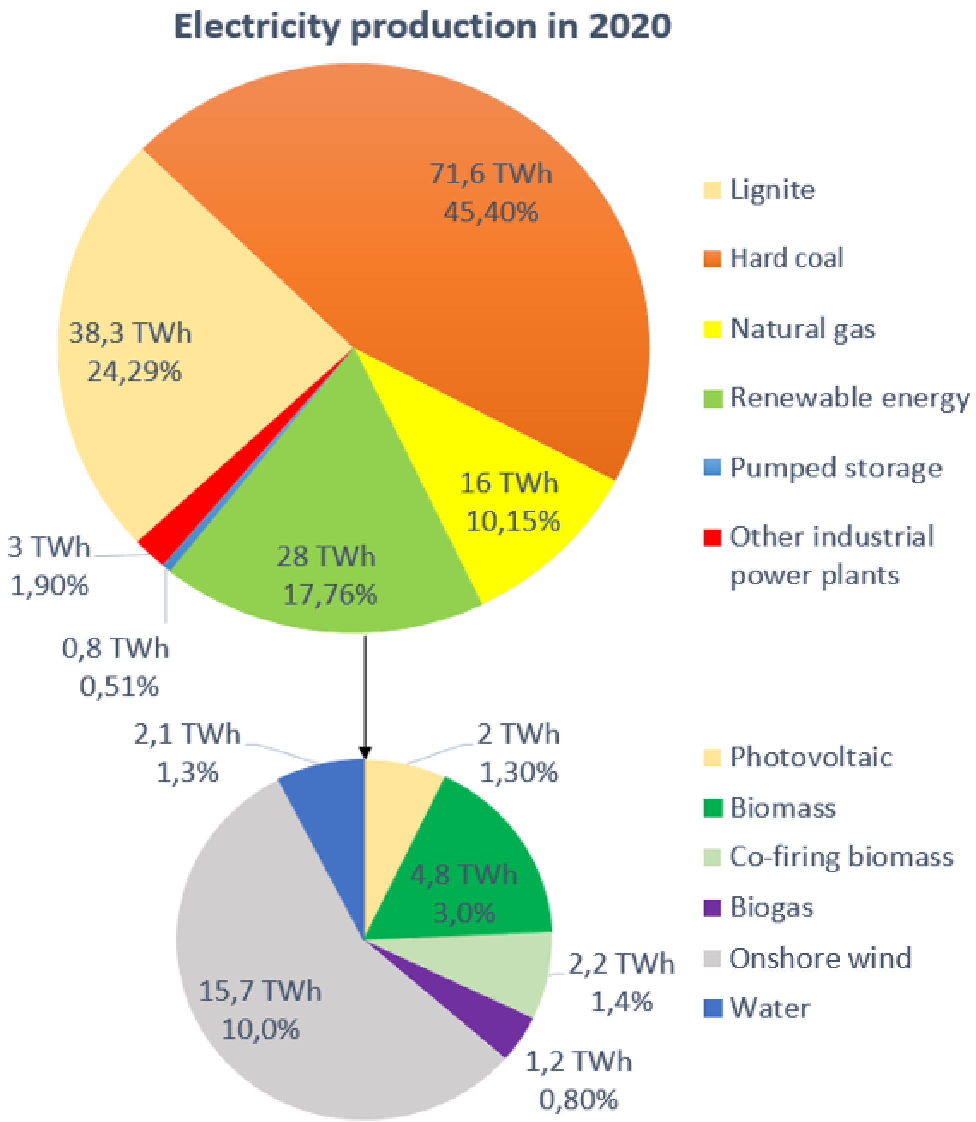
1.0 Introduction

In connection with international involvement in mitigating the effects of climate change, necessary steps are being taken, including measures to reduce fossil fuel consumption and greenhouse gas emissions. In the case of Poland, all actions require adjustment of the country's climate and energy policy to the requirements of the European Union (EC, 2019), which plans to create an energy union system containing a common energy market for all EU entities.

1.1 The state of the power industry in Poland

Poland's current energy mix is still based on outdated coal-fired power stations, the average age of which in Poland is 47 years. There is no doubt that this information indicates a requirement to shut down these units for technical reasons or to carry out uneconomic modernizations of the units (Tygodnik, 2021). Referring to the data (Jędra, 2021) of 2020, it can be seen that the COVID-19 pandemic has left a significant mark on past power sector performance. There has been a significant decline in coal-fired power generation, with its share falling below 70% to 69.7% for the first time in Poland's history (figure 1), despite the introduction of new coal-fired capacity into the system. In addition, the new commissioning of gas-fired units and the decline in electricity demand have contributed to this. In addition, the weakening competitiveness of power generation in domestic units and the impact of cheap energy imports with the development of renewable energy.

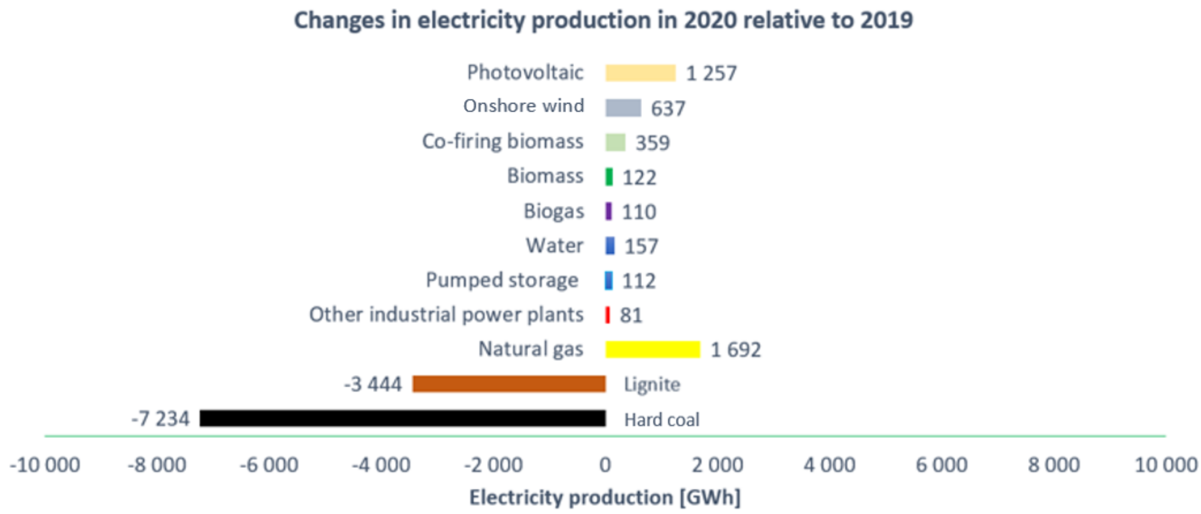
Figure 1. Electricity production in 2020



Source: Own elaboration based on: (Jędra, 2021)

Analyzing the data summarized in figure 2, it can be seen that the most dynamically developing source of electricity was photovoltaics, which increased the amount of electricity produced by 3.5 times compared to 2019. In addition, there was an increase in energy volumes from onshore wind power and natural gas, which according to the Polish Energy Policy until 2040 (PEP 2040) is to be a transitional fuel in Poland's energy transition. Referring to this document, it can be said that it provides an important roadmap for the development of Poland's electricity sector.

Figure 2. Changes in electricity production in 2020 relative to 2019



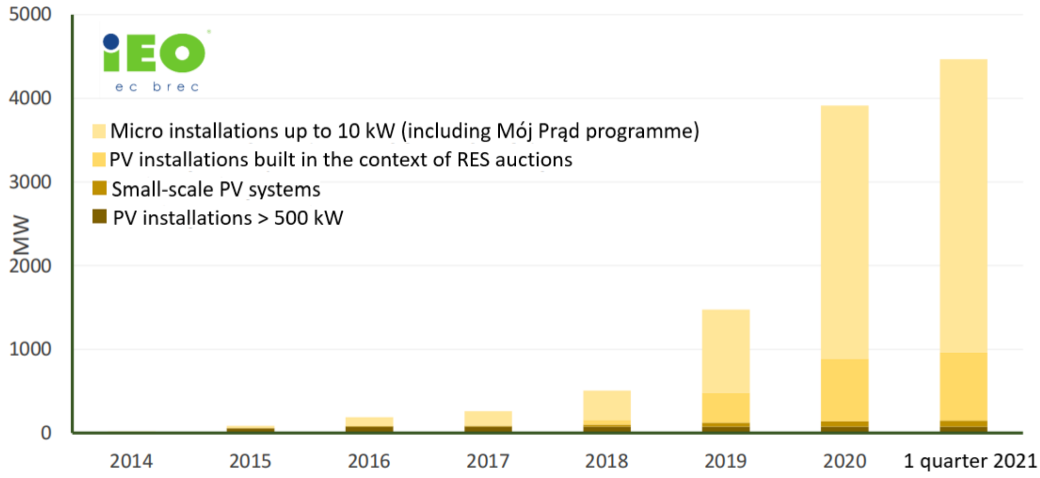
Source: Own elaboration based on: (Jędra, 2021)

Through ambitious plans, PEP 2040 assumes a sharp increase in the share of renewable energy sources in the total generation system. It is estimated to achieve around 40% of renewables in the electricity sector in 2040 (PEP 2040). Currently, referring to the data of the Energy Market Agency (ARE, 2021) in the period January-May 2021, more than 17.96% of energy came from RES. Additionally, it is expected that from 2030 1/3 of MWh generated on Polish territory will come from RES (Kurtyka, 2021). The PEP 2040 document assumes that the above-mentioned targets will be achieved through the development of offshore wind farms on the Baltic Sea reaching a total installed capacity of 11 GW by 2040 and increasing onshore capacity volumes, the construction of nuclear energy reaching 6 to 9 GW and photovoltaic investments yielding 10 to 16 GW within two decades. In addition, the biogas and biomethane sector is to be an important focus of the energy transition. The development of micro-cogeneration biogas and biomethane plants is planned, which will enable, among other things, the greening of natural gas by injecting the methane produced in this technology into the national distribution network and the development of bioLNG and bioCNG as alternative fuels for transport. The significant development of other revolutionary low and zero carbon technologies such as heat pumps, hydrogen, electromobility and energy storage should also take note.

There is no doubt that the development of renewable energy sources is an opportunity to create an electricity system with a completely different, decentralized model. The increasing prices of CO2 emission rights, which currently oscillate within the range of 53-55 EUR/tonne (CIRE,2021), impose ever-increasing costs on electricity, hitting industry and household end users. Prices in the future will also be driven by the implementation of the 'Fit for 55' package by the European Commission, which assumes, e.g. gradual inclusion of the transport and construction sectors in the EU-ETS emission trading scheme, or amendment to the RES Directive (the so-called RED II), planning to increase the share of renewable energy in the energy mix in 2030 from 32% to probably ca. 40% (Europarl, 2021). To align to this, Poland should strive to create an optimized system by creating socially acceptable prices. Therefore, one of the megatrends related to the energy of the future is the reliance on low-carbon stabilized distributed generation units of RES, which will form self-balancing energy areas.

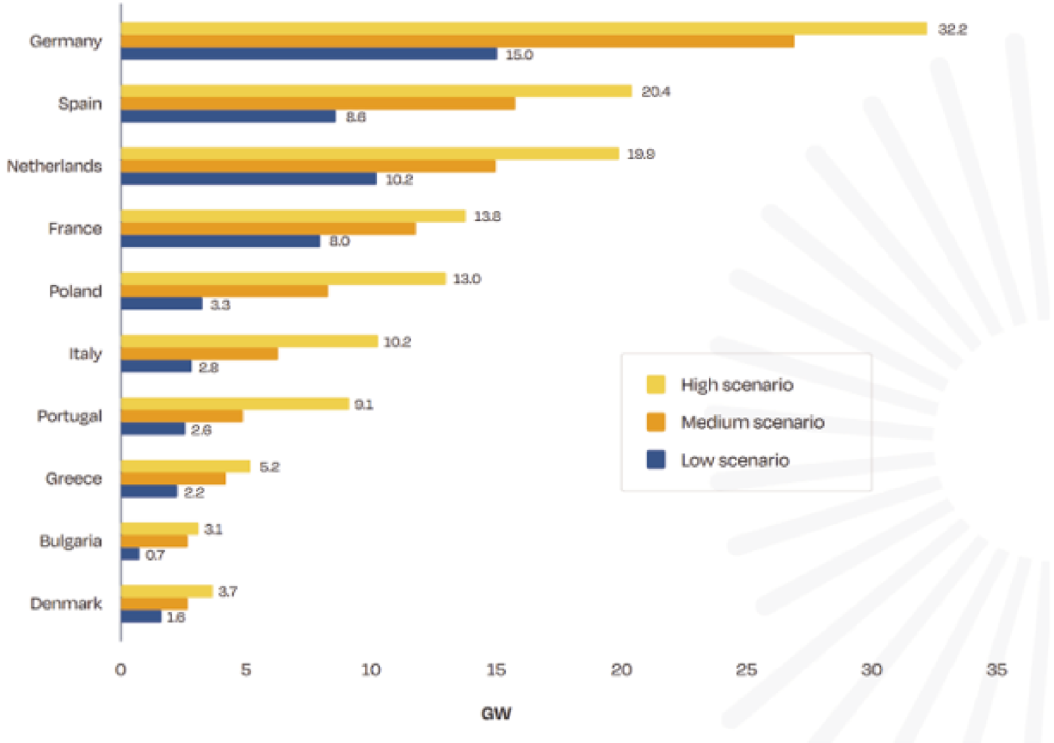
PEP 2040 assumes activation of this area of power industry by creating up to 300 collective entities called energy communities by 2030, including energy clusters and energy cooperatives. Additionally, the goal is to develop the prosumer movement, which is to form the backbone of the civic energy sector by generating 1 million prosumers by 2030. The progressive change of the generation model from coal-centralized to decentralized, i.e. distributed, in the future may bring many positive aspects. Apart from the fact of creating a certain self-balancing, stable energy area along with a reduction in electricity prices, there is also the activation of local communities with their energy potential. In addition, it will enable to relieve the pressure on the National Power System and increase the competitiveness of local enterprises and industry by bringing them together in these areas, enabling the creation of synergies. Additionally, it will improve air quality and reduce the demand for electricity, which is observed in the summer (Mataczyńska & Kucharska, 2020). A particularly important element of support for distributed energy is the development of photovoltaics, which has become a kind of "game changer" of the prosumer movement, mainly due to the government programme Mój Prad (GOV, 2021). This programme supports citizens by allowing co-financing of investments connected with installation of domestic photovoltaic installations. Currently, referring to ARE data, at the end of May 2021 the number of prosumers amounted to over 560 thousand, generating an installed capacity of 4 973 MW (ARE, 2021). The historical growth of photovoltaic installations in Poland can be seen in (figure 3) which, shows that over the past 7 years.

Figure 3. The cumulative installed capacity in Poland for successive years, distinguishing between installation types. (Rynek Fotowoltaiki w Polsce, 2021).



Poland has been ranked first in the EU, with a cumulative growth rate of 114% (EU average is 10.3%). Data (Solar Power Europe, 2020) shows that Poland is ranked 4th in the European Union in terms of installed PV capacity (figure 4). This was mainly due to individual prosumers, which confirms the high potential and strength and position of the Polish photovoltaic market (Rynek Fotowoltaiki w Polsce, 2021).

Figure 4. Three-year forecast of added PV capacity for the 10 largest EU markets in 2021-2024 (Solar Power Europe 2020).



1.2 The state of prosumers, energy clusters and energy cooperatives

In Poland there are currently 66 collective entities acting as energy communities as energy clusters. Energy clusters can be understood as a civil law agreement that may include natural persons, legal persons, scientific entities, research institutes or local government units, concerning the generation and balancing of demand, distribution or trade in energy from RES or from other sources or fuels, within a distribution network with a voltage rating lower than 110 kV, in the area where the cluster operates not exceeding the borders of one county or 5 municipalities. The main objectives of clusters are: providing energy security, especially within local borders; improving the environment; and enhancing the competitiveness of businesses operating within them. Agreements of this type have a direct impact on increasing the energy efficiency of the local, and indirectly also the national energy system. Moreover, they create self-sufficient and self-balancing electricity areas, reduce energy prices, relieve the budgets of local governments and inhabitants living within their scope, create new jobs and contribute to the expansion of the RES share in national energy consumption by using the local potential of the regions covered by the agreement (Siudek & Klepacka, 2020).

Unfortunately, in the case of energy cooperatives, there is only one located in Raszyn, Mazowieckie voivodeship (GlobEnergia, 2021). Energy cooperatives are very similar structures to clusters. The purpose of their existence is to produce energy for their own use and in case of overproduction to sell it back to the national grid system. They have legal personality and are established to carry out economic activities. Very importantly, they primarily use RES. Energy generation inside such institutions is limited depending on the type of energy and is 10 MW for electricity and 30 MW for heat (KOWR, 2021).

Apart from the highly active development of the prosumer movement, it is in the area of collective entities that barriers to the implementation of distributed energy are encountered. The main problem of development is the failure to adapt legal regulations to European requirements in the field of distributed energy. In the case of energy cooperatives there is a kind of paradox. This entity, having a comprehensive legal regulation, i.e. a support mechanism eliminating the distribution fee, allowed the creation of only one such entity, where in the case of energy clusters, despite the lack of support mechanisms, over 60 entities were created. In addition, the problem is the statutory requirement to install sufficient RES capacity to ensure demand for no less than 70% of the cooperative's and its members' needs. The result of this provision is increased financial outlays already at the initial stage of investment implementation, even before the cooperative is transformed into an energy entity. Another barrier is the prosumer model of the support system, which gives the possibility to give surplus energy to a virtual power plant in the distribution network, which can be received at a ratio of 1:0.6 in net-metering system. The net-metering it is the accounting of the electricity produced from the PV installation with the electricity consumed during the billing period - kWh produced for kWh consumed (Górnowicz & Castro, 2020). This system makes it impossible for the entity to sell electricity, which discourages potential investors. At the same time, the very system of settlements between the cooperative and the obliged seller is complicated and, through the lack of appropriate procedures and regulations governing this aspect, effectively discourages future owners of the entity (Marzec, 2021). An additional problem is the requirement for a limit of 1,000 members of a given energy cooperative and the limitation of capacity to 10 MW. Moreover, there is no extension of this model to urban areas, which is quite a popular practice e.g. in Denmark (Mizieliński, 2019). It is worth noting that in these areas there are housing communities with fairly large free spaces where photovoltaic façade systems (building integrated photovoltaics, BIPV) can be installed, which are becoming increasingly popular. This will reduce the rising costs of electricity and heat for housing associations and communities (Agathokleous et. all, 2018). Information (Energetyka24, 2021) gives hope for an improvement of the current situation. At the end of July 2021, a draft amendment to the Law on Renewable Energy Sources was submitted to the Polish Parliament, which assumes, among other things, the abolition of the power limit, the extension of cooperatives' activities to urban areas and the possibility to store and sell energy, provided that this is not the main focus of the entity. These measures give hope for an acceleration of the energy transition, but the assumed amendment of the law will have to wait.

Returning to the subject of barriers and the number of 66 energy clusters without support mechanisms in place, it should be mentioned that this procedure took place in connection with two editions of a competition that gave interested parties the opportunity to obtain certificates. The Ministry of Energy at that time, when deciding on this step, guaranteed priority in access to funds for entities holding a certificate. So far, the energy clusters that have been awarded certificates have not had a dedicated support system developed, apart from the fact that investors had previously been involved (Biznesalert, 2020). However, referring to July 2021, the National Fund for Environmental Protection and Water Management has announced a call for proposals for the third edition of the New Energy programme. This programme offers for the first time co-financing in one of the six areas which are energy clusters. The programme is to be implemented until 2025 and up to 150 million PLN in repayable and non-repayable loans have been allocated to support clusters (NFOŚIGW, 2021). An additional positive aspect is the project launched by the Minister of Agriculture and Development on 30 March 2021 called "Rural development through renewable energy sources - Renew(albe) your Region - RENALDO. It is aimed at 6 municipalities in the Podlaskie and Kujawsko-Pomorskie Voivodeships and is designed to provide substantive support in the preparation of pilot energy cooperatives. In addition the project aims to transfer expert knowledge and experience in the operation and design of these entities in German rural areas (Marzec, 2021). Undoubtedly, the abovementioned measures constitute an important beginning of creating a support mechanism for such entities operating in the area of distributed energy.

1.3 The state of biogas technology

The complicated and unstable legal system has for some time also reached one of the most promising renewable technologies in Poland, namely biogas technologies. Referring to the operation of the legal system, attention should be drawn to the fact that one of the main barriers to development is the administrative and procedural difficulties and the widespread bureaucratization, which make it difficult to obtain a building permit for an installation or to connect it to the grid. Additionally, the legal system, being too slowly updated to meet the requirements of the European Union, intensifies the unwillingness of potential investors (Igliński et. all, 2020).

According to data (Rynekbiogazu, 2018) Poland, due to the specific nature of its economy with a strong agricultural focus, has the potential to produce 19 bcm of biogas per year, not including energy crops. The main problems for the development of this sector have been the lack of an appropriate legislative framework, the low level of support from the banking sector and the protests of local communities concerned mainly about the odour problems of installations (Wysokienapięcie, 2017; Fernandez et al., 2021). The biogas market in Poland is currently undergoing a renaissance with the introduction of a feed-in-premium (FIP) for installations >1MW covering 90% of the difference between the announced reference price and the average market value of energy sales. The reference prices are determined on the basis of the Regulation of the Minister of Climate and Environment of 16 April 2021 on the reference price of electricity from renewable energy sources in 2021 (Regulation, 2021) and the periods applicable to generators that won the auctions in 2021 (URE, 2021). In addition, a popular feed-in tariff (FIT) system was introduced, which for installations >500kW enables electricity to be sold at a fixed 90% of the reference price. (Magazynbiomasa, 2021).

1.4 The state of onshore wind energy

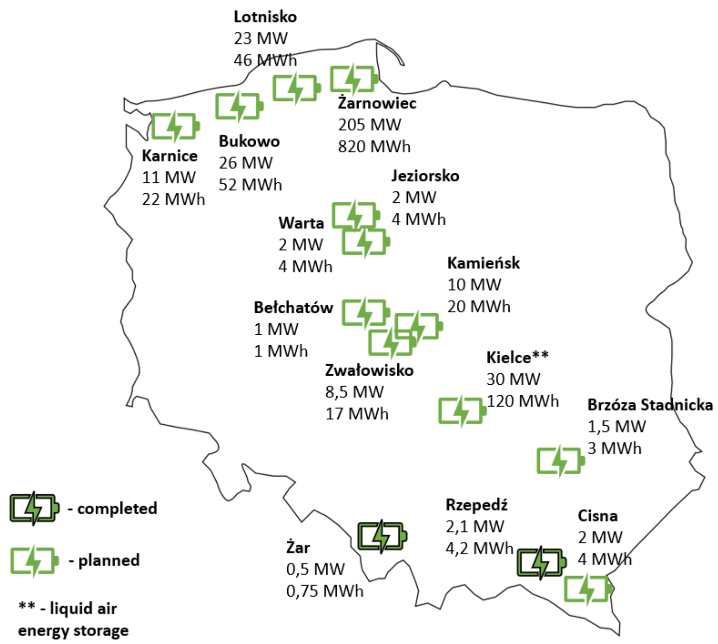
Another complication for the implementation of distributed energy is the proper preparation of the ground for the development of the cheapest renewable energy source, i.e. onshore wind energy. A certain limitation is the currently binding law on investments in wind power plants, commonly referred to as the 10H distance law. Under it, wind turbines may not be installed at a distance of no less than 10 times the height of the turbine (counting the highest point of the blade) from residential buildings and forest complexes including forms of nature conservation. The amendment to the Act, planned for autumn 2021, assumes, among others, flexibility of the 10H rule to adopt an absolute minimum distance of 500 meters from residential buildings, maintaining the requirement to locate installations on the basis of Local Spatial Development Plans, changing the area delimited by the 10H rule to the projected sector of impact (Infor, 2021). Analyzing the problems of the wind industry in Germany, e.g. the fear of low-frequency and infrasound noise and the impact on the landscape postulated by residents, or the protests of pro-environmental organizations and the blocking of defensive air corridors, it is necessary to keep in mind not to allow the over-saturation of onshore installations by designing regulations in such a way that they are socially acceptable (Kędzierski, 2020). This aspect is extremely important, because thanks to local involvement, giving the community a chance to participate in location decisions, it is possible to effectively develop distributed energy. Thanks to this, there is a prospect of increasing the ecological awareness of the inhabitants, which should be driven by local governments activating the local community through educational campaigns and ecological activities using available EU and national programmes. (Mataczyńska & Kucharska, 2020).

1.5 The impact of distributed generation on the power system

Commenting on the aspect of barriers and challenges, the impact of distributed generation on the electricity system should be mentioned. It is worth mentioning that renewable energy sources developing in dispersion, although they ensure lower transmission losses over a short distance to the final consumer, complicate the operation of the entire management system. This is due to the large number of energy exit points, through which the system is obliged to increasingly complex control and monitoring of network operation. Control problems may manifest themselves in losses, e.g. in the form of dissipated heat. In addition, frequency, voltage or phase shift disturbances are likely to occur. The legal requirement of the National Power System to receive energy from RES itself limits the autoregulation mechanism of the grid by a deviation of the nominal frequency: a decrease of the frequency when the grid is overloaded and an increase when it is underloaded. mode of operation of generation turbines with a deviation of a few percent, if there are larger deviations, problems arise with the operation of the grid, forcing, for example, the shutdown of inverters in PV installations. Referring to photovoltaics, but also to wind power plants, some daily and weather conditions have to be mentioned, i.e. passing cloud banks, windless periods, which influence the overall balancing of the grid. As a result of sudden drops in energy generation from RES, e.g. PV, dynamic increases in power demand can occur due to shortfalls in energy production. The more connections are integrated into the network, the more difficult it is for proper operation through problems with advance planning and ongoing stabilization measures. The cooperation of actors with distribution network operators should be supported by advanced ICT technologies, the development of smart meters and appropriate metering. Thus, by creating an active distribution network, the balance between electricity supply and demand will be improved (Skomudek, 2021; Piotrowski, 2021)

There is no doubt that the dynamic growth of RES capacity should be covered by stable generation sources, e.g. biogas plants, and intensive development of energy storage technologies (liquefied or compressed gases, chemical conversion of hydrogen). Referring to energy storage, information (Wysokienapięcie, 2021) show a certain upward trend. Energy storage projects are being implemented and planned, e.g. by Polish Energy Group - PGE, which plans to have 800 MW (figure 5), primarily in Tesla modular battery systems (GKPGE, 2021).

Figure 5. Planned and completed energy storage by PGE.

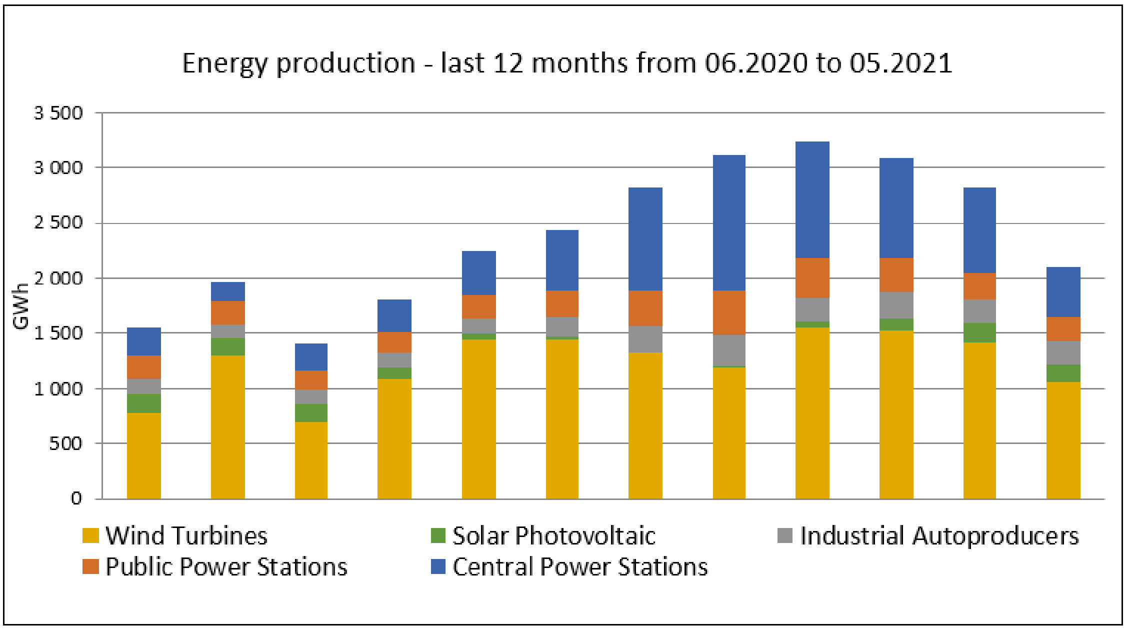


Source: Own elaboration based on: (Wysokienapięcie, 2021)

2.0 Distributed energy in Denmark

Denmark is a precursor of wind energy development and a clear leader in its implementation through local communities. Analyzing data from 2020, as much as 61% of electricity was generated from wind power supported by photovoltaic installations, with total production from wind at 46.5% (ENERGINET, 2021). Local energy communities forming cooperatives and wind energy guilds are a key element of the Danish model. By 2001, as many as 150,000 households were owners in wind projects; in 2015, small private wind power operators accounted for 50% of the total electricity market share (Johansen, 2021).

Figure 6. Energy production in last 12 months in Denmark (Energinet, 2021)



The history of development of Danish distributed energy goes back to the 1980s, when during the oil crisis it was decided to introduce a stable system in the form of FIT tariffs. In addition, Denmark with its very good weather and location conditions proved to be an ideal place for the development of this type of energy, including in particular wind turbines. The development was interrupted to some extent in 2003-2008, when legislative and political problems were encountered that limited the development of this energy segment. It was not until the introduction of the "Act on the Promotion of Renewable Energy Sources" allowed the reactivation of the energy transformation process (Mizieliński, 2019). The most important clause requires wind energy developers to offer for sale at least 20% of the value of projects in ownership shares to local investors, including individuals. The new provisions gave individuals the option to receive a right of first refusal of up to 50 shares if they reside within 4,500m of the development. It additionally introduced an increase in the FIT for installations that have a provision in the agreement to transfer a further 10% of ownership shares to citizens (residing within 16 km). In addition, a special early project risk mitigation measure for local groups has been introduced in the form of a guarantee fund, which, if the project comes to fruition, is converted into low-interest loans of up to a maximum of EUR 70 000 to cover the costs of a feasibility study. In addition to the state guarantees, citizens have the possibility to apply for compensation payments for the siting of wind installations at distances exceeding 25 metres. This is possible if there is a loss of property value of more than 1%. It should also be mentioned that the basic support scheme in Denmark based on a feed-in-premium (FIP) system since 2014 is financed directly by the relevant tax law. For wind energy, on-shore turbines are supported at a maximum of 0.33 PLN/kWh. Small wind turbines >25 kW are supported by a fixed FIT tariff depending on year of allocation and capacity for 12 years. Off-shore installations use an auction system, where the Danish Energy Agency determines the FIP together with its payment period by determining the number of hours the turbine operates under maximum load (Gorroño-Albizu, 2020; Mizieliński, 2019).

For PV installations in Denmark, there is a FIP system with net-metering. Energy producers with installations up to 50 kW are exempted from additional taxes, e.g. the Polish equivalent of the RES fee. Installations above this ceiling are only exempted from part of the obligation.. (Dziaduszyński et al., 2018). An interesting solution is a form of prosumer acting in groups. The 2013 Energy Agreement, which was signed by the government side, business representatives and pro-environmental organizations included a project called "zip code rose". This project involves the creation of a distanced net-metering model. In this model, energy consumers receive an energy tax deduction for the amount of energy produced by a collective RES project located in their postcode area or in a contiguous area. This deduction amounts to up to 10 Euro cents per kWh (Kooij et al., 2018).

2.1 Examples of local initiatives in Denmark

The wind turbine project in Hvide Sande is a flagship example of local initiative and citizen-business cooperation in the creation of local zero-carbon energy. The project in Hvide Sande came about after an unsuccessful initiative by private developers that was met with a lack of public acceptance. It was only with the establishment of the civic foundation 'Hvide Sande Business Development' in 2010 that as much as 9 MW of power could be implemented on the site, which was under the authority of Denmark's fifth largest port. Provisions were made to ensure 80% ownership of the wind farm by the foundation, with the remaining 20% belonging to the local community. Generated profits are used by the foundation to develop port infrastructure and other local facilities, providing a lever for employment and generating profits for the city. A model has been created aimed at activating the region by allowing citizens, local communities and the city to be a driving force towards the use of renewable energy sources (Folkecenter, 2016).

Another interesting solution is the local district heating company Fjernvarme Amba, which is co-owned by the heat consumers, i.e. the residents of the city of Gram. Almost all residents are connected to the network (2,500 people), the number of connected buildings is more than 1,200. Figure 7 shows the photovoltaic installation for water heating and the storage tank. In the background you can see the town and the heat storage tank at the gas CHP plant.

Figure 7. The solar water heating and heat storage pit. (Neimeier, 2021).

The project is innovative in that the heat store, which is powered by, among other things, solar energy that provides up to 61% of the demand and low-emission production, makes it possible to use the stored heat at times of fluctuating energy production from wind and PV power plants. In addition, at times when electricity prices are low (there is an oversupply of energy from renewable sources) a 10 MW electric boiler is used to produce energy, which accounts for 15% of the total heat production. Heat pumps, on the other hand, produce heat continuously except when the price of electricity is too high or the grid voltage is too low. If one of these reasons applies, heat can be produced by a cogeneration unit that is combined in an appropriate way with the heat pump and the electric boiler (Neimeier, 2021).

3.0 Summary

Progressive change in the electricity sector is a reality. A new energy mix based on new low- and zero-emission energy sources is a challenge that can be supported by exploiting opportunities for the development of distributed generation. The new configuration of the Polish energy sector is a great opportunity to build sustainable, local energy security, thus increasing the competitiveness of the region and activating the local community. In order to do so, Poland faces a number of challenges and barriers, which must be overcome to some extent in order to achieve the intended objectives contained in strategic documents, i.e. PEP2040.

Conclusions:

1. The lawmaking system needs to be improved, especially in the area of renewable energy sources. Current legislative processes should be brought in line with current EU legislation. Particular attention could be focused on reducing the level of bureaucracy and facilitating administrative and decision-making procedures. Additionally, it is necessary to accelerate authorization procedures for both the construction of installations and the connection to the grid.
2. In order to raise funds efficiently, Poland needs to create efficient regulatory tools and appropriate, clearly written laws that will enable and encourage more investment projects. Furthermore, it is recommended to implement a rule on support for the energy transformation process by local government units which will conduct educational campaigns to raise awareness of climate and energy issues among the inhabitants and encourage them to promote the development of RES.
3. The creation of laws must take place on the basis of previously developed standards, good practices e.g. from other countries such as Denmark or Germany, as well as public consultations. An interesting way of activating local societies is the Danish model giving the possibility to buy ownership shares in e.g. wind farms, thus increasing the competitiveness of the region.
4. Support programs i.e. Mój Prąd promote changes in the structure of electricity generation. There is a visible increase in the share of solar energy, which is the leader of distributed sources in Poland.
5. The development of local energy entities should be focused on diversified sources of electricity. Poland, due to its large potential of stable sources of green energy from biogas and biomethane, should focus on the development of this segment of the energy sector drawing on experience from other countries and using modern Polish technologies.
6. The National Electricity System requires continuous modernization and development of transmission and distribution infrastructure to meet the demands of weather-dependent renewable sources. Development should be based on the use of the latest information and communication technologies that will enable real-time and future planning. Additionally, it will enable the creation of new tools to support local energy solutions.
7. Analyzing the Danish experience, it is necessary to create areas based on a closed-circuit economy, aiming to maximize the use of energy, heat and cold.

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The biogas sector in Poland as compared to other European countries

Jakub Jacyszyn

Abstract: Biogas can be an important fuel for the European economy. It is a green energy source that will help achieve climate neutrality by 2050. It is very likely that there will be an increase in biogas production in Europe, especially in countries with great potential, such as Poland. This paper will present the current status of biogas in Poland. It also shows the characteristics of this sector and a comparison with other European countries.
The analysis shows that other countries are successfully using biogas. They have similar agricultural conditions to Poland, such as Germany. Therefore there is a real chance for the development of these installations also in Poland.
Key words: Biogas, Poland, Biogas plants, Europe, Renewable energy sources

Introduction

Biogas production has been known for many years, but the need to reduce greenhouse gas emissions may accelerate its development. Climate change and human impact on the environment are the subject of global discussions and international agreements. Some countries, including Poland, need to make a major energy transition to reduce the negative impact on our planet. The problem is the current energy structure of these countries, which are dependent on fossil fuels. To reduce the consumption of harmful conventional fuels, low- and zero-carbon technologies need to be developed and used. Biogas can be one of such green sources. Additionally, it can help in waste management, such as from agriculture or the food industry.

Biogas is a product of anaerobic digestion of organic matter. This organic matter can be domestic, agricultural or industrial waste, as well as, for example, targeted energy crops. The biggest advantage of biogas plants is the reduction of greenhouse gas emissions and the possibility to produce green energy.

Biogas plants are part of a circular economy. They also develop the local energy economy and diversify energy sources. Biogas has many advantages and is an alternative to domestic energy.

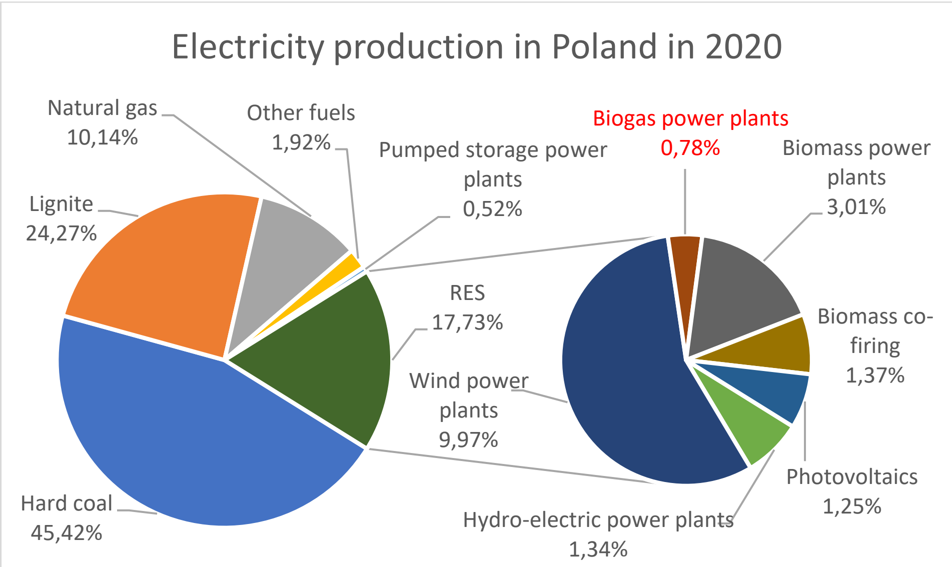
This paper provides an overview of the biogas sector in Poland and compares it with the situation in other countries. It presents the characteristics of Polish biogas plants, their number and share in the national energy structure. The study is a theoretical research paper based on analysis and comparison. The research question is: how developed is the biogas sector in Poland compared to other European countries.

Energy structure in Poland

The national energy mix in Poland is based mostly on solid fuels: hard coal and lignite, which account for 70% of electricity production. Natural gas is responsible for 10%, and renewable energy sources (RES) account for nearly 18% of production. There are also other fuels (about 2%) and pumped storage power plants (0.52%). (ARE, 2020)

More than half of the renewable energy sources are onshore wind power plants. Power plants that use biogas represent 4% of renewable energy sources and 0.78% of total electricity production. Other green sources are: solar energy from photovoltaic installations, hydroelectric energy from hydropower plants, biomass in biomass power plants and biomass co-firing (ARE, 2020).

Figure 1. Electricity production in Poland in 2020 - share of energy sources



Source: Own study based on Statistical Information on Electricity No. 12 (324) - December 2020 (ARE, 2020) (access: 28.06.2021 r.).

According to this data, Poland produced 157747.6 GWh of electricity in 2020. Biogas plants were the second lowest source of electricity production in Poland in 2020 after pumped storage plants. The amount of electricity produced from biogas was 1231.39 GWh. The reason for the low production is the small installed capacity in biogas power plants. In December 2020 it was 248 MW (0,48 % of the total installed capacity which was 51861MW). This was the smallest share of all installations (ARE, 2020).

Table 1. Electricity capacity installed at the end of December 2020 in Poland

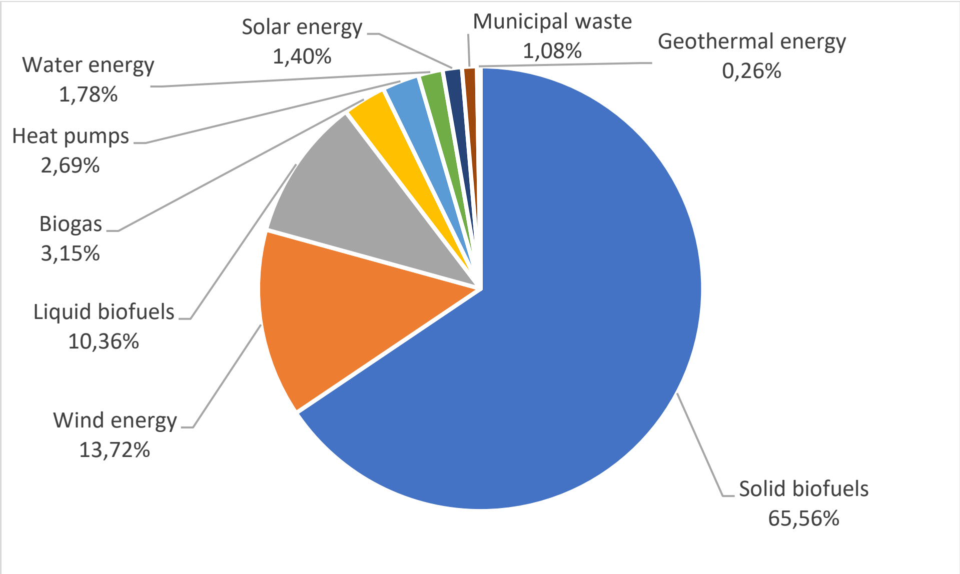
Sources of installed power	Installed capacity [MW]	Percentage share [%]
Hard coal	24 883	47,98%
Lignite	9 292	17,92%
Natural gas	3 203	6,18%

Other fuels	579	1,12%
Pumped storage power plants	1 413	2,72%
Hydro-electric power plants	974	1,88%
Wind power plants	6 402	12,34%
Biogas power plants	248	0,48%
Biomass power plants	907	1,75%
Photovoltaics	3 960	7,64%

Source: Statistical Information on Electricity No. 12 (324) - December 2020 (ARE, 2020) (access: 28.06.2021r.).

From the data presented, the percentage contribution of biogas to electricity production (0,78%) is higher than that of installed capacity (0,48%). It is quite different for photovoltaics. Although it has 16 times more installed capacity than biogas it produces only 0,47 percentage points more electricity. The reason is the changeable weather conditions and the inability of PV panels to produce energy at night. This makes biogas plants a more stable source of energy and resistant to changes in the time of day or weather conditions, which is their great advantage.

Figure 2. Structure of renewable energy generation in Poland by carrier in 2019.



Source: Own study based on Statistics Poland (GUS) - Energy from renewable sources in 2019 (https://stat.gov.pl/obszary-tematyczne/srodowisko-energia/energia/energia-ze-zrodel-odnawialnych-w-2019-roku,10,3.html) (access: 28.09.2021 r.).

Comparing the energy sources of all renewable energy sources, solid biofuels have the largest share (65,56%). Biogas is fourth (3,15%). There is a significant difference between biogas and liquid biofuels (10,36%), which are in third place. (GUS, 2020)

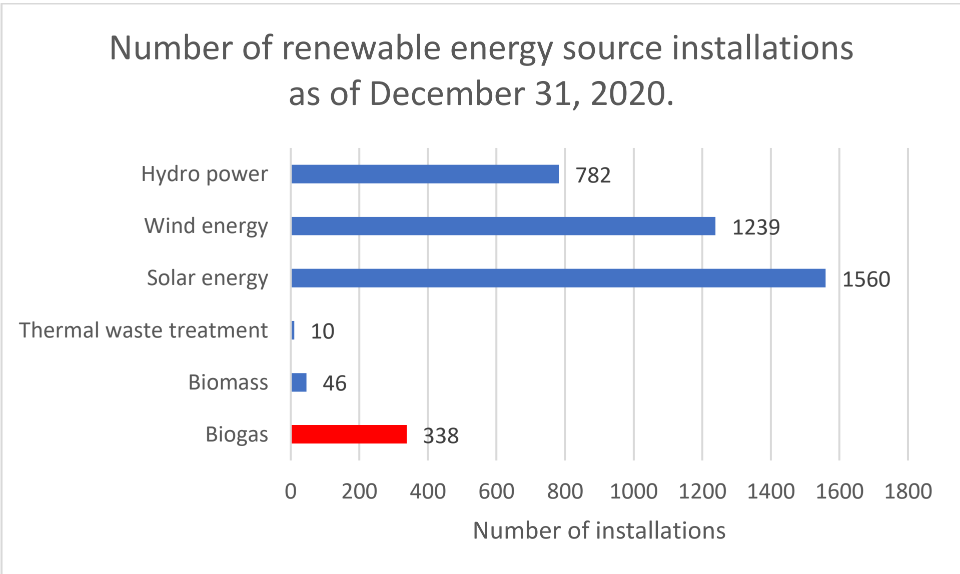
European and national climate goals require decarbonization of the presented energy mix. An additional problem is the high cost of CO2 emissions, which currently amounts to over 52 euro per tonne (on 19.07.2021). (PSE, 2021) Assuming an upward price trend, this will remove the most emitting sources. In the case of immediate removal of coal from the Polish structure, the National Power System would not be able to meet the needs for electricity in the country. It is difficult to base power generation solely on renewable energy sources such as wind and solar. They are characterized by unstable operation depending on weather conditions. Energy storage technologies are a solution, but they are not so common at the moment, and they are still in development. It is necessary to choose a strategy for the future energy mix, taking into account environmental and economic aspects.

The most realistic scenario is the removal of coal, using natural gas as a transition fuel. This fuel has significantly lower greenhouse gas emissions into the atmosphere and can effectively replace coal-fired units in the short term. The popularity of natural gas is demonstrated by such national investments as the LNG Terminal in Świnoujście, the Baltic Pipe gas pipeline (under construction) or the Floating Storage Regasification Unit (FSRU) in the Gulf of Gdańsk (planned). In Europe, the confirmation of a greater demand for natural gas is the TurkStream pipeline or the construction of Nord Stream II from Russia to Germany. Gas will remain, at least for some time, in the European economy. This is important because biogas is an environmentally friendly alternative or supplement to natural gas. It could also use the existing gas infrastructure or be used in other ways.

Biogas plants in Poland

The current state of biogas plants in Poland is not large. Compared to some European countries, there are few biogas installations in Poland. This topic has been under discussion for a long time. Just over 10 years ago there were plans to have at least one biogas plant in each commune by 2020 that would produce electricity and heat. Unfortunately, so far the government programs and assumptions have not been a success and the biogas sector has grown slowly. Currently, according to the Energy Regulatory Office, Poland has 338 biogas installations with a total installed capacity of 255.7 MW (data as of 31.12.2020). (URE, 2020) The number of biogas plants is small compared to wind, hydro or solar installations. Especially that Poland has a large potential for agricultural biogas.

Figure 3. Number of RES installations in Poland



Source: Own study based on Renewable energy installations - as of December 31, 2020 (URE, 2020) (access: 28.06.2021 r.).

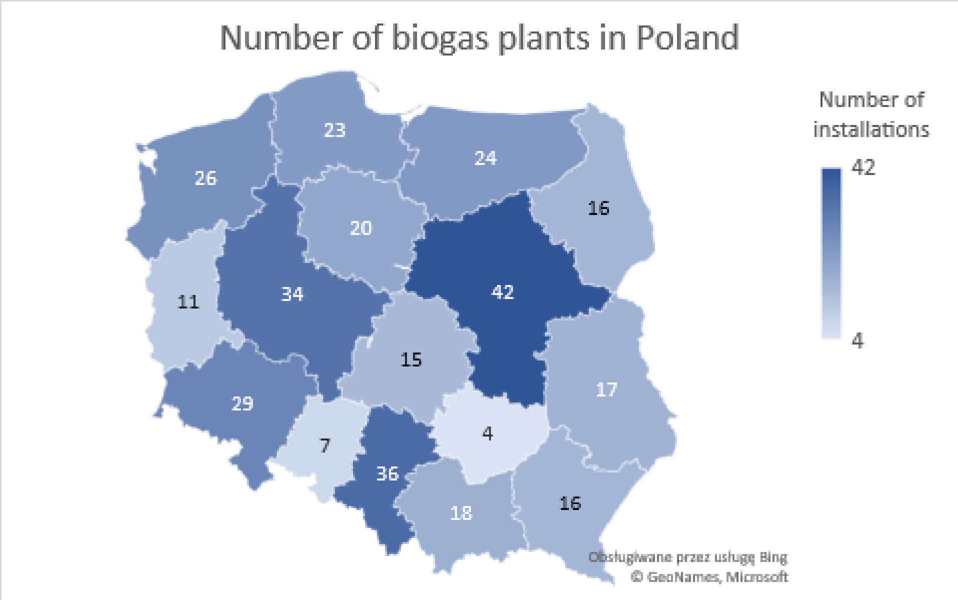
According to this data (URE, 2020), the total installed capacity from all RES at the end of December 2020 was 9979.176 MW in Poland. The installed capacity in biogas (255.7 MW) accounted for 2.56% of the RES share. The others: wind energy (6347.1 MW) 63.6%, solar energy (887.43 MW) 8.89%, biomass (1343.06 MW) 13.46%, hydro energy (976.05 MW) 9.78% and thermal waste conversion (169.83 MW) 1.7%. It can be seen that biogas played a marginal role in this comparison. It is worth noting, however, that 46 biomass plants had a bigger share of installed capacity than the 338 biogas plants. This shows that biogas installations have a smaller capacity than, for example, thermal waste or biomass installations. The average installed capacity of one biogas plant in Poland is 0,76 MW. Only photovoltaic installations are smaller (0,57 MW). The average power of other installations: biomass (29,2 MW), thermal waste treatment (16,98 MW), wind energy (5,12 MW), water energy (1,25 MW).

The installed capacity of biogas plants has been growing since 2005. An exception to this trend is the years 2016 - 2018 when there was an investment slump due to legislative and legal problems and low green certificate prices. In 2017 they reached their lowest level of about 24 PLN/MWh. (Magazyn Biomasa, 2020) This resulted in high uncertainty for investors, as well as financial collapse of some installations. In the last 10 years there has been an increase in biogas capacity of more than 65%. However, this is not much compared to other installations. Since 2010, wind and biomass installations have experienced the highest growth. Photovoltaics has also seen dynamic growth in the last two years.

Characteristics of biogas sector in Poland

Most of the 338 biogas plants in Poland are located in the Mazovian (42 installations), Silesian (36 installations) and Greater Poland (34 installations) Voivodships. The least biogas plants are located in the Świętokrzyskie (4 installations), Opolskie (7 installations) and Lubuskie (11 installations) Voivodships. The smallest average installed capacity per installation is in Podkarpackie voivodship (average 0.47 MW) and the largest installations are in Pomorskie voivodship (average 1.13 MW). The largest installed capacity of biogas plants is in the Wielkopolskie (28,67 MW), Mazowieckie (28,55 MW) and Pomorskie (26,09 MW). The provinces with the smallest installed capacity are Świętokrzyskie (3,82 MW), Opolskie (3,95 MW) and Lubuskie (5,53 MW). Counting per one installation, the lowest average installed capacity is in Podkarpackie (average 0.47 MW) and the highest in Pomorskie (average 1.13 MW). (URE, 2020)

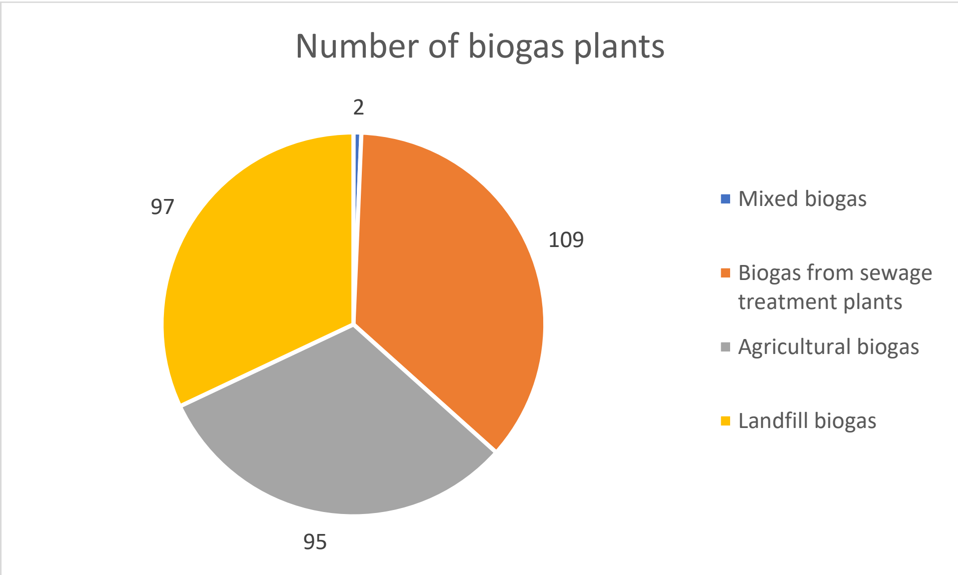
Figure 4. Number of biogas installations in Poland by province as of December 31, 2020.



Source: Own study based on Renewable energy installations - as of December 31, 2020 (URE, 2020) (access: 28.06.2021 r.).

There are three main types of plants: agricultural biogas plants, landfill biogas plants, and plants from sewage treatment plants. The ERO data, which also specifies what type of biogas plant a biogas plant is, is from 2018. The most recent data does not separate this division.

Figure 5. Number of biogas installations in Poland as of December 31, 2018, by type

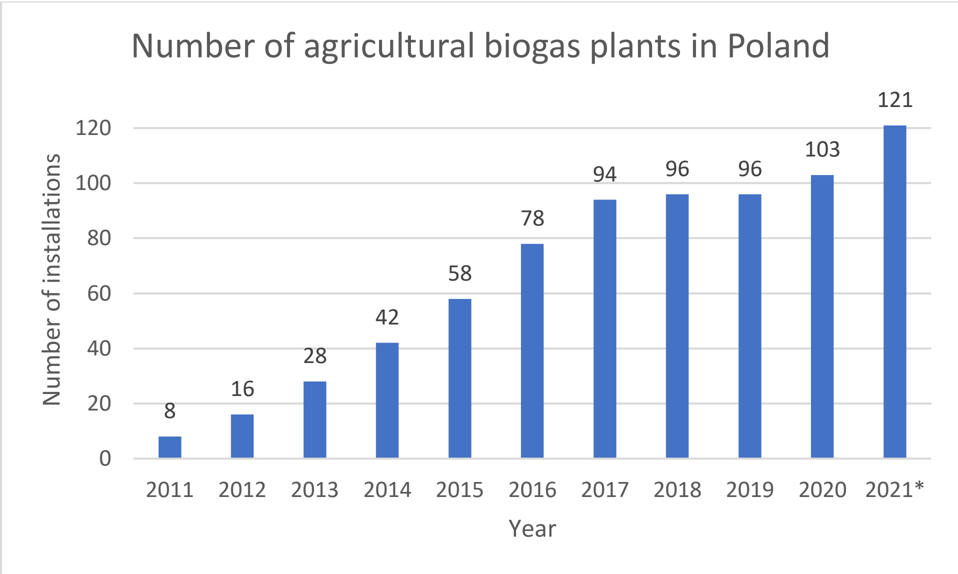


Source: Own study based on Renewable energy installations - as of December 31, 2020 (URE, 2019) (access: 28.06.2021 r.).

Currently, agricultural biogas plants are more important. This is proven by the data determining the production of heat and electricity in Poland made available by the Central Statistical Office (GUS, 2020). Heat production from biogas was 1004, 2 TJ in 2019. 3.5% of this value came from biogas from landfills, 10.5% from sewage treatment plants, 86% was agricultural and other biogas. On the other hand, the total share of biogas in electricity generation was 1162 GWh in 2019. Of this, 15.3% was biogas from landfills, 30.2% was biogas from wastewater treatment plants, and 54.5% was agricultural and other biogas.

The great importance of agricultural biogas plants is also confirmed by the large increase in installations over the last year. Based on data from the National Agricultural Support Centre (KOWR, 2020), there were 116 agricultural biogas plants at the end of 2020. According to the latest information, as of 5 July 2021, the number was already 121 installations, which belong to 104 business operators. (magazynbiomasa.pl, 2021) Most of the agricultural biogas plants are located in northern and central Poland. The production of agricultural biogas in 2020 amounted to 325,395 million m^3. (KOWR, 2020) This amount is increasing every year, just like the installed capacity of biogas installations in Poland. Everything indicates that this growth dynamics will be increasing.

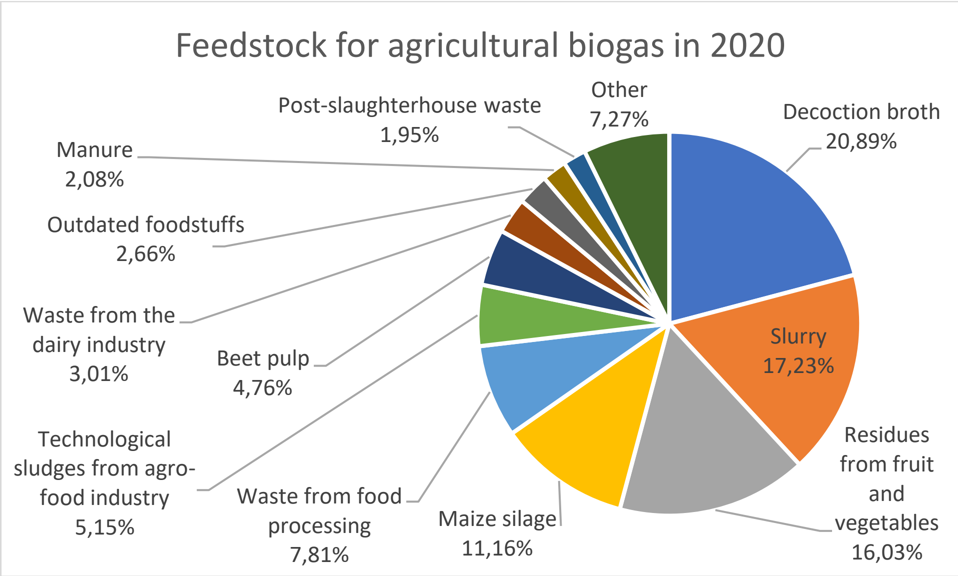
Figure 6. Number of installations in the register of agricultural biogas producers in Poland



Source: Own study based Data on the activity of agricultural biogas producers from 2011 to 2020 (KOWR, 2020) (access: 03.07.2021 r.) and * (magazynbiomasa.pl, 2021) (access: 18.07.2021 r.)

There are many raw materials from which agricultural biogas is produced in Poland. In 2020, 4,409,054.9 tons of substrates were used for this purpose. The largest part of the feedstock was decoction broth (920,995 tonnes), slurry (759,774 tonnes) and fruit and vegetable residues (706,945 tonnes). The rest of the raw materials were maize silage (491,869 tons), food processing waste (344,329 tons), process sludge from the agri-food industry (227,148 tons), beet pulp (209,816 tons), dairy industry waste (132,910 tons), outdated foodstuffs (117,184 tons), manure (91,681 tons), and slaughterhouse waste (85,777 tons). The rest of the raw materials are included in the "Other" category (320,625 tons).

Figure 7. Types and quantities of raw materials used for the production of agricultural biogas in Poland in 2020



Source: Own study based Data on the activity of agricultural biogas producers from 2011 to 2020 (KOWR, 2020) (access: 03.07.2021 r.).

Barriers to biogas development in Poland

The biogas market in Poland had barriers that effectively slowed down its development. Between 2014 and 2017 there was an intense drop in green certificate prices which led to a crisis in the biogas market and financial problems for many investors. The sector became unstable and uncertain, even after legal changes and the introduction of new support systems. This is particularly shown in Figure 6. From 2017 to 2019 there was stagnation in the biogas market in Poland. No new installations were built during this period. This was related to investors' fears and high risks. The barriers also include high investment costs or legal regulations related to the biomethane market. Currently, there is a large increase in the number of new installations (18 new installations this year), which confirms a better time for biogas and stabilisation of the market.

Biogas in Europe

Renewable gases, including biogas, are supported in Europe through the European Green Deal (EGD). The use of biogas helps achieve the EGD's goal of climate neutrality by 2050. Biogas reduces greenhouse gas emissions from agriculture and waste management. This is confirmed, for example, by a document - the EU strategy for reducing methane emissions, which was published in October 2020. (European Commission, 2020)

There are large differences in the level of development of the biogas sector in Poland compared to other European countries (e.g. Germany). The document Bioenergy Europe Statistical Report Biogas 2019 says that gross biogas energy consumption has expanded 25 times since 1990. The report also says that despite the increasing trend, biogas represented only 1% of total gross domestic energy consumption in the EU-28 member states in 2017, with 12% of bioenergy used across the European Union coming from biogas. In the EU-28, Switzerland, Norway and Serbia, there were a total of 17,783 biogas plants in 2017. The largest number was located in Germany and Italy. The fewest were in Bulgaria and Romania. The only country that did not have such an installation in the EU was Malta (Bioenergy Europe, 2019).

Table 2. Number of biogas plants in EU-28 countries in 2017. (number of installations)

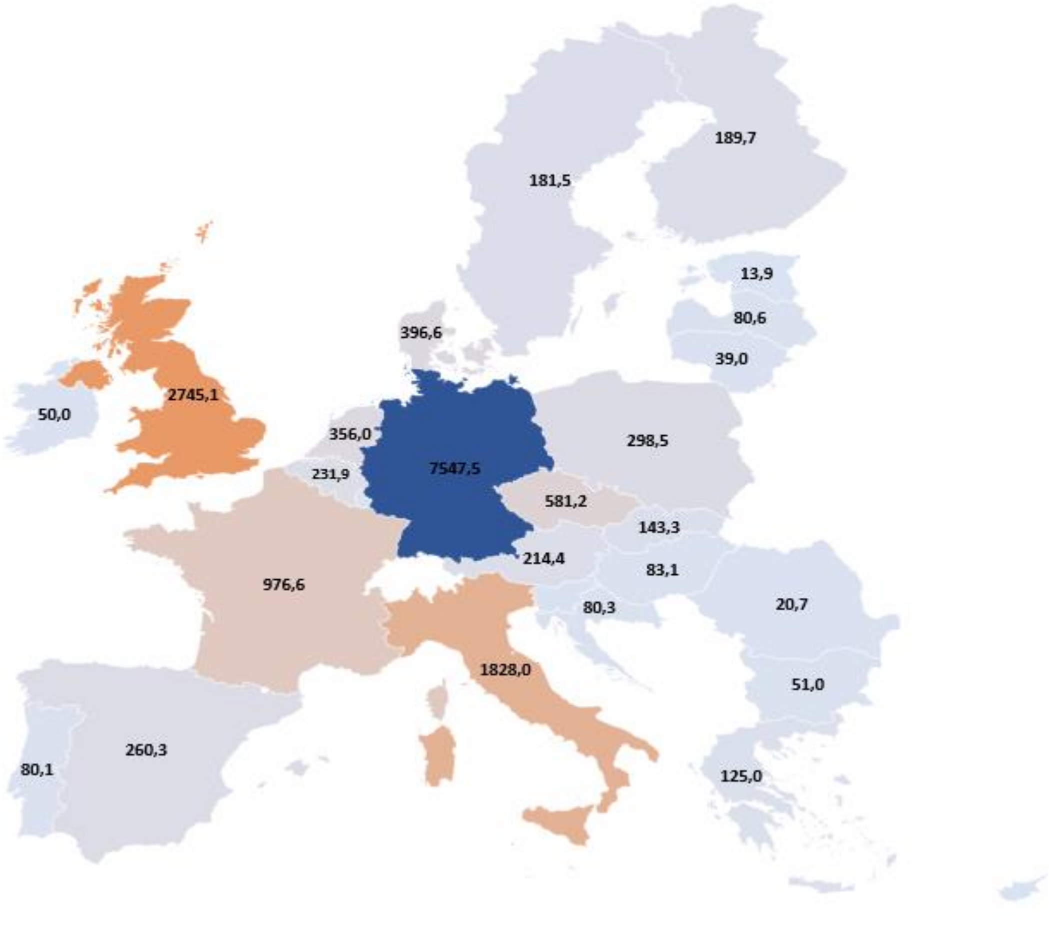
Country	**Number of biogas plants**	**Percentage share in EU**
Germany	10971	64,54%
Italy	1655	9,74%
France	742	4,36%
United Kingdom	613	3,61%
Czech Republic	574	3,38%
Austria	423	2,49%
Poland	308	1,81%
Netherlands	268	1,58%
Spain	204	1,20%
Sweden	198	1,16%
Belgium	186	1,09%
Slovakia	179	1,05%
Denmark	144	0,85%
Finland	96	0,56%
Hungary	81	0,48%
Portugal	64	0,38%
Latvia	56	0,33%
Greece	37	0,22%
Lithuania	36	0,21%
Luxembourg	30	0,18%
Ireland	29	0,17%
Croatia	26	0,15%
Slovenia	26	0,15%
Estonia	18	0,11%
Cyprus	13	0,08%
Bulgaria	11	0,06%
Romania	11	0,06%
Total	**16999**	

Source: Own study based Statistical Report 2019 Biogas (Bioenergy Europe, 2019) (access: 09.07.2021 r.).

Among the EU-28, Switzerland, Norway and Serbia had the highest number of biogas plants based on agricultural feedstocks in 2017 with 12721 installations. Biogas plants from wastewater treatment plants were 2854 installations, while biogas plants from landfills were 1374 installations. In each country, the use of feedstock for biogas production is different. In Sweden, Spain and the UK, most biogas comes from wastewater from treatment plants. Countries like Austria, Latvia, Cyprus and Germany use a lot of energy crops. In the case of Finland, bio-waste and municipal waste account for the largest share. In Belgium, biogas production is based on industry (food and beverages). In Italy, Denmark, Poland and France agricultural residues have the biggest share. In Hungary and Germany they are also of great value. (Bioenergy Europe, 2019)

The leader in biogas production in Europe is Germany (7547.5 ktoe). Less are produced by: United Kingdom (2727.1 ktoe), Italy (1828.0 ktoe) and France (976.6 ktoe) but even the combined total of biogas production at the end of 2019 of these three countries is less than the production in Germany. It is worth highlighting the large production in the Czech Republic (581.2 ktoe), which is a relatively small country. Biogas production there is almost twice as large as in Poland. (EurObserv'ER, 2020)

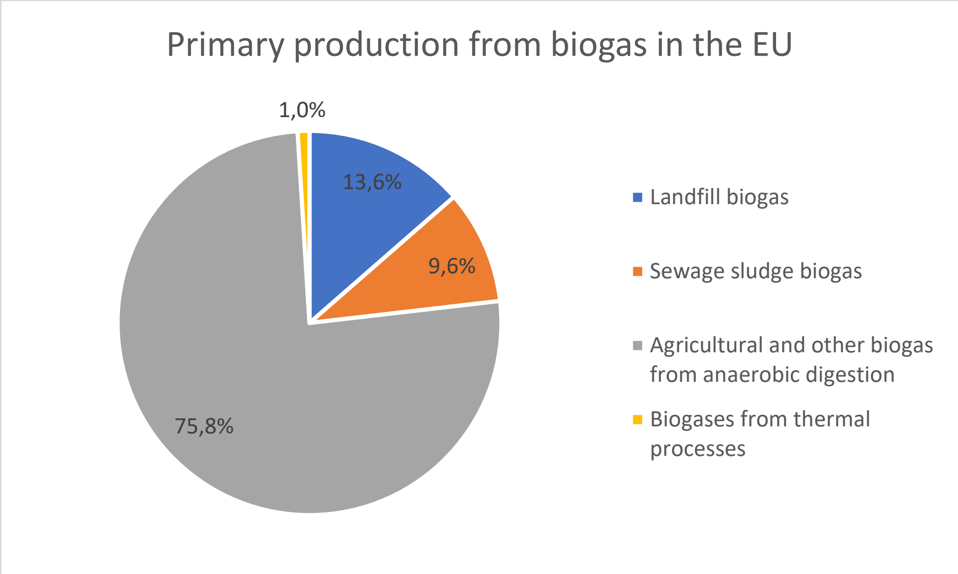
Figure 8. Biogas production in European Union countries at the end of 2019* [ktoe].**



Source: Own study based Biogas barometer (EurObserv'ER, 2020) (access: 17.07.2021 r.).
*Estimated production. When information was not available, data were estimated by EurObserv'ER for 2019 using the 2018 distribution.
** 1 toe = 11,63 MWh

In 2019, total biogas production in the EU-28 was 16,629.8 ktoe. More than 75% of this was agricultural biogas (12612 ktoe), 13.6% was landfill biogas (2259.5 ktoe) and 9.6% was sewage sludge biogas (1593.5 ktoe). Biogases from thermal processes accounted for 1% of the share (164.7 ktoe).

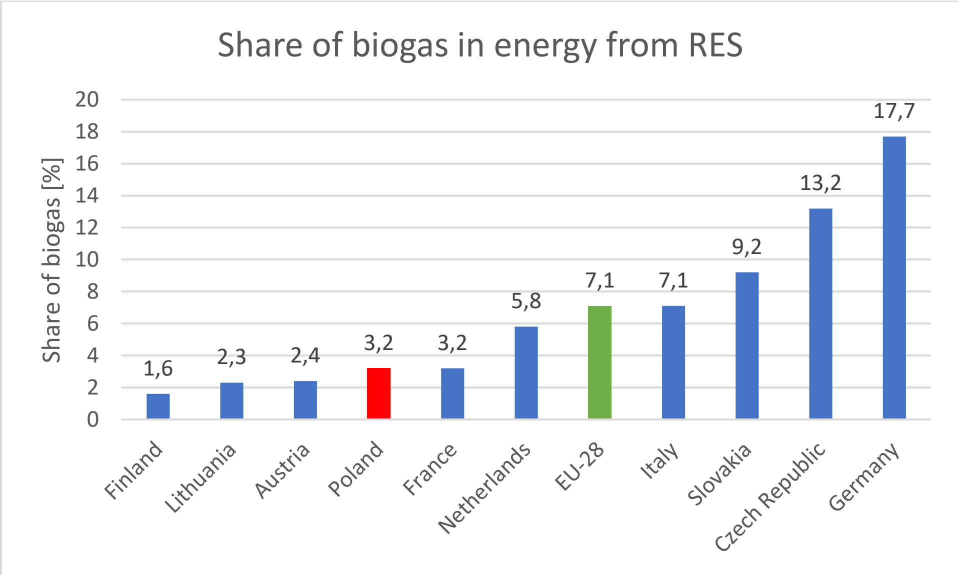
Figure 9. Primary production from biogas in the European Union in 2019* by biogas type



Source: Own study based Biogas barometer (EurObserv'ER, 2020) (access: 17.07.2021 r.).
*Estimated production. When information was not available, data were estimated by EurObserv'ER for 2019 using the 2018 distribution.

Taking into account the share of biogas energy in the generation of energy from renewable sources, according to the Central Statistical Office (GUS, 2020), in 2018 Poland was below the European Union average (7.1%). The highest percentage share was held by Germany (17.7%) and the already mentioned, Czech Republic (13.2%). Slovakia also had a share above the average (9.2%).

Figure 10. Share of biogas energy in renewable energy generation in 2018 in selected countries



Source: Own study based Energy from renewable sources in 2019 (GUS, 2020) (access: 21.07.2021 r.).

Summary

The biogas sector in Poland is in a development phase. The current state is below the European Union average. Other countries such as Germany have been consistently developing this sector for many years. At the same time in Poland the growth dynamics was moderate. In 2017-2019 there was a crisis on the renewable energy market in Poland which resulted in a lack of investment in new biogas plants (Figure 6). The support system for these installations needed improvement. Only from 2020 we can see an increase in the number of investments.

The energy sector in Poland requires large investments in zero- and low-emission energy sources. The reason for this is the decarbonization of the energy mix and new climate goals. Therefore there is a big interest in renewable energy sources, including biogas. It is one of the elements of Poland's Energy Policy until 2040. There has been a big increase in agricultural biogas plants in Poland recently. This is the direction in which this sector will develop, just like in other European countries. Poland has a very big potential in biogas. Especially in agricultural biogas due to a developed agricultural economy. This is confirmed by Eurostat data, which show a significant share of Polish farms in comparison to other European countries. Poland is one of the biggest producers of vegetables and fruits as well as the biggest poultry meat producer in the EU. A large potential is also a developed food and beverage industry (Eurostat, 2020). Data of the Poznań University of Life Sciences say that the potential of biogas in Poland is 13-15 billion m3/year. This is very high compared to the current production. Poland can become an important part of biogas production in Europe if it provides support and good conditions for investment. The Czech Republic, for example, which has more biogas plants than Poland, confirms the possibilities for development of this sector. A lot of countries use agricultural waste for production which also has a big potential in Poland. Additionally biogas can be used to produce biomethane. It is a popular direction, also among European countries.

There are positive aspects to the development of Polish biogas and promising forecasts for the future. This is confirmed by the letter of intent for the development of the biogas and biomethane sector in Poland signed in October 2020. It also includes plans to create a sectoral agreement. Thanks to the cooperation it will be possible to develop the biogas market in Poland faster. It is also worth noting the support programs in the form of subsidies such as "Agroenergia" (National Fund for Environmental Protection and Water Management) or the FIT/FIP support system. They are aimed at encouraging investors to build new biogas plants. The use of biogas will help achieve both economic and environmental goals. The biogas sector in Poland has great potential and may, like in other European countries, have a large share in obtaining energy from renewable sources.

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Analysis of the possibility of using KPIs in measuring the achievements of business entities from the energy sector – case study

Karolina Czerwińska, Andrzej Pacana

Summary: Each performance measurement and management system should be updated and reorganized so that it can be adequate to the changes occurring in the economic entity and the sector in which it operates. In addition, the performance measurement system should evolve with the organization's changing strategy and continually updated management objectives. The purpose of the study was to analyze the possibility of applying key performance indicators in an economic entity from the energy sector and to indicate their role and importance in the context of effective management and monitoring of progress in achieving pre-defined objectives. In the study, a coherent set of KPIs was designed, which were used to evaluate the existing concepts in the business entity and, at the same time, served as guidelines for choosing new directions of improvement and development concerning, among others, reorganization and restructuring in the customer service model through the introduction of a training system and organization design (a system of values and employee motivation), as well as obtaining permanent savings in operating costs through reduction of own costs will make it possible to pursue an effective pricing policy.

Key words: key performance indicators, performance measurement system, improvement, quality engineering

Introduction

Progressive globalization processes, dynamically changing market, increased competition and threats related to crisis phenomena require companies to develop and implement innovative management systems (Czerwińska and Pacana 2019: 3-4; Blind et al., 2021: 33-34; Martincevic and Kozina 2021: 1262-1263; Zwolenik and Bełch 2021: 19-20). For companies, maintaining a stable position and competitive advantage means choosing and applying an appropriate management strategy related to increasing efficiency and often innovation (Brzóska et al., 2011: 6-7; Ulewicz et al., 2016: 89-90; Grabowska, 2017: 105-106: Svikruhova et al., 2021: 831-833). Types of management strategies, as well as activities implemented in this plane, have been widely described in the literature (Fredriksson and Larsson, 2012; Kazmerczak, 2000; Legutko, 2009; Wilczarska, 2012; Antosz and Ciecińska, 2011; Antosz et al. 2013; Wolniak, 2021:100-102). One of the most important tools for monitoring the level of performance and management in organizations are key performance indicators (ang. Key Performance Indicators, KPI). They are to facilitate the assessment of the company's performance by measuring the degree to which the objectives established in it have been achieved - which in turn facilitates decision-making, appropriate prioritization of activities and improvement of the company's development strategy (Babcanova, 2012: 117; Parmenter, 2016: 33-34; Grabowska, 2017: 107-108; Banu, 2018: 906-907).

The purpose of the study was to analyze the possibility of applying key performance indicators in a business entity from the energy sector and to highlight their role and importance in the context of effective management and improvement and monitoring of progress in achieving previously set objectives, as well as to present the direction of their evolution in the context of changing operating conditions for the analyzed entity.

Key performance indicators in an energy business entity

The subject of consideration in the study was to indicate the possibility of implication of KPIs and to indicate their effectiveness in monitoring the progress in achieving pre-defined objectives. Therefore, it is worthwhile at the very beginning to refer to the explanation of the essence of key performance indicators. However, it is important to note that explicitly capturing KPIs is not straightforward. Analyzing the extremely rich literature in this area, one can notice the ambiguity of interpretation, as well as the frequent multifaceted treatment of.

KPIs are one of the tools of Business Performance Management, i.e. a group of concepts from the field of operations management, promoting improvement of the effectiveness of the organization's functioning with the use of measures, processes, monitoring systems and management of the organization's results. At the same time, KPIs are an integral part of a set of global best manufacturing practices known as World Class Manufacturing (WCM). In the literature there are over 2000 definitions of various KPIs functioning in organisations from all sectors (Valimirovic et al., 2011: 63-64; Parmenter, 2016; Piasecka-Gluszak, 2017; Gonzalez et al,. 2017: 559-560). Selected KPI definitions are included in Table 1.

Table 1. Selected definitions of key performance indicators

Lp.	Note	Definition of
1.	Neely, Adams and Kennerly, 2002	A parameter to quantify the effectiveness and/or efficiency of past actions.
2.	Clifton, 2012	Any, measure, percentage, ratio or average that can help an organization quickly understand incoming data in the right context and at the right time.
3.	Reh, 2012	Kpi are measurable measurements, previously agreed upon, that reflect the key success factors of the organization.
4.	Kang, et al., 2015	A set of measurable and strategic parameters depicting the operational achievements of a company, playing a key role in the creation of a measurement system (achievements).
5.	ISO 22400-1:2014, 2014	The quantifiable level of achievement of the critical objective. ISO 22400 also states that key performance measures come directly from the aggregation function, physical measurements, data and other KPIs.
6.	Barone et. al., 2011	They are measures or indicators that assess performance against certain objectives. They are routinely used by the organization to measure both success in achieving strategic goals and the quality of.
7.	Tesoro and Tootson, 2000	KPIs can explain a set of numbers used to measure a process or outcome so that the effect within the organization is determined relatively easily.
8.	Marr, 2010	Key performance measures (KPIs) help organizations understand how well they are performing against their strategic objectives. In the broadest sense,

		a key performance measure provides key performance information that enables organizations or their stakeholders to know whether the organization is on the right track. Key performance measures are used to simplify organizational characteristics into a small number of key metrics to increase organizational effectiveness.
9.	Kaplan, 2009	KPIs or key performance measures are selected metrics that provide insight into business performance and enable decision makers to take action to achieve desired results. Organizations that measure performance identify several key success factors that address specific strategic objectives.
10.	Al-Mutairi, 2012	Key performance measures are commonly used by companies as a tool to assess performance. They form the basis of an achievement system that turns the company's strategic goals into short-term objectives. Establishing clear and actionable KPIs serves to manage performance well.
11.	Peng et al., 2007	A KPI is a tool used to convey knowledge about the relative health of a company or part of a company. A Kpi is a specific measure (a quantitative, periodic measurement of one or more processes) selected from among all collected or possible indicators in a company in such a way as to provide as much information as possible in a single measurement (key measurement).

Note: Own elaboration based on: Neely et al., 2002; Clifton, 2012; Reh, 2004; Kang, et al., 2015; ISO 22400-1:2014, 2014; Barone et. al., 2011; Tesoro and Tootson, 2000; Marr, 2010; Kaplan, 2009; Al-Mutairi, 2012; Peng et al., 2007.

The analysis of the definitions of KPIs contained in Table 1, contributed to the formulation of the definition of key performance indicators, which reads as follows: a key performance indicator is a carrier of information, in the form of an index, an absolute measure or statistics of a specific process, serving to quantify achievements (of the technical, organizational and economic sphere), identify priority processes, operations, activities and values mobilizing employees to achieve the objectives and corporate strategy. Given the wide range of KPI applications in organizations, in the authors' opinion, they are a convenient tool for building an effective performance measurement system.

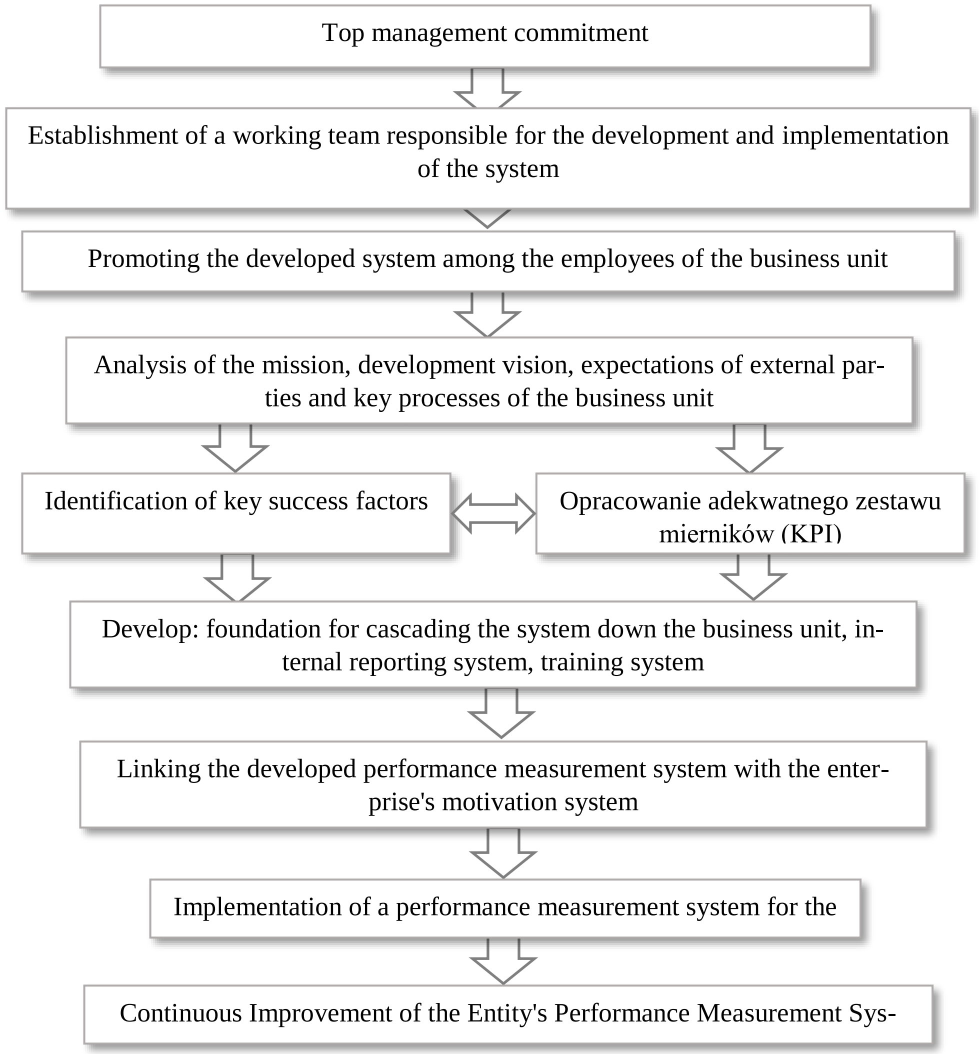
Methodology of building performance measurement system

The measurement of the achievements of business entities can be carried out on many levels. It is possible to measure all economic aspects in the organization, i.e. processes, phenomena, streams, but the preparation and implementation of the performance measurement method should be adequate to the specificity of the organization. This action can be divided into two parts (Nowak 2012: 39):

1. thorough analysis of the economic entity and development of an appropriate performance measurement system,
2. implementation of the developed performance measurement system and its improvement and ensuring its adequacy.

The indicated two stages of activities can be divided into nine actions contributing to ensuring an appropriate level of effectiveness of the performance measurement system. These activities are shown in Figure 1.

Figure 1 The main stages of building an effective performance system of an enterprise



Source: own elaboration based on: Nowak 2012

An enterprise's performance measurement system should facilitate the effective quantification of all major areas of enterprise activity. A properly developed and implemented measurement system should be consistent with the company's strategy, oriented to the needs of external stakeholders and should be adequate in terms of: critical success factors, performance reporting, multi-faceted scope of measurement, critical measurement factors, and at the same time it should be oriented to employees' motivation and future.

Proposal of using KPIs within the performance measurement system

The analysed business entity is located in Poland and considers trading in natural gas and electricity as its key area of activity. Due to the lack of a clearly defined performance measurement system in the organization, it was decided to propose the use of selected key performance indicators as part of activities improving the management of the unit. A one-year period of activity was examined.

Under the current Energy Law, transmission and distribution activities were separated from generation and trading activities (Journal of Laws 2020.833 of 2020.05.11), which forced operators to create a new and effective performance measurement system. The new system should be adapted to operate in free market conditions (Bartnik 2015: 20-21; Skoczylas and Wasniewski 2017: 185-186), and therefore redesigned in such a way that in the analyzed entity it is directed only to the numerical capture of phenomena related to commercial processes. On the basis of the presented premises, in the analyzed economic entity the concept of management by objectives has been introduced, which consists in the continuous pursuit of the achievement of the assumed provisions, taking into account the current conditions of the economic entity and its capabilities. This concept allows delegating the organization's goals and employees' responsibilities, making it possible to evaluate the degree of their realization and linking the results to the bonus system (Tschernitz and Gross 2011: 261; Mondy 2012: 456; Leśniewski 2016: 82-84; Czerwińska and Pacana 2020: 13-14). The organization's revised performance measurement system takes into account two areas: the internal and external areas of the business entity. Internal orientation refers to the measurement of the achievements of individual workplaces and organizational units and serves the management of the analyzed organization. On the other hand, in relation to the external area, the system is used to evaluate the results of the economic entity as a whole and is implemented for the owners.

In the group of proposed measures we can distinguish internally oriented measures and externally oriented measures in the classification of variable and constant. Selected performance measurement indicators from the presented groups are listed in Table 2.

Table 2. Selected internally and externally targeted key performance indicators

<table>
<tr><td colspan="5">Internally Focused Key Performance Measures</td></tr>
<tr><td colspan="2">Entity as a whole</td><td colspan="2">Organisational units</td><td>Workstation</td></tr>
<tr><td colspan="2">Receivables turnover ratio</td><td colspan="2" rowspan="6">Number of tariff group customers acquired during the specified period, implementation of the orders of the Chief Operating Officer implemented for implementation during the period evaluated</td><td rowspan="6">Produce reporting reports on time to a quality standard</td></tr>
<tr><td colspan="2">Unit sales margin</td></tr>
<tr><td colspan="2">Volume of gas sold</td></tr>
<tr><td colspan="2">Quantity of electricity sold</td></tr>
<tr><td colspan="2">Number of customers in given tariff groups at the end of the settlement period</td></tr>
<tr><td colspan="2">Degree of implementation of the sales plan</td></tr>
<tr><td colspan="5">Key performance indicators externally oriented - variables</td></tr>
<tr><td>Meter</td><td>Calculation method</td><td>Unit of measurement</td><td>Target value</td><td>Scale of assessment within the defined level of achievement of the objective</td></tr>
<tr><td>Level of implementation of initiatives:
- (1) Launch eServices for specific customer groups (A, B, C),</td><td>Evaluation of the implementation of the initiatives in accordance with the developed timetable and the effects of the activities carried out</td><td>pkt</td><td>100</td><td>Exceeding expectations - 110,
Meeting expectations - 100,
Satisfactory - 70,
Moderate - 50,</td></tr>
</table>

- (2) launch e-invoicing for specific customer groups (A, B, C), - (3) upgrading of specific gas transmission sections (lots: 1, 2, 3, 4)				Weak - 25 Unsatisfactory -0
Develop and refine a plan to maintain gas and electricity sales	Completion of the task on time	pkt	70	Exceeding expectations - 110, Meeting expectations - 100, Satisfactory - 70, Moderate - 50, Weak - 25 Unsatisfactory -0
Value index of sales of new products and services	$\frac{A}{B} \cdot 100\%$ A - net profit, B - revenues from sales	%	X	X% and above - 110, X% - 100, X% - 70, X% - 50, X and less - 0
Level of customer satisfaction with service	Evaluation based on the result of the customer satisfaction survey (application of CSI - Customer Satisfaction Index)	%	70	80% and above - 110, 78% - 100, 76% - 70, 74% - 50, 72 and less - 0
Externally oriented key performance measures - fixed				
Meter	Calculation method	Unit of measurement	Target value	Scale of assessment within the defined level of achievement of the objective
The change in the number of customers in the domestic market during the year under review (as determined by measuring capacity orders)	$A + B1 \cdot C1 + \cdots + B5 \cdot C5$ A - power ordered by customers, B1 .. B5 - difference in number of clients C1 .. C5 - assumed coefficient of ordered power	m^3/h	X	X m^3/h i więcej - 110, X m^3/h - 100, X m^3/h - 70, X m^3/h - 50, X m^3/h i mniej - 0
Prepaid receivables ratio over 60 days	$\frac{(A + B - C)}{D} \cdot 100\%$ A - value of receivables over 60 days past due,	%	X	X m^3/h i więcej - 110, X m^3/h - 100, X m^3/h - 70, X m^3/h - 50, X m^3/h i mniej - 0

	B- value of bad debts written off, C - value of receivables recovered in a given period, D - revenue in a given period			
Prepaid receivables ratio over 30 days	$\frac{(A+B-C)}{D} \cdot 100\%$ A - value of receivables over 30 days past due, B- value of bad debts written off, C - value of receivables recovered in a given period, D - revenue in a given period	%	X	X m^3 /h i więcej - 110, X m^3 /h - 100, X m^3 /h - 70, X m^3 /h - 50, X m^3 /h i mniej - 0
Implementation of own costs	$\frac{(A-B)}{B} \cdot 100\%$ A - actual costs in a branch in a given settlement period B - costs planned in the branch in a given settlement period	%	X	X m^3 /h i więcej - 110, X m^3 /h - 100, X m^3 /h - 70, X m^3 /h - 50, X m^3 /h i mniej - 0

Source: own study

In Table 2, values for which commercial confidentiality applies are indicated as 'X.

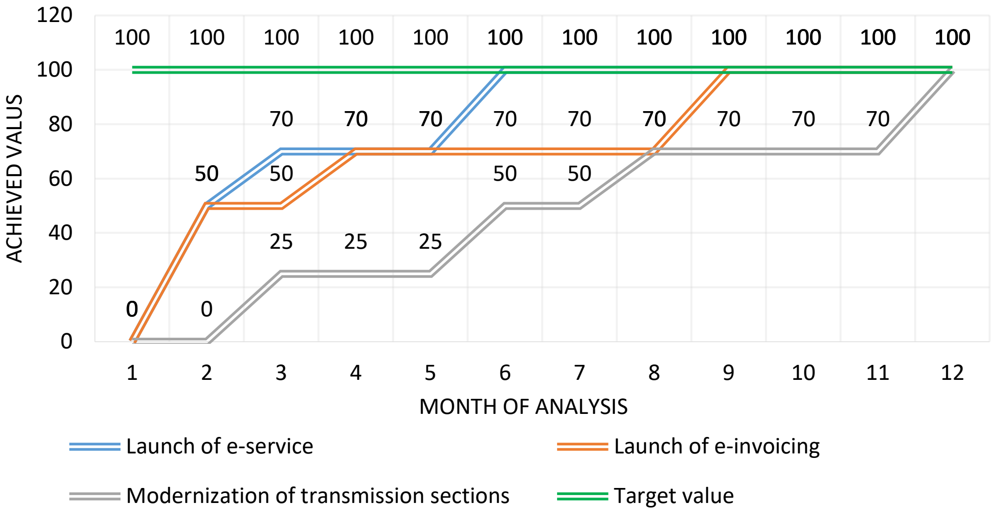
A separate group in the analysed entity are the internal indicators (Table 2), which are used to measure and evaluate processes for the needs of the top management of the organisation.

Externally-oriented indicators - fixed, are quantitative and qualitative in nature. These indicators are characterised by repetition in each analysed period. On the other hand, externally oriented indicators - variables, are characterized by their qualitative nature. This set of indicators is initiated according to changes in the structure of both internal, external conditions and needs. The configuration of the group of variable indicators is modified depending on factors such as: the initiatives of the supervisor, the implications determined by the update of the strategy in relation to the trading area, the progressive conditions of the external environment.

Results and analysis

The research analyzed the results obtained by the business unit over a period of 2 years. Due to the selective ability to present results, the analysis presents key performance measures externally targeted in a group of variables. The results in terms of the level of implementation of the initiatives are illustrated in Figure 2.

Figure 2. Level of implementation of planned initiatives

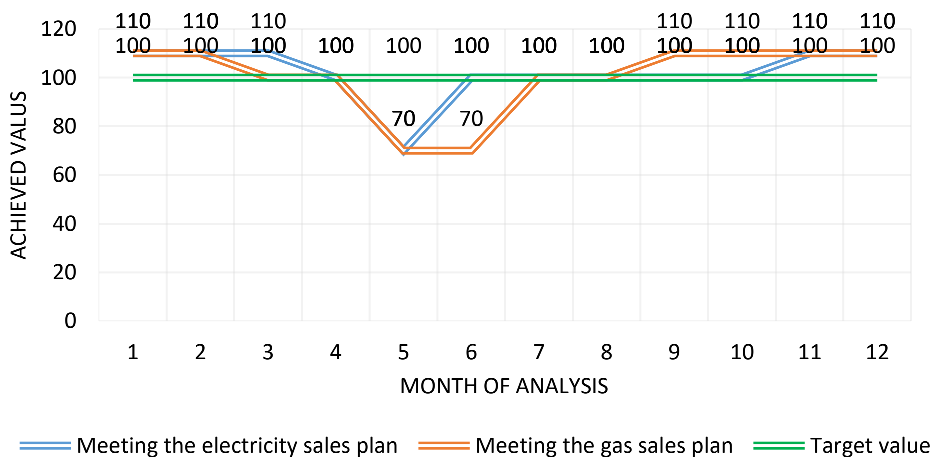


Source: own study

As shown in Figure 2, the utility has completed the activities necessary to implement the three planned initiatives (launching eServices for specific customer groups, launching eInvoicing for specific customer groups, upgrading four transmission segments. The most quickly implemented initiative was the launch of eServices. The process in the second month reached a moderate level of implementation - which meant launching the service to one of three groups of customers - individuals. In month 3, a service for large entrepreneurs was launched. In the fifth month, the goal was fully achieved. Activities concerning the launch of e-invoicing for all customer groups lasted 9 months. The initiative to upgrade certain transmission sections took 12 months, most likely due to the significant costs incurred by the company.

Sales is an important element in the activities of any business entity, because it largely generates profits that are information about the financial health of the organization. However, in order to achieve profits by obtaining a proper level of sales, it is necessary to plan it properly (Pindelski 2011:196-197; Cybulski 2010: 87; Adamowicz and Łuniewska 2015: 363). Data on the level of sales of natural gas and electricity are presented in Figure 3.

Figure 3. Level of achievement of assumptions regarding the sales plan

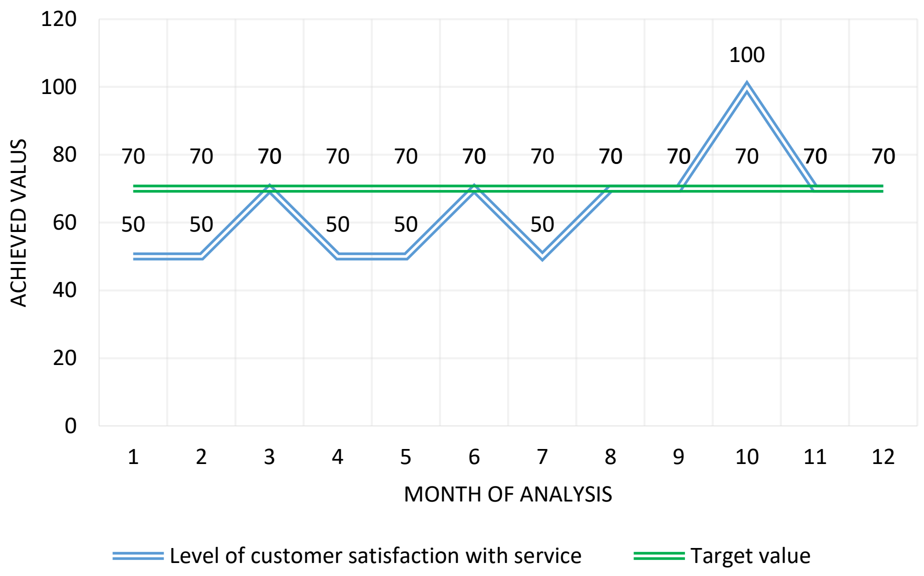


Source: own study

In the period under review, a maintenance plan for gas and electricity sales was developed, under which a sales target was set. Figure 3 shows that the planned level of sales was achieved; moreover, both gas sales (6 months) and electricity sales (4 months) exceeded expectations.

The company aims to maintain an appropriate level of satisfaction with the services provided, as one of the most important aspects affecting the development of the company is the customer's opinion and satisfaction with the services received. Customer satisfaction surveys are one of the basic tools enabling to build a long-term relationship between the customer and the business entity (Wolniak and Skotnicka 2008: 20-25). The result regarding the level of satisfaction among customers of the analyzed organization is shown in Figure 4.

Figure 4. Level of customer satisfaction with service



Source: own study

The level of customer satisfaction of the business unit is on average at a moderate level, which indicates the need for improvement in the way of providing service and customer care. Only in one month did the satisfaction level exceed the target value threshold.

The main goal that the organization should achieve in the future is to retain current customers by increasing customer satisfaction, attracting new buyers and increasing sales volumes. The achievement of the indicated objectives will be possible thanks to:

- reorganization and restructuring in the customer service model through the introduction of a training system and organization design (system of values and motivation of employees),
- gaining sustainable savings on operating costs by reducing the cost of ownership it will be possible to implement an effective pricing policy.

Taking into account the proposed activities aimed at functioning in new conditions of operation, the organisation should design an adequate group of key performance indicators to measure the effectiveness of the performed restructuring activities.

Conclusion

A performance measurement system that is not adapted to the individual nature of the business unit contributes to a loss of control, which translates into an inability to effectively manage the organization. For this reason, it seems crucial to develop an adequate measurement system for the needs and specificity of the organization with the use of appropriate measures - KPIs. The correct development and positioning of measures in relation to the conditions and needs of a given economic entity will ensure the effective and reliable assessment of the objectives pursued by the entity. Therefore, the performance measurement system should be updated due to emerging changes not only in the company itself, but also in the environment. The use of KPIs has made it possible to prioritize activities, which facilitates rapid decision-making.

The study confirmed the effectiveness of using KPIs in a business unit in the energy sector. The proposed indicators made it possible to monitor the level of fulfillment of the established initiatives and modernization plans, and made it possible to identify the critical areas in the organization (low level of satisfaction). It was found that the shape and scope of the performance measurement system depends on the structure of factors that determine the functioning of a business unit. The study indicates the framework and directions of development of key indicators of the performance measurement system based on the premises resulting from changes in the environment.

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