The Recent Development of High-Efficiency Cogeneration Units in Poland

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Abstract

Combined heat and power generation is a tool for achieving energy policy goals – improving energy efficiency, improving energy security, diversifying the structure of energy generation, the wider use of renewable resources, developing competitive markets and reducing the environmental impact of the energy sector. The broader use of combined heat and power, including high-efficiency cogeneration in particular, contributes to saving the primary energy contained in fuel and reducing the carbon footprint calculated in terms of the combined electricity and heat produced. Electricity generation in high-efficiency cogeneration units has found recognition in many European Union countries. These countries have introduced support systems to stimulate the development of these sources. Poland also has significant potential for the development of high-efficiency cogeneration. In Poland, a dedicated law promoting electricity from high-efficiency cogeneration was adopted in 2018. The law was implemented in the second half of 2019. Other schemes were also implemented in Poland, in which high-efficiency cogeneration units may participate for development purposes. The purpose of the all-new regulations is to further develop high-efficiency cogeneration, guaranteeing the possibility of building new sources or activities related to the modernisation or operation of existing sources. The article presents support systems for high-efficiency cogeneration, together with an assessment of their implementation and the impact on the development of these sources.

Key words

energy management, energy efficiency, cogeneration, Renewable Energy Sources.

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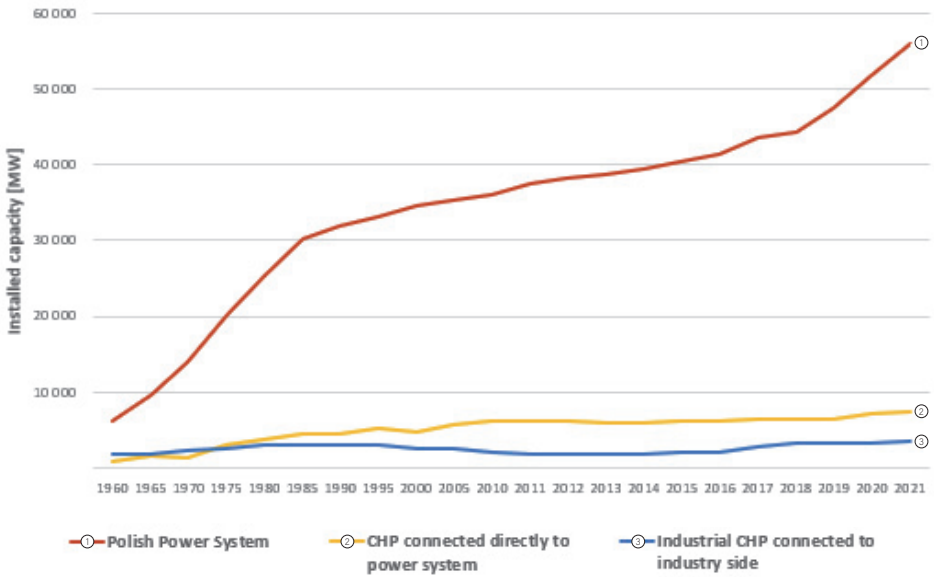
Introduction

Cogeneration, also known as Combined Heat and Power (CHP), is a process in which electricity and heat are generated together in one process or using one energy source. Compared to traditional methods of electricity generation, the cogeneration of electricity and heat is more efficient in converting the primary energy of fuel into useful energy and produces less emissions per unit of energy generated (i.e. electricity and heat in total).

The Polish heating sector makes significant use of cogeneration, mainly in units fired with hard coal, biomass and natural gas. The share of cogeneration in heat production (calculated by volume) amounted to 62.1% in 2022, and 131 out of 355 heating professional utilities produced heat in cogeneration [15]. The share of electricity produced in CHP units has remained stable at approximately 12% for many years [12]. Figure 1 shows the installed capacity of the Polish Power System and the capacity of cogeneration units in 1960–2021.

Graph 1. Installed capacity of the Polish Power System, including cogeneration units – based on Energy Market Agency (EMA) statistical data



Source: own elaboration

An analysis of the statistical data on the installed capacity of the Polish Power System shows that new investments in cogeneration units are stagnant or growing only slightly. Thus, the purpose of this publication is to analyse the existing support mechanisms for high-efficiency cogeneration and assess how effective they are in spreading this technology in the Polish power and heating systems.

1. Cogeneration in Poland

The Polish Power System presently contains 1.5 GW of cogeneration capacity fired with natural gas and 5 GW of coal-fired

cogeneration capacity. Industrial CHP plants have 1.8 GW of gas-fired capacity and 1.2 GW of coal-fired capacity [13]. Industrial CHPs generate electricity and especially heat for industrial processes and are usually located on industrial sites; they are sometimes able to deliver surplus electricity and heat to the household sector.

Cogeneration plays an important role in producing heat for district heating systems that supply energy to approximately 16 million customers in Poland. The main fuel used for heat production in cogeneration is hard coal, accounting for around 59.21% of all fuel consumed to produce heat in CHP, followed by biomass at 15.18%, slightly ahead of natural gas at 8.76%. Table 1 shows the consumption of fuels for heat production in 2022 according to figures from the Energy Regulatory Office (URE) [15].

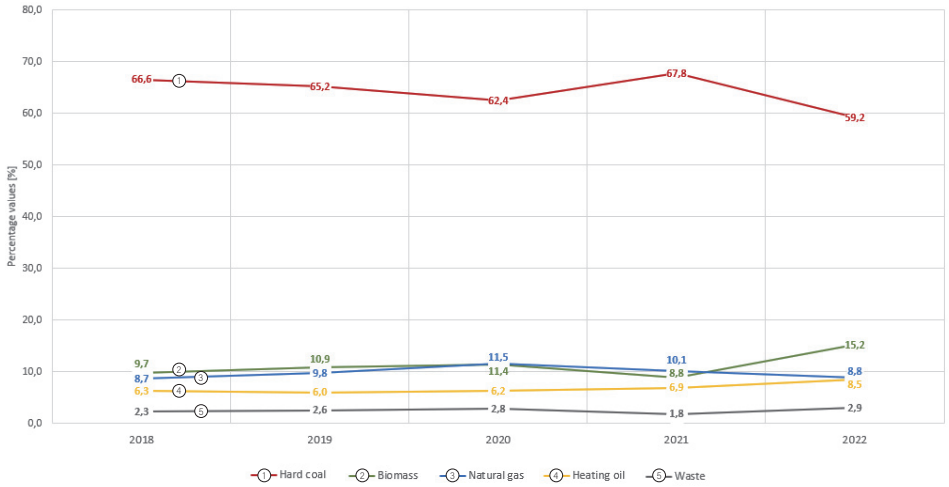
Table 1: Fuel consumption for heat generation in 2022 – compiled based on URE data [15]

	Fuel consumption for heat production			
Fuel type	**Total [GJ]**	**Cogeneration [GJ]**	**Total [%]**	**Cogeneration [%]**
Hard coal	291,644,203.64	186,548,701.00	65.19	59.21
Lignite	4,601,984.61	4,047,859.81	1.03	1.28
Heating oil	29,204,065.13	26,811,878,32	6.53	8.52
Natural gas	41,398,026.71	27,600,420.39	9.25	8.76
Biomass	54,869,015.75	47,837,882.39	12.26	15.18
Biogas	275,772.09	246,825.09	0.06	0.08
Other RES	1,203,504.64	29,234.81	0.27	0.01
Waste	9,251,847.67	9,251,098.23	2.07	2.93
Other fuel	14,918,198.42	12,675,628.01	3.33	4.02

Source: own elaboration

It is worth pointing out the change in the fuel structure for cogeneration units in terms of the previous years. Dating back to 2018, it is possible to observe a steady share of hard coal, which only fell below 60% in 2022. There is also a noticeable increase in the importance of biomass and heating oil. It is worth mentioning that the war in Ukraine and sanctions on fuel imports from Russia led to an increase in hard coal and natural gas prices in Europe. The market situation justified the search for alternative energy sources, which turned out to be biomass and heating oil. It is worth noting that biomass, biogas and other RES technologies accounted for more than 15% of the heat generated in CHP in 2022, which constitutes an upward trend compared to previous years. Graph 2 shows fuel consumption for heat generation in cogeneration for the period of 2018–2022.

Graph 2. Fuel consumption for heat generation in cogeneration for the period of 2018–2022 – compiled based on data published annually by URE



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The profile of electricity production in cogeneration depends on the seasonality of heat production: heat is mainly consumed in autumn and winter, from September to May. Conversely, electricity demand is constant throughout the year. For cogeneration units that are producing steam for industry, the constant heat consumption throughout the year allows the primary energy of the fuel to be saved to the greatest extent. Today, when an increase in renewable energy sources is observed in Poland, especially wind and PV units, flexible cogeneration units can play a significant role in satisfying the projected generation balance in the power system [13].

The development of CHP units is also linked to urban development. In Poland, almost every major city is supplied with heat from a district heating network. Currently, there is a trend of population movement from the countryside to the cities, followed by the development of urban centres. This involves the construction of new buildings which are connected to district heating networks. Along with this, the demand for heat and electricity, and therefore for more generation from CHP units, is growing. Connections of new consumers to district heating networks in large cities with over 500,000 inhabitants amount to approximately 20–40 MW/year, except for the Warsaw district heating system, to which over 100 MW of new customers have been connected annually in recent years. This enlargement of district heating systems requires the modernisation, reconstruction and construction of new high-efficiency cogeneration units. However, the development of cogeneration units will be reconsidered due to regulatory conditions, in particular the availability of support systems [14].

New cogeneration units have significant development potential in Poland, primarily due to the conditions on the heating market, the projected growth in demand for capacity in the power system and the need to phase out older, obsolete units. The share of cogeneration in the production of heat and electricity is projected to rise gradually, with increasing emphasis on the development of units using renewable energy sources (approximately 20% of the installed cogeneration capacity will come from renewable energy sources in 2030) [8]. According to the Polish Energy Policy until 2040, the majority

of new CHP units will be powered by natural gas. Approximately 2.5 GW of new units of this type may be built by 2030, and then another 3.5 GW by 2040 [11].

To achieve this potential, dedicated operational support mechanisms have been implemented, namely a support system for high-efficiency cogeneration and a support system for renewable energy sources. High-efficiency cogeneration units can also participate in the capacity market [22, 26, 27].

2. Cogeneration in the European Union Policy and Regulations

EU climate policy promotes the use of cogeneration, inter alia, by gradually raising energy efficiency ambitions. The *Fit for 55* package of regulations calls for the reduction of greenhouse gas emissions in Europe by 55% by 2030 (compared to the 1990 level) and the achievement of climate neutrality by 2050. The analysis of EU regulations comprising the *Fit for 55* package suggests that high-efficiency cogeneration can be used to achieve the fundamental goals of the EU climate and energy policy: reducing greenhouse gas emissions, improving energy efficiency and expanding the use of renewable energy resources.

2.1. Emission trading system

The revision of the Directive establishing a system for trading greenhouse gas emission allowances in the European Union [1] included in the *Fit for 55* package calls for the faster withdrawal of CO_2 emission allowances. The directive establishes a separate emissions trading system for the construction and transport sectors and for fuels for additional sectors. The new system will apply to heat suppliers (including in-house energy producing installations with a total nominal thermal capacity below 20 MWth) if the installations are not subject to the existing emission trading system. This system will oblige these undertakings to submit emission allowances from 2027, with the maximum price of emission allowances set to 45 EUR/tCO_2. The amount of 45 EUR is based on 2020 prices and will be indexed based on the consumer price index. The regulatory environment thus created is to encourage undertakings to seek further opportunities to reduce CO_2 emissions and thus cut the operating expenses of utilities, which can be done, among others, by investing in high-efficiency cogeneration. All of the directive regulations stimulate market players to undertake activities related to decreasing CO_2 emissions. Cogeneration may play a vital role in this area.

An important element of the revision of the ETS Directive is the free allocation of an additional 30% of allowances for the district heating sector in certain member states. The main condition for receiving an additional allocation is the presentation of a climate neutrality plan by an installation operator specifying investments that are to be made, such that by the end of 2030 there will be a significant reduction in CO_2 emissions. The value of the additional allocation of free emission allowances must reflect the investment costs incurred in accordance with the climate neutrality plans. Therefore, for the heating sector in Poland, this is an opportunity to obtain additional funds for investment.

2.2. Energy efficiency

The tightening of the European Union's climate policy has led to a new definition of the energy efficiency improvement target: reducing final energy consumption in 2030 by at least 11.7% compared to 2030 energy consumption projections made in 2020. Energy Efficiency First is a core principle that is reflected in legislation and actions undertaken by national and EU institutions. Poland has set the following national contribution to the 2030 EU target: primary energy consumption of 91.3 Mtoe in 2030 and final energy consumption of 67.1 Mtoe in 2030.

These values, however, need to be adjusted to reflect the more ambitious approach presented in the *Fit for 55* package.

In the period of 2011–2021, Poland undertook significant improvements in the field of energy efficiency. Total primary energy consumption increased in the period of 2011–2021 from 96.6 Mtoe to 104 Mtoe (a cumulative annual growth rate of 0.74%). Final energy consumption increased in the same period from 64.7 Mtoe to 75.2 Mtoe, which means that the cumulative annual growth rate was 1.5%. The fastest rate of energy efficiency improvement between 2011 and 2021 was recorded in the industrial sector (1.3% per year) followed by households (1.1% per year) and transport (0.9% per year) [25]. Increased energy efficiency can occur, among other things, by transforming existing power plants and heating plants into combined heat and power plants, as well as building new high-efficiency cogeneration units which maximise the use of primary energy.

High-efficiency cogeneration represents one of the components of efficient district heating systems as defined by the Energy Efficiency Directive [3]. Maintaining the status of an efficient district heating system is a condition for receiving financial support for investment projects in the DH system. At the same time, EU regulations rule out financing cogeneration that emits more than 270 gCO_2/kWh of electricity and heat generated and therefore cannot be defined as being high-efficiency. High-efficiency gas-fired cogeneration will maintain the status of effective district heating systems at least until the end of 2034; from then on until 2045, the share of renewable energy sources and waste heat will have to be gradually raised in order to maintain such status.

2.3. Energy efficiency of buildings

A change in the definition of zero-emission buildings was proposed during work on the Energy Performance of Buildings Directive [2]. From 2030, all new and thoroughly modernised buildings should comply with the definition of zero-emission buildings. Such buildings are to be supplied with energy only from renewable sources via an efficient district heating system. The proposed regulations rule out the use of heat from high-efficiency cogeneration for zero-emission buildings. EU regulations view high-efficiency cogeneration fired with biogas, biomass or waste most favourably, and high-efficiency cogeneration fired with natural gas less favourably.

Currently, more than half of the energy demand for heating residential buildings in Poland is satisfied by coal, mostly by means of indirect use in district heating systems. However, residential buildings remain largely energy-inefficient. Only about 20% of Polish district heating systems qualify as energy-efficient in line with the existing definition of efficient district heating systems. Moreover, 76% of district heating systems in Poland are based on coal, and most of those systems are based on cogeneration.

2.4. Renewable energy sources

The share of energy from renewable energy resources as a percentage of the total energy consumed in the EU is targeted to reach 42.5% by 2030 (the previous target was 32% by 2030 and has been tightened by revision of the Directive). Based on the current Directive, the goal may be additionally raised by 2.5 percentage points, which would raise the 2030 target to 45%. Cogeneration is a technology that uses renewable fuel efficiently. The revisions introduced by the new Directive on the promotion of the use of energy from renewable sources will impact the wider use of biomass [4]. The Directive limits the use of biomass by power plants due to the low efficiency of fuel conversion, and designates this fuel stream for CHP units which, by generating two energy streams – electricity and heat – can use this fuel much more efficiently. The lack of

access to certified biomass may impact the ability of Polish district heating systems to maintain their efficient system status. As of 2022, biomass was the second most popular fuel for cogeneration units in Poland after coal.

The *Fit for 55* package continues the climate and energy policy followed so far. The new regulations, as with previous legislative packages, will affect energy undertakings, including heating ones, and will drive their strategy and investment projects [10]. EU regulations play an important role in determining the form of member states' support systems. This is because state aid to economic operators that affects the internal market of the European Union is prohibited in principle. EU law permits the use of state aid only if it is justified by material reasons (e.g. aid for environmental activities). However, every aid case is treated as an exception to the rule and, in principle, requires justifications and approval by the European Commission. It is important to adjust the implemented support instruments to the *Fit for 55* package without delay so that cogeneration becomes a real tool for implementing Polish policies and achieving the intended goals.

3. Cogeneration in Polish Regulations

3.1. High-efficiency CHP support scheme

The Act of 14 December 2018 on promoting electricity from high-efficiency cogeneration (hereinafter: the "**CHP Act**") [19] entered into force on 25 January 2019 and specifies the operating principles of the support system dedicated to high-efficiency cogeneration. The purpose of the CHP Act is to develop high-efficiency cogeneration by supporting the construction of new sources and promoting activities related to the modernisation or operation of existing sources.

The CHP Act divides cogeneration units into existing, modernised, significantly modernised and new – planned to commissioning. The CHP Act defines modernisation as an investment process aimed at restoring the original condition or changing the operating or technical parameters of a cogeneration unit. The Act also regulates the quality of materials and components used for the construction and modernisation of CHP units – they cannot be manufactured more than 60 months prior to the date of the initial generation of electricity from a particular unit. Additionally for modernisation, the capital expenditure during this investment must be within the range of 25% to 50% of that for a comparable new cogeneration unit. A significant modernisation is one where the capital expenditure exceeds 50% of that for a comparable new cogeneration unit.

Another important criterion for CHP units is the installed capacity [9]. Cogeneration units are split into the following installed capacity ranges:

- up to 1 MW (small CHP plants);
- from 1 to 50 MW;
- more than 50 MW;
- more than 300 MW.

The regulations apply an emission benchmark of 450 gCO_2/kWh. The emission benchmark laid down in the CHP Act may be revised when the *Fit for 55* package is transposed into the national legal system. The maximum duration of support for new units is 15 years from the date of commissioning – supplying electricity to the grid and selling it from this unit. Support for new cogeneration units may be provided in the following forms:

- guaranteed premium – below 1 MW (small CHP plants);
- cogeneration premium – from 1 to 50 MW;
- individual cogeneration premium – above 50 MW.

Table 2: Support parameters under the high-efficiency cogeneration support system in 2024 compared to 2023 (values in brackets)

Installation type	Gas fuels [PLN/MWh]	Solid fuels [PLN/MWh]	Biomass [PLN/MWh]	Others [PLN/MWh]
Guaranteed bonus – new or modernised small CHP unit	**161.24** (181.53)	**0** (0)	**0** (0)	**119.95** (106.52)
Guaranteed bonus – substantially modernised small CHP unit	**109.64 – 161.24** (123.44 – 181.53	**0** (0)	**0** (0)	**71.97 – 119.95** (64.03 – 106.72)
Individual co-generation bonus Guaranteed bonus – modernised; Cogeneration unit with an installed capacity between 1 and 50 MW; Reference values for a new cogeneration unit	**324.42** (390.83)	**0** (458.44)	**418.38** (415.35)	**278.06** (301.45)
Reference values for a significantly modernized cogeneration unit	**220.61 – 324.42** (265.76 – 390.83)	**0** (183.38 – 458.44)	**167.35 – 418.38** (166.14 – 415.35)	**166.84 – 278.06** (180.87 – 301.45)
Guaranteed bonus – existing cogeneration unit with an installed capacity between 1 and 50 MW	**168.97** (435.01)	**0** (0)	**0** (0)	**36.13** (69.32)
Guaranteed bonus – existing small CHP unit	**91.86** (374.52)	**0** (0)	**0** (0)	**0** (0)

Source: own elaboration

Guaranteed premium

The guaranteed premium is paid for each MWh of electricity generated from a new cogeneration unit with less than 1 MW of installed capacity. Electricity does not have to be supplied to the power grid for support to be received. It may be delivered on the industry side or delivered directly to the customer. Existing or modernised units with a capacity from 1 MW to 50 MW can be supported with the guaranteed bonus, but support for these units is conditional on supplying power to the grid. The subsidy amount under the guaranteed premium scheme is determined annually by the Minister of Climate and Environment. A generator intending to receive the guaranteed premium must file an application for a license, build a cogeneration plant, and then apply to the President of the Energy Regulatory Office for admission to the guaranteed premium system and for premium payment.

Cogeneration premium

Generators using new cogeneration units with an installed electrical capacity from 1 MW to less than 50 MW may apply for the cogeneration premium. Generators operating significantly modernised units are also entitled to the cogeneration premium. Support for the cogeneration premium is granted through cogeneration premium auctions announced at least every quarter. The maximum amount of the cogeneration premium is determined annually by the Minister of Climate and Environment.

Individual cogeneration premium

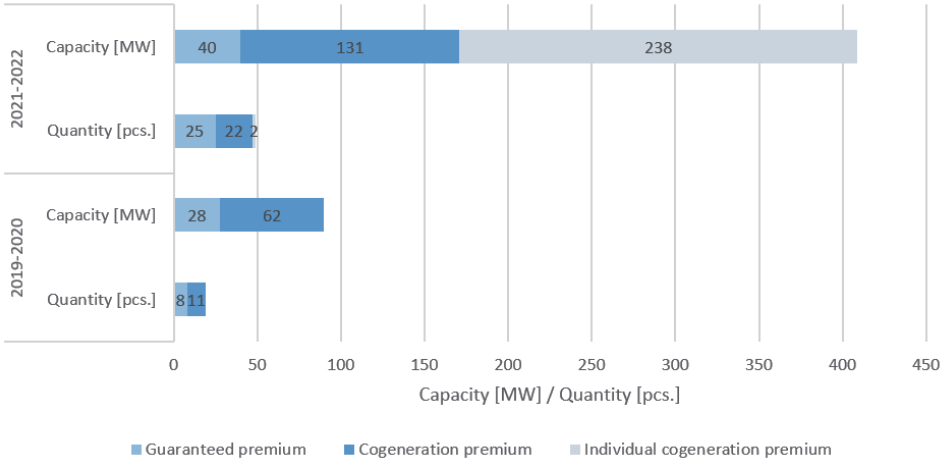
Generators operating new or significantly modernised cogeneration units with an

installed electrical capacity of 50 MW or more are entitled to the individual cogeneration premium dedicated to individual CHP units. Support in the form of the individual cogeneration premium is granted through calls published at least once or twice a year. The maximum amount of the individual cogeneration premium is determined annually by the Minister of Climate and Environment. Generators using units with more than 300 MW of capacity are a special case and may receive support only after individual approval is granted by the European Commission.

Summary

According to information published by the President of the Energy Regulatory Office (ERO) in regular reports on the conditions for undertaking and conducting business in the generation, transmission or distribution of electricity and gas fuels in 2019–2022, support under the CHP Act was granted to approximately 500 MW of installed electrical capacity in 68 new cogeneration units. Graph 3 presents the capacity and number of new cogeneration units contracted under the high-efficient cogeneration support scheme [16].

Graph 3. New cogeneration units contracted under the high-efficiency cogeneration support system in 2019–2022, compiled based on Energy Regulatory Office (ERO) data



Source: own elaboration

A comparison of the above values compiled based on Energy Regulatory Office (ERO) data with Energy Market Agency (EMA) data brings to light discrepancies in how these two authorities collect and present data. EMA data are based on information from power system operators pertaining to the connection of new electricity-generating units. According to EMA data, 617 MW of installed capacity in 40 cogeneration units was commissioned in 2021–2022. Data from the President of the ERO indicate that 409 MW of installed capacity was built in 49 cogeneration units, which were built with state aid. However, assuming that the difference between these two values provides an estimate of the number of units built outside the support scheme is not correct. For example, ERO data excludes the Żerań CCGT unit, which received support as part of the capacity market. EMA data, on the other hand,

excludes cogeneration units that were supported with guaranteed premiums, because this support is not conditional on supplying energy to the grid.

The growth of new capacity in cogeneration units is not impressive, and the support system for high-efficiency cogeneration is failing to achieve the desired results. The operation of the high-efficiency cogeneration support mechanism also significantly deviates from the projections made in the impact assessment of the CHP Act. When drafting the Act, legislators planned for new installed capacity to grow by 2,900 MW in 2019–2022 under the high-efficiency cogeneration support system. Instead, only 17.2% of the planned capacity was contracted by the end of 2022. Table 3 shows the increased capacity from cogeneration units expected during regulation drafting.

Table 3: Installed electrical capacity volume of cogeneration units planned to be supported in 2019–2023 –compiled based on the CHP Act impact assessment

Installed electrical capacity (MW)	2019	2020	2021	2022	2023
Auctions	100	400	300	300	300
– solid fuel	20	75	75	75	75
– gas fuel	80	300	200	200	200
– other fuel	0	15	15	15	15
– biomass	0	10	10	10	10
Small cogeneration units	50	50	50	50	50
Call	600	600	250	150	100
TOTAL	**750**	**1050**	**600**	**500**	**450**

Source: own elaboration

The high-efficiency cogeneration support system for 2023–2024 will require adaptation to new EU regulations. This includes, among others, a new definition of high-efficiency cogeneration, hence lowering the emission benchmark to 270 gCO2/kWh. The Fit for 55 transposition period may also offer an opportunity to introduce broader changes to improve the operation of the CHP Act.

3.2. Capacity market

High-efficiency cogeneration units may be supported as part of the capacity market introduced in Poland. This mechanism is governed by the Act of 8 December 2017 on the capacity market (hereinafter: the "**Capacity Market Act**") [18]. As part of the capacity market, generating units can bid capacity obligations or demand side response at capacity market auctions [5]. The maximum amount of capacity obligation that may be bid at a capacity auction is calculated based on the installed capacity of a given generating unit and the capacity utilisation factor determined individually for each technology by way of a Regulation [6, 21].

The capacity market in Poland was established as a response to the need to ensure available capacity in the power system to guarantee the security of power supply to consumers [20]. Under this mechanism, energy generators, operators of energy storage and DSR offer their generation capacities

at dedicated capacity auctions, and receive payment for this available capacity determined by the results of this auction. Then, the transmission system operator verifies whether the obligatory capacity supply was delivered; if the capacity obligation has not been fulfilled, the generator may be charged a financial penalty. Cogeneration units are entitled to take part in capacity market mechanisms.

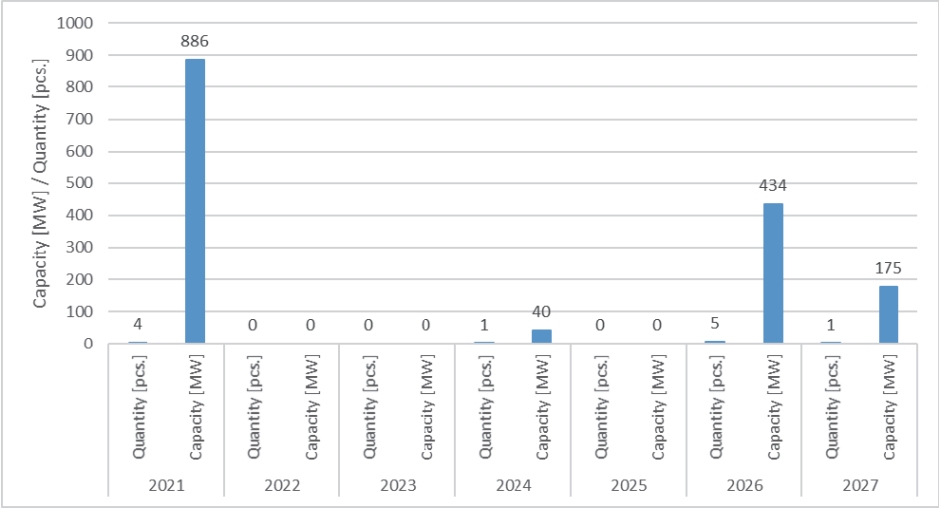
The capacity market includes main auctions and additional auctions. Main capacity market auctions are held annually for the delivery year five years thereafter. In principle, both new and existing units can bid in main capacity market auctions, but for existing units, support is provided for no more than one year. Cogeneration units generating more than 30% of electricity in high-efficiency cogeneration annually can bid at both the main auction and the additional auction for the same delivery year. It is worth noting that the Capacity Market Act refers directly to the notion of high-efficiency cogeneration, which in the coming years will mean cogeneration with emission lower than 270 gCO_2/kWh of energy produced by combined heat and electricity generation.

The maximum period of support for new units as part of main capacity market auctions is 15 years and may be extended by two years if the unit carbon dioxide emission rate is lower than 450 gCO_2/MWh of electricity and heat in total. This solution is dedicated primarily to cogeneration units, which can thus benefit from the capacity market for 17 years. The emissivity criterion of the capacity market is yet another criterion that will have to be changed once the negotiations of the *Fit for 55* package are finalised, because some units, in order to be recognised as high-efficiency cogeneration, will have to demonstrate emissions of less than 270 gCO_2/kWh.

In addition, cogeneration units must supply at least half of the generated heat to a district heating system in which hot water is the heating medium. The capacity market also offers additional auctions held in the first quarter of the year for the next year of delivery. Additional auctions are, firstly, to "top up" the capacity in the system purchased at the main auctions, and secondly, to account for the seasonality of electricity production at some generating units, in particular CHPs. At additional auctions, support is granted for a specific quarter of the next delivery year.

Determining which cogeneration units bid at capacity auctions requires reviewing information about investment projects selected at capacity auctions that is reported publicly. The officially published results of capacity auctions do not identify the technology or fuel used. It should be emphasised that the capacity reported by the media and in the results of capacity market auctions concerns the capacity contract, so it is not the same value as the installed electrical capacity of the generating unit. A detailed analysis of the final results of capacity auctions suggests that approximately 1,535 MW of capacity was contracted from 12 new cogeneration units at all previous main auctions (delivery years 2021–2027). The results of capacity market auctions for cogeneration units are presented in Graph 4.

Graph 4. New cogeneration units contracted on the capacity market for the 2021–2027 delivery years – compilation based on capacity auction results



Source: own elaboration

To date, seven main auctions have been held for the 2021–2027 delivery years. At those auctions, at least 1.5 GW of installed electrical capacity of new cogeneration units was contracted. Neither PSE (the Polish TSO) nor the Energy Regulatory Office distinguishes cogeneration units in the published capacity auction results. Detailed data on this subject should be presented by the Cabinet in the assessment of the capacity market operation by the end of 2024. The capacity market supports and can continue to support the development of high-efficiency cogeneration units in Poland in the future. A comparison of the results of the main capacity market auctions to the support system for high-efficiency cogeneration shows greater investor interest (by volume) in the capacity market. The capacity market is dominated by investments in large cogeneration units.

The future of the capacity market in Poland is determined by EU regulations concerning the internal electricity market. Currently, a reform of the energy market proposed by the European Commission is in the process of legislative work (New Market Design). During the negotiations, Poland ensured the extension of the derogation for the capacity market emission performance standard. The applicable EU regulations exclude any financial aid for generating units with emissions exceeding 550 kg CO_2/MWh, but for Poland, a derogation until June 2025 was already provided during the work on the *Winter Package*. New Market Design may extend the derogation until the end of 2028, which will allow Poland to carry out the necessary investments while maintaining energy security. At the same time, New Market Design clearly indicates that from a long-term perspective, the capacity markets across the EU should become a tool supporting investments in DSR and energy storage solutions.

3.3. RES support scheme

Cogeneration units using renewable energy resources may be supported through the mechanisms established in the Act of 20 February 2015 on renewable energy sources (hereinafter: the "**RES Act**") [17]. The

support systems provided for in the RES Act include an auction support system, a feed-in tariff system ("**FIT**") and a feed-in-premium system ("**FIP**"). Renewable energy support systems are to provide support for 15 years. The FIT and FIP systems are addressed to smaller units and specific technologies. The technology list is common and includes biogas (all types), hydropower and biomass. It is worth noting that, unlike the auction support system, the FIT and FIP systems do not obligate generators to produce a specific amount of energy.

Feed-in tariff system (FIT)

The FIT system guarantees the sale of electricity supplied to the network at a fixed price equal to 95% of the reference price. Reference prices are published for a calendar year by way of a regulation of the minister responsible for energy and determine the maximum amount of support that can be received by a given technology using renewable energy resources. Renewable energy installations eligible for the FIT must have less than 500 kW of total installed electrical capacity and be fitted with a separate set of equipment for power output. The purchasing entity is the so-called obligated seller appointed by the President of the Energy Regulatory Office.

Feed-in premium system (FIP)

The FIP system is designed for generators with installations from 500 kW to 2.5 MW of installed capacity (except for biomass, for which the installed capacity cannot exceed 1 MW) who sell electricity to a selected entity other than an obligated seller. The FIP system entitles the generator to have their negative balance covered (by a premium) up to the difference between the reference price and the average market price of electricity. The generator is authorised to apply for negative balance coverage, and the entity competent to settle it is the Settlement Administrator.

Renewable energy auctions

The RES Act governs the so-called auction support system, as part of which the President of the Energy Regulatory Office announces, organises and conducts auctions divided into specific technology baskets every year. The subject of the auction is the sale of electricity generated by a renewable energy installation and fed into the grid. The President of the Energy Regulatory Office regularly publishes the schedule of auctions to be held in a given year with the division into technology baskets. Auctions may be organised annually for CHP units within the following technology baskets:

- for agricultural biogas – in cogeneration or in simple cycle, above 1 MW;
- for agricultural biogas – in cogeneration or in simple cycle, up to 1 MW;
- for biogas from landfills, from sewage treatment plants, other biogas, waste to energy, biomass or hybrid systems – in cogeneration or simple cycle, above 1 MW;
- for biogas from landfills, from sewage treatment plants, other biogas, waste to energy, biomass or hybrid systems – in cogeneration or simple cycle, up to 1 MW.

Separate reference prices (maximum auction prices) were introduced for some technologies, including cogeneration, from 25 January 2019. Table 4 shows reference prices for individual technologies, both with and without (values in parentheses) cogeneration in 2019–2022.

The published reference prices increase year by year, with reference prices for cogeneration growing faster. Unfortunately, the increase in new cogeneration capacities supported by renewable energy auctions does not go hand-in-hand with an increase in reference prices, which determine the maximum amount of support. Table 4 and Graph 5 below present the reference prices of selected renewable energy technologies from 2019.

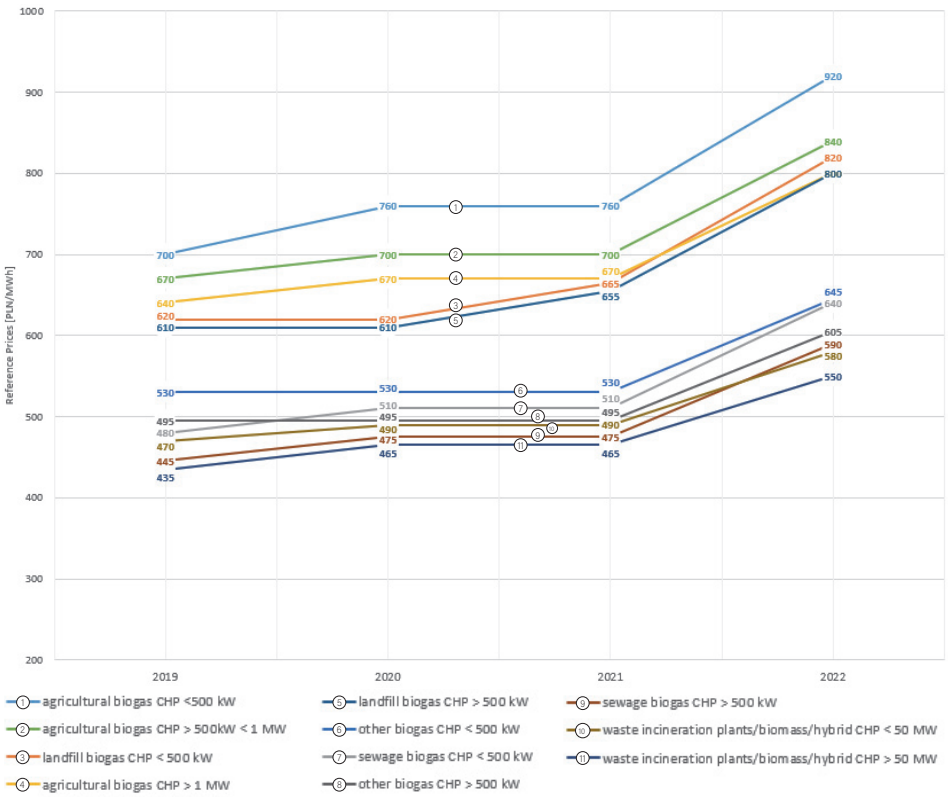
Table 4: Reference prices for renewable energy installations with and without cogeneration – own elaboration

Installation type	Reference price of selected technologies with cogeneration (reference price without cogeneration) [PLN/MWh]			
	2019	2020	2021	2022
Agricultural biogas < 500 kW	700 (650)	760 (650)	760 (650)	920 (785)
Landfill biogas < 500 kW	620 (560)	620 (560)	665 (605)	820 (730)
Sewage treatment biogas < 500 kW	480 (420)	510 (420)	510 (420)	640 (515)
Other biogas < 500 kW	530 (500)	530 (470)	530 (470)	645 (570)
Agricultural biogas 500 kW–1 MW	670 (590)	700 (590)	700 (590)	840 (715)
Agricultural biogas > 1 MW	640 (570)	670 (570)	670 (570)	800 (700)
Landfill biogas ≥ 500kW	610 (550)	610 (550)	655 (590)	800 (705)
Sewage treatment biogas ≥ 500kW	445 (385)	475 (385)	475 (385)	590 (470)
Other biogas ≥ 500kW	495 (435)	495 (435)	495 (435)	605 (525)
Waste to energy, biomass or hybrid system ≤ 50 MW	470 (435, 350)	490 (465, 350)	490 (465, 350)	580 (525, 420)
Waste to energy, biomass or hybrid system > 50 MW	435 (435, 350*)	465 (465, 350*)	465 (465, 350*)	550 (525, 420*)

Explanation: * – a separate reference price applies to waste to energy plants.

Source: own elaboration

Graph 5. Reference prices for renewable energy installations with cogeneration – own elaboration



Source: own elaboration

Summary

According to information published by the President of the Energy Regulatory Office in regular reports on the conditions for undertaking and conducting business in the generation, transmission or distribution of electricity and gas fuels in 2018–2022, 121 certificates allowing the sale of unused electricity at a fixed price were issued for cogeneration plants. The total installed electrical capacity of such units approximated 77 MW. It should be emphasised that this number includes both existing and new installations – the figures published by the Energy Regulatory Office do not divide the plant capacity into existing and new sources. Therefore, it can be assumed that no more than 77 MW of installed power was contracted from 121 new cogeneration units using agricultural or landfill biogas in 2018–2022. Table 5 lists certificates issued by the President of the Energy Regulatory Office for the sale of electricity from cogeneration units.

Table 5: List of certificates issued in 2018–2022 allowing the sale of unused electricity at a fixed purchase price, categorised by installation type – compiled based on ERO data [16]

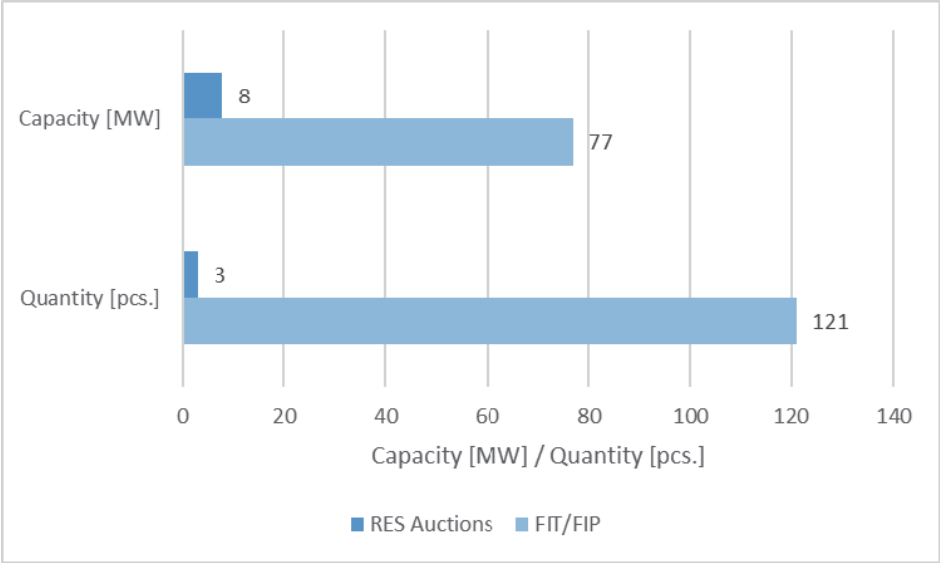
Type of cogeneration plant	Number of certificates issued [pcs.]	Installed electrical capacity (MW)
Agricultural biogas	112	69.394
Landfill biogas	9	7.631
Sewage treatment biogas	0	0

Source: own elaboration

The capacity of new high-efficiency cogeneration units supported through renewable energy auctions can be estimated by analysing auction results from 2019–2022. 2019 saw a number of renewable energy auctions, as existing and new installations were allowed to bid at auctions: twelve auctions were held altogether, with cogeneration units allowed to bid at seven of those. With regard to new installations for which auctions were held in 2019, it is worth noting the auction for biogas from landfills and from sewage treatment plants, other biogas, waste-to-energy, biomass or hybrid systems above 1 MW, where one winning bid was selected out of four placed by the same undertaking. No bids were accepted in auctions for agricultural biogas installations up to 1 MW and above 1 MW, respectively. Eight auctions were held in 2020, four of which were open to cogeneration plants, and again no transactions were finalised at many auctions. It is worth noting the auction for biogas from landfills and from sewage treatment plants, other biogas, waste-to-energy, biomass or hybrid systems above 1 MW, in which two generators were selected, both heating utilities, which means that cogeneration installations were most likely contracted at this auction. In 2021, eight auctions were organised, including four for cogeneration plants. No transactions were finalised at any of these auctions. The situation was similar in 2022, when seven auctions were held, with cogeneration units allowed at three of them; all auctions ended unsuccessfully.

In essence, approximately 8 MW of installed electrical capacity from three new high-efficiency cogeneration units using renewable energy may have been contracted at auctions held in 2019–2022. RES auctions, FIP and FIT could have supported approximately 85 MW of installed electrical capacity of new cogeneration units altogether using renewable energy in 2019–2022, as presented in Graph 6. The RES auctions held so far have not provided significant support for new cogeneration units. Even though several auctions are announced every year at a minimum, the vast majority of them are unsuccessful in regard to CHP.

Graph 6. New cogeneration units contracted under the renewable energy support system – own elaboration



Source: own elaboration

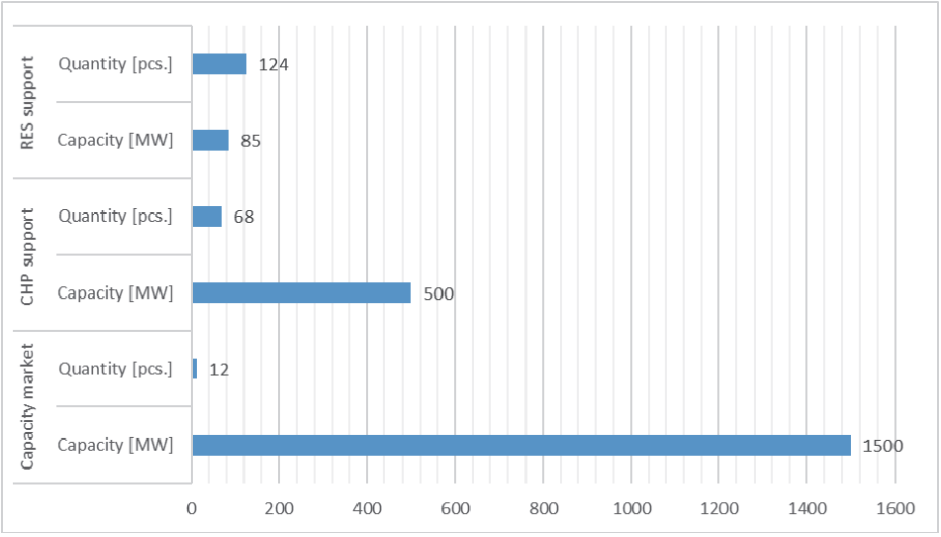
4. Summary

Most high-efficiency cogeneration units have been or are being built thanks to support from the capacity market. Approximately 1.5 GW of capacity of 12 high-efficiency cogeneration units were contracted at all main capacity market auctions conducted so far (2018-2022), of which almost 900 MW (four units) were launched before 2021. Mainly producers operating large CHP units seek support as part of the capacity market.

The support system under the dedicated Act on promoting high-efficiency cogeneration has successfully delivered approximately 500 MW of installed electrical capacity in 68 new high-efficiency cogeneration units since 2019. Producers mainly receive support in the form of cogeneration premiums, which means that the system supports new units with more than 1 MW of installed capacity.

The support system for renewable energy sources has delivered no more than 85 MW of installed capacity in 124 new cogeneration units supplied with renewable energy. It is worth noting that support is mainly provided through the FIT and FIP systems to biogas units, which are installations of up to 1 MW in capacity. Graph 7 summarises the new generation capacities of cogeneration units built under the auspices of the above support mechanisms.

Graph 7. New high-efficiency cogeneration units supported under various systems – own elaboration



Source: own elaboration

The Polish power system and heating sector require new installed capacity of cogeneration, particularly that supplied with renewable energy. These types of units have a special role to play in the context of the EU climate and energy policy and the policies of individual member states, including Poland. The development of Poland's major large cities is associated with increased demand for heat and electricity. New residential buildings under construction, as well as industrial and commercial facilities, are being connected to the district heating network. This determines the development of district heating systems. High-efficiency cogeneration units can bring ready-made technological solutions for these systems while strengthening the goals of improving energy efficiency, reducing emissions and developing the use of renewable energy sources.

Despite the great potential for the development of cogeneration in Poland and the various support mechanisms implemented for these units, the spectacular effects of these systems are not observed. The assumed goals, as indicated by statistical data, have not been realised. Regulations bring moderate development of high-efficiency cogeneration units. The statistics collected for this paper indicate that the growth rate of high-efficiency cogeneration in Poland is insufficient. The support systems established are not effective in terms of realising the full development potential of these units. There are reasons to review the support mechanisms, assess their impact on the development of cogeneration and district heating in Poland, formulate recommended revisions to the law and make the necessary legislative changes to ensure the desired development of these sources. Revision and changes are needed in particular in the dedicated Act on promoting the use of high-efficiency cogeneration. Neither has the Act on renewable energy sources led to the construction of cogeneration units using biomass, biogas and other renewable resources that would stabilise the operation of generating units in the National Power System.

The development of cogeneration in Poland is conditioned by numerous regulations at the EU level. Energy utilities formulate their development strategies based on European Union and national regulations. Heating utilities using cogeneration should adopt a proactive approach to the changing regulatory environment, including by taking an active part in debates on energy sector development at both the national and EU levels. In this respect, a broad presentation of the national conditions of the Polish heating sector would be reasonable.

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