PTEC

Impact of EU regulations on the transformation of the centralized district heating sector in Poland

assessment of the effects and recommendations for national regulations

Report by Polish Association of Heat Energy

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Preface

Dear Sirs,

Poland's centralized district heating sector is in a transition process that aims to achieve climate neutrality in 2050. The implementation of the EU's climate and energy goals (the European Green Deal and the „Fit for 55" package) poses a number of decarbonization challenges for the sector and will require energy companies to work closely with both local governments and final customers for heat. I believe that only full involvement in the transformation of all market participants will make it possible to achieve the assumed decarbonization goals in the timeframe required by the EU legislator. A key challenge for energy companies posed by EU regulations is to meet the criteria for an efficient centralized district heating system, while ensuring the price competitiveness of system heat and minimizing the burden of transition costs on Poland's residents. This report is a signpost of possible paths for decarbonizing district heating systems, as their starting point are the „Fit for 55" package regulations, commercially available technologies and fuels. This report provides information on the financial effort ahead for heat generators, distributors and final customers.

According to the results of expert analyses by the Polish Association of Heat Energy (PTEC), capital expenditures for the transformation of the centralized district heating sector will, depending on the scenario, amount to between PLN 299 billion and PLN 466 billion by 2050.

The process of decarbonizing centralized district heating is a huge challenge for all its participants and beneficiaries; therefore, for the time being, it is the national legislation that seems to be the key element in the process. That legislation should support the sector's drive for investment and open up new opportunities for financing these projects.

I hope that the proposals contained in this report will provide a starting point for further discussions and changes in the regulatory environment supporting investment in the energy industry.

Handing the report over to you,
I hope you will find it an interesting read.

Dariusz Marzec
President of the Management Board
Polish Association of Heat Energy

1. Executive summary, conclusions and recommendations

Centralized district heating sector – basic data

- In Poland, centralized heat guarantees thermal comfort to about 15 million Poles, representing more than half (52.2%) of all households.

- In 2022, cogeneration heat production accounted for 62.1% of total heat production by licensed power companies.

- The share of RES in heat production reached 12.6% in 2022, 97% of which results from the use of biomass for energy. Achieving the European Union's climate-policy ambitions will require further increases in the share of RES in heating and cooling. National targets have not been defined definitively – but the share should be estimated at 32.1% to 35.4%, depending on the country's ambitions. This means that the share of RES in heating and cooling should be increased by at least 19.5 percentage points by 2030.

Impact of regulations on the direction and pace of decarbonizing centralized district heating

- This report conducts a variant analysis of the economic, technical and regulatory adaptation of centralized district heating utilities to the regulations contained in the „Fit for 55" package. Its main objective was for the district heating system to achieve or maintain the status of an efficient district heating system for individual heat markets that differ in size and demand structure. This is a key regulation for the sector arising from the (EU) Energy Efficiency Directive (EED), which determines the possibility for obtaining financing to implement the decarbonization process.

- The long-term prospects for the development of district heating systems are also affected by the adopted legal solutions contained in the (EU) Directive on the Energy Performance of Buildings (EPBD), which will cause:
  1. Increased pace of thermal retrofit of existing buildings to reduce final and primary energy demand;
  2. Tightening technical guidelines for new residential construction toward high energy efficient and passive houses.

  This will result in a degradation of the heat market, understood as a reduction in heat demand for the existing mass of buildings and lower demand from new connections of buildings from the primary and secondary markets (with reduced demand for central heating), which will have a significant impact on the structure of individual heat markets.

- The process of decarbonization of the sector is complemented by regulations contained in the (EU) Directive on the Promotion of the Use of Energy from Renewable Sources (RED III) and the (EU) Directive establishing the Union's greenhouse gas emission trading scheme (EU ETS). Both directives support an increase in the share of renewables and low-carbon sources in district heating through RES share targets (national and sectoral) or additional allocations of free CO_2 emission allowances for achieving significant emission reductions before 2030 and incurring investment costs equal to at least the value of the additional allowances.

Results of the analysis – investment expenditures on the transition of the centralized district heating sector at the level of PLN 299 billion to PLN 466 billion by 2050.

- The analysis, described in detail in Chapter 7, was carried out for heat markets specific to Poland, classified according to contracted capacity. The model is based on detailed macroeconomic, market and technology assumptions for reference heat markets for the period 2024–2050. Four technology options were proposed for each market to meet the definition of an efficient district heating and cooling system. The developed model in each year recalculates the most cost-effective heat sources, taking into account not only the fulfillment of the requirements of an efficient district heating system, but also the variable costs of production, and – for each year – arranges the stack of generating units writing them into the demand resulting from the heat profile for a given variant of the district heating system. This means that the heat production of each unit is based on the demand of a given market and the margin situation in a given year. The generating units with the lowest variable cost operate at the base of the district heating system.

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MEC Piła (Grupa Enea)

- The technology options of the transition were selected in such a way that a one-time investment process would have the potential to meet the regulatory requirements with regard to the effective district heating system in the run up to 2050. The heat markets were divided according to the contracted thermal capacity:
  - up to 20 MW_t;
  - from 20 to 50 MW_t;
  - from 50 to 100 MW_t;
  - from 100 to 300 MW_t;
  - from 300 to 500 MW_t;
  - above 500 MW_t.
- The report analyzes the most important technologies and fuels that can be used to decarbonize the centralized district heating sector. Chapter 5 of this report describes in detail the range of possible technologies for the sector, their working characteristics, and the possibility of participation in the decarbonization or fuel change process. Given the macroeconomic and market assumptions and the technical assumptions adopted for the multi-variant economic model that determines the most cost-optimal options for implementing the „Fit for 55" package, the key technologies in the decarbonization process are as follows:

- gas sources,
- biomass sources,
- geothermal sources,
- large-scale heat pumps,
- electrode boilers powered by electricity from RES.

The authors of the report assumed that, in the future, cogeneration units could also be fueled by decarbonized gases (green hydrogen or biomethane), but this still requires the development of a market for these fuels to ensure their actual supply, as well as adequate transmission and distribution infrastructure. The use of waste heat similarly can be one means for transforming the sector, but its availability varies strongly from location to location. An important technology in the transformation process, which will be worth developing further, is heat storage technology, which brings tangible benefits, including improved flexibility in the operation of generating units.

- This analysis estimates the scale of capital expenditures needed for the transmission and distribution infrastructure segment to bring high-temperature networks (which are predominantly in operation in Poland) in line with the requirements under the „Fit for 55" package for heat quantity and quality, i.e. modernization into low-temperature pre-insulated networks. To estimate the scale of capital expenditures, estimated unit expenditures for the replacement of district heating networks from 2024 were used, and assumptions were made about the diameter of individual district heating networks.

- In the case of Poland, meeting the requirements of the EU's „Fit for 55" package will, depending on the scenario, require expenditures of:
  - from PLN 102 billion to PLN 211 billion – expenditures for generation infrastructure,
  - from PLN 82 billion to PLN 106 billion – expenditures for transmission and distribution infrastructure,
  - from PLN 115 billion to PLN 149 billion – expenditures for modernization of demand facilities.

  that is, in total – from PLN 299 billion to PLN 466 billion for the decarbonization of the centralized district heating sector in the run up to 2050.

  It is important to point out the likelihood of a non-inflationary increase in capital expenditures due to the following: the need to modernize the entire segment at the same time (the opening of a large work site), the saturation of the Contractors' market or the interruption of the supply chain due to the geopolitical situation. These aspects are important given the assumed schedule and the need to meet further milestones for the definition of an efficient district heating and cooling system.

Results of the analysis - reference fuel mix for the centralized district heating sector

- In creating the reference fuel mix for Poland's centralized district heating sector, it was assumed that coal assets would be phased out – scheduled to be phased out by the end of 2030.

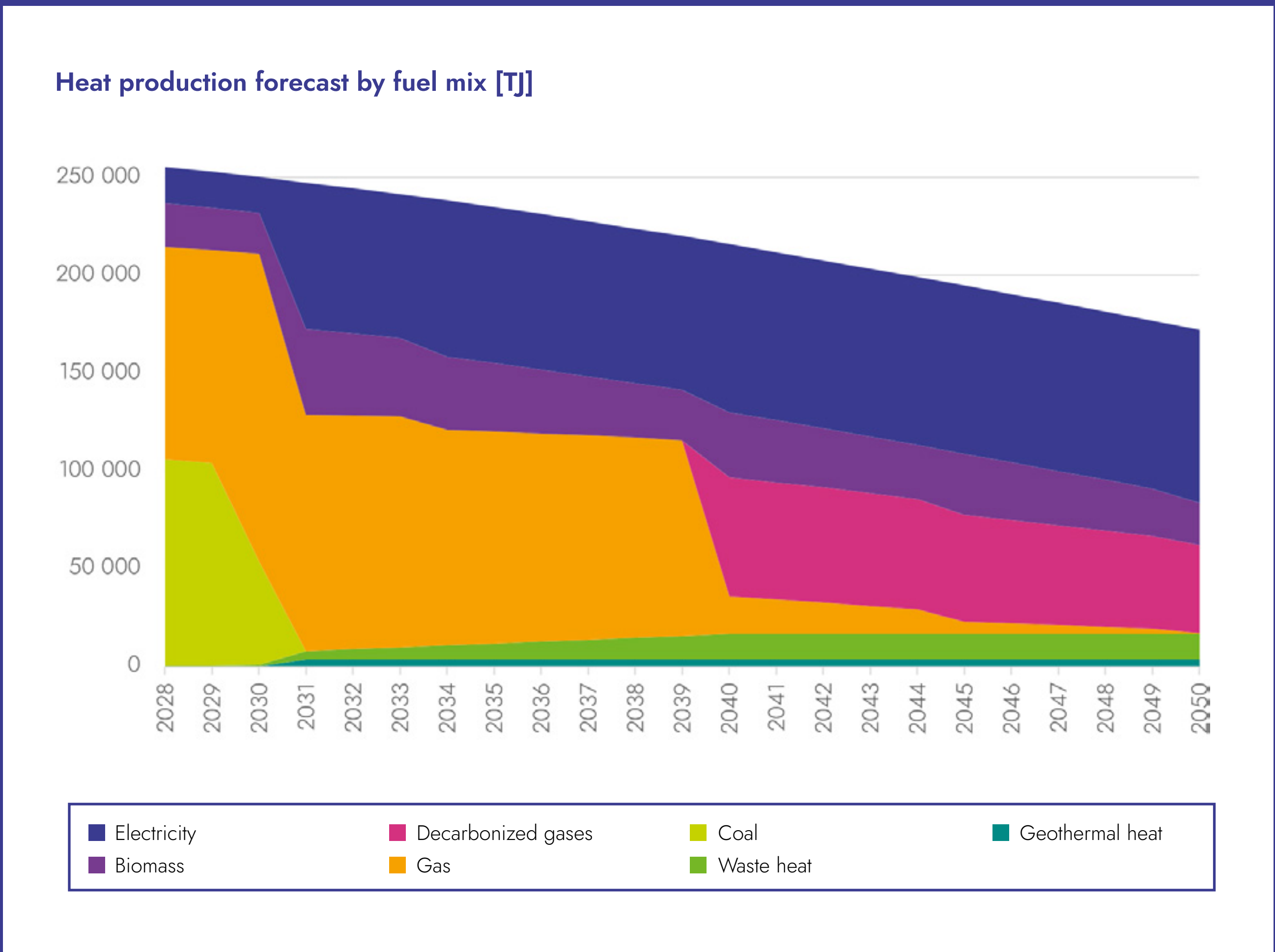
- The issue of the share and duration of operation in the system of a plant defined as high-efficiency cogeneration is in line with the provisions of the EED Directive. According to Annex III of the EED, the new limit for the specific CO_2 emission rate for high-efficiency cogeneration (based on fossil fuels) amounting to 270 g CO_2/kWh will apply to new and substantially modernised units after the transposition date of the aforementioned Annex. Existing cogeneration units may waive this requirement until January 1, 2034, provided they have an emission reduction plan to achieve the 270 g CO_2/kWh threshold by January 1, 2034, meaning that the period can still be extended to the end of 2033.

- The analysis showed that the intermediate fuel for achieving the various milestones in Article 26 of the EED will continue to be natural gas, particularly high-efficiency gas cogeneration, the use of which fits, in terms of the regulations, into the definition of an efficient district heating system by the end of 2039. After this period, as long as a sufficient volume of decarbonized gases is available, it is possible to use some of these assets as RES plants.

- The share of Power to Heat sources will gradually increase in the fuel mix, and the use of heat pumps and electrode boilers with heat storage will be of particular importance to ensure a proper optimization of their operation.

- The share of biomass will increase due to the gradual increase in the share of RES in the „Fit for 55" package requirements. An alternative solution to reducing the volume of biomass burned for district heating is the use of decarbonized gases in the existing gas-fired (to date) generating units in the future, which will allow the regulatory requirements to be met using the assets that are already in place. The important thing, therefore, is the available volume of this fuel – if it is not provided, the key role in meeting the requirements of the „Fit for 55" package will continue to be played by biomass-fired sources.

- The reference fuel mix for the centralized district heating sector is gradually reducing the level of the emissions factor, which is in line with the European Commission's decarbonization expectations.



- It should be noted that, given the need to increase the volume of heat from RES and waste heat, which will be gradually replacing CHP heat in the district heating system baseload operation, there may be a balancing problem for the national power system (in which CHPs account for approximately 15% of the overall generating capacity), especially given the planned increase in capacity at Power to Heat facilities. The above trend may increase the risk of power shortages in the national power system. In order to ensure the stability of the electricity system and improve the security of energy supply in the local market to reduce transmission losses, it is necessary to recognize the leading role of gas cogeneration in ensuring flexibility, availability and support of the national power system in national energy security. The more renewables there are in the system, the greater the need for stable flexible units, and this is the role of gas-fired cogeneration. It is reasonable, taking into account the above-mentioned economic aspects and the change in the role of district heating systems in relation to the national power system (from supplier to consumer of electricity), to introduce an appropriate mechanism that would reward the flexibility/availability of cogeneration units.

Considerations for the cooperation between heat market participants

- A key condition for the successful implementation of the decarbonization of centralized district heating in Poland is that all parties participating in the heat market should be involved in the process, as the different measures being implemented depend

Reference market emission factor forecast [kgCO_2/MWh]

on each other. The burden of transformation should not only be borne by heat producers, which could result from the basic requirement related to the need to change the energy mix in district heating systems, but also by district heating network operators (adaptation to the change of the heat-carrying medium parameters) or final consumers (activities involving thermal performance improvement of buildings and retrofit of demand facilities), which in total will impact the optimization of decarbonization costs.

- In addition to the increasing time pressures, the key challenges of the transition are issues related to the optimal choice of capacity, siting and technology for the new sources. It is therefore important to ensure that the planning process is properly conducted, in close cooperation between the local government administration which plays a crucial role in the heat supply planning process, the heating undertaking/undertakings operating in the location (the heat network operator, the heat generator – if these are separate

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entities) and the final customers. The local government, playing a coordinating role, should cooperate with all market participants whose complementary knowledge of the network segment, as well as the generation segment, will allow the preparation of assumptions for the heat supply plan, taking into account the fulfillment of requirements for an efficient district heating system and those arising from the strategic documents (the National Energy and Climate Plan, the Polish Energy Policy 2040). The coordinating role of the local government is crucial, especially in markets where the district heating system is fed from multiple heat sources and the distributor is a separate entity.

- Effective decarbonization of the district heating system in a given location should also include the end customer who is often directly accessed by the heat supplier (district heating network operator). Generating units produce energy for specific customer needs, hence proper management of the demand side is important in terms of the level of capacity to which generating units need to be restored. This refers to measures to optimize heat consumption by consumers. It includes the implementation of strategies and technologies that help control and reduce heat demand, which may bring tangible benefits in terms of energy and financial savings.

- Designers in Poland rely on climate calculation data from the 2006 PN-EN 12831:2006 standard, which explicitly cites the 1982 division into 5 climate zones with calculation temperatures from -24 to -16 degrees C. The latter's calculation temperatures are averaged values from weather stations over 20 years, meaning that the applicable climate zoning is derived from data for 1962–1981. Currently, a trend of climate change is observed and the resulting increase in the level of the minimum ambient temperature. When designers rely on outdated data this leads to the selection of oversized heating equipment. This exposes end customers and investors (for buildings, the distribution network, as well as the generation equipment) to unnecessary capital expenditures and makes it difficult to optimize equipment operation, as well as hampering the efforts to increase the efficiency of district heating systems.

- The condition necessary for the implementation of the next generation district heating networks is the change of the adjustment of district heating station units and adaptation of indoor systems for operation under low temperature regime. The scale and scope of the work required to adjust internal systems should be evaluated on a case-by-case basis, taking into account the fact that demand facilities are generally oversized.

- Given the directional growth in the use of electricity from renewables in district heating, it is important to emphasize the growing influence of the power industry on the decarbonization of the sector. This is not only about the need to increase renewable electricity generation for district heating, but also the efforts of the Polish Power Grid Company in expanding the transmission infrastructure.

Recommended regulatory changes – the key to accelerating the decarbonization process

- The changing regulatory environment at the EU level is forcing centralized district heating utilities to continually transform themselves to meet the requirements of the „Fit for 55" package, which will involve significant capital expenditures. With this in mind, and taking into account the need to carry out the decarbonization process in a way that protects end users from a drastic increase in heat prices, mechanisms should be introduced to mitigate the costs of the „greening of district heating systems". To this end, PTEC members are proposing to introduce new mechanisms or changes to the current solutions, including:

- A mechanism to reward availability with respect to key units from the perspective of balancing the national power system;
- Operational support mechanism for Power to Heat;
- Trading in guarantees of origin for heat from renewables in a market broader than that covering a specific district heating system and extending guarantees of origin for heat to include waste heat
- Increasing and facilitating the possibility of obtaining white certificates;
- The possibility of co-firing RDF and biomass that meets the sustainability criteria;
- Improving the operation of the support mechanism for high-efficiency cogeneration units.

■ Given the EU's ambitions to reduce CO_2 emissions in the coming decades and the significant investment needs associated with the decarbonization, energy companies operating in the heating sector should have the broadest possible and preferential access to assistance funds to support investment.

■ With the sector's intensifying decarbonization, changes in heat tariffs should follow, including:
- flexibility in developing the tariff for cogeneration units;
- enabling tariffs for heat accumulators;
- additional component of the capital cost formula;
- additional component of the formula for the cost of equity capital;
- increased WACC to cover justified costs for renewable energy technologies, waste heat, and to allow for efficient district heating system status.

■ Technical aspects of the operation of the heat market will translate into faster achievement of the goal of increasing the share of RES heat and waste heat, so it is necessary to introduce, among other things, the following:
- an exemption from the obligation to connect RES plants in accordance with the full catalog of the type of energy included in the definition of an efficient system;
- updating the design parameters used in the design of heating loads in buildings;
- a change in the definition of waste heat.

■ The centralized district heating sector is an essential element in stabilizing the operation of the national power system through combined heat and power production. At the same time, the district heating industry has immense potential to take advantage of surplus renewable electricity generation, as well as its storage and conversion to renewable heat. For an even greater cooperation between the sectors, it is necessary to:
- enable a widespread use of Power to Heat in the heating industry;
- introduce the possibility to qualify the entire heat stream generated by heat pumps (classified as a renewable energy source) as heat from renewables for the purpose of meeting the definition of an efficient district heating system;
- introduce a possibility to classify heat generated in electrode boilers as heat from RES for compliance with the definition of an efficient district heating system.

■ Environmental regulations are one of the key areas supporting the transition of the centralized district heating sector in Poland. What is referred to here are those regulations that affect the cost of carrying out licensed activities related which involve the use of the environment, and therefore also affect prices for end users of heat, as well as the mechanisms for financing investment projects. Among the key environmental demands are the Polish government's actions at the EU level in the area of the Climate Neutrality Plans, and consequently, the access to additional funds for investments.

- In order to accelerate the transformation of the heating sector, selected administrative procedures should be streamlined and simplified, which includes:
  - adopting a fast track in administrative proceedings for investment projects related to the decarbonization of the heating industry, including significantly speeding up and simplifying the issuance of decisions on environmental conditions for project implementation;
  - facilitating the investment process for the construction/reconstruction of the district heating network.

- The „Transformation determinants related to the cooperation between heat market participants" section points to the special role of cooperation between undertakings, local government and final customers in the decarbonization of the sector. The signposts for the aforementioned heat market participants are the strategic planning documents at the national and local government levels. In this regard, it is crucial to synchronize the activities of municipalities and the strategies of energy undertakings for heat supplies.

For a full list of mechanisms and tools needed to be implemented to support the centralized district heating transition process, see Chapter 7 of the report.


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2. Conditions for the operation of the centralized district heating sector in Poland

2.1. Statistics of the Polish centralized district heating sector

The district heating sectors can be divided into two areas: centralized (district heating) and decentralized ones. The former covers district heating systems which include district heating networks and generating units, whereas the latter refers to individual heat sources in houses and buildings, as well as heat generated and consumed in industrial plants.
In Poland, centralized district heating plays a key role, covering more than half (52.2%) of households[1], placing our country among the European leaders in that field.
According to the Statistics Poland (GUS), in 2022, the heat consumption in Poland declined slightly compared to the previous year, reaching 439.8 thousand TJ. This means a decline by 4.5% compared to the previous year. Within the aforementioned quantities, 35.7% of heat was used for household purposes[2].
Large-scale heat generation (above 5 MW) requires that a license be obtained and is subject to pricing regulations of the Energy Regulatory Authority (URE). As of the end of 2022, 392 enterprises held licenses for various aspects of the district heating business, such as generation, transmission, distribution, and trade in heat (a total of 810 individual licenses for a given type of activity with respect to heat supply to consumers).
Detailed data showing the characteristics of licensed district heating in Poland over the past two decades are given in Table 1.

Table 1. Characteristics of licensed district heating in the years 2002–2022[3]

Specification	2022 r.	2012 r.	2002 r.
Number of licensed district heating companies	392	466	894
Installed capacity in MW	53 188	58 147,9	70 952,8
Contracted capacity in MW	34 924	34 142,5	38 937
Length of networks in km	22 578	19 794,1	17 312,5
Employment in jobs	27 772	36 084	60 239
Total heat sales in TJ	357 703	389 364,5	469 355,5
Heat returned to the network in TJ	265 658	283 920,9	336 043
Heat supplied to network-connected consumers in TJ	233 134	248 040,1	298 938

1. Statistics Poland, Energy carrier consumption in households in 2021
2. Consumption of fuels and energy carriers in 2022, Statistics Poland, Warsaw, Rzeszów, December 2023
3. Own study based on "Heat power engineering in numbers – 2022", Energy Regulatory Office, Warsaw, October 2023, and "Heat power engineering in numbers – 2012", Energy Regulatory Office, Warsaw, July 2013

Energy undertakings licensed for district heating activities operate on a diverse and fragmented technical infrastructure. Its scale is determined by the following two main parameters: thermal capacity of installed equipment and length of the district heating network. Based on the parameters in question, a given district heating system can also be characterized (in terms of its size).

In 2022, their total installed thermal capacity was 53,188.4 MW, representing a slight decline from 54,109.6 MW in the previous year. At the same time, the length of district heating networks increased to 22,578.4 km in 2022 from 22,223 km in 2021.[4]

It is worth noting that the network length provided includes both main networks connecting heat sources to heat distribution units and low-parameter networks, i.e. external consumer systems.

An analysis of the structure of enterprises in terms of their network infrastructure has shown that:

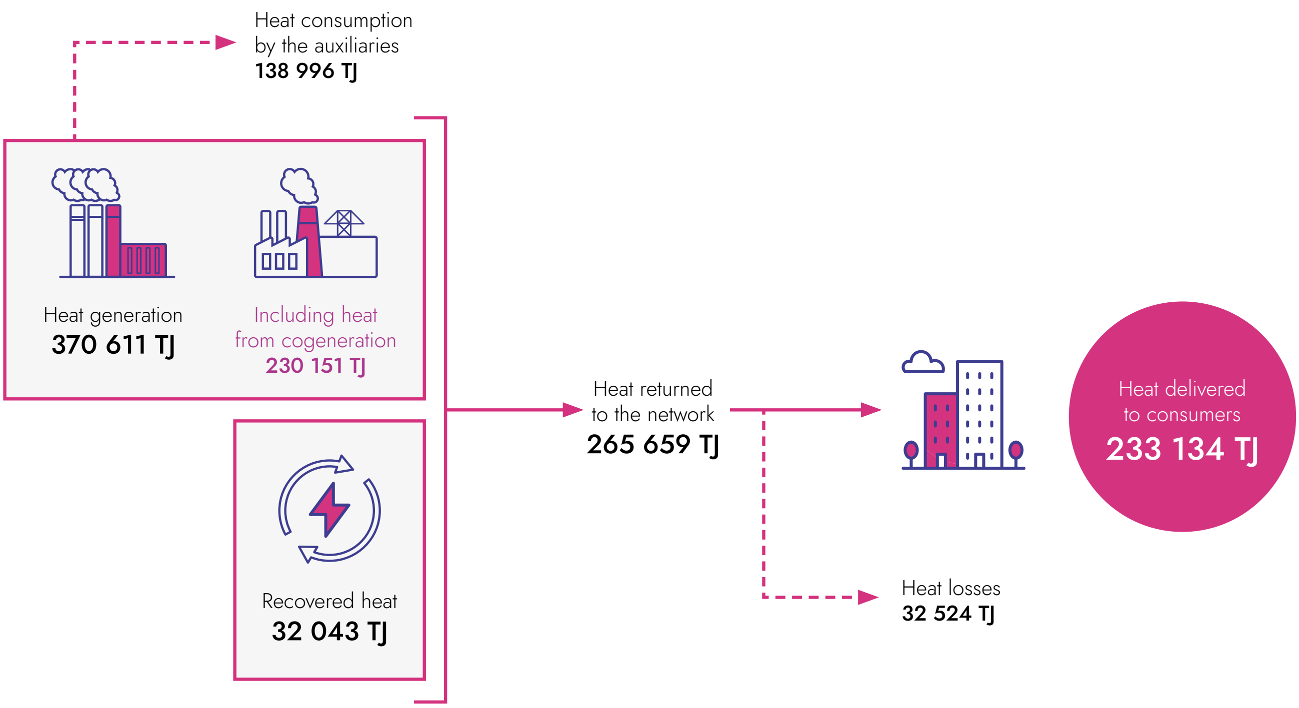
- 46 companies did not have their own district heating networks;
- 268 enterprises had networks longer than 10 km;
- 88 companies in that group managed networks more than 50 kilometers long.

The licensed district heating sector is dominated, in terms of numbers, by small generating units of up to 50 MW, of which there are 220. However, it is the eight largest enterprises, each with a capacity of more than 1,000 MW, that account for about a third of the industry's total generation capacity. Those large entities are also active in electricity generation.

In 2022, the total heat generation by licensed enterprises, taking into account heat recovered from technological processes, amounted to 404.7 thousand TJ. This represents a decrease by 4.8% compared to 2021, when 425.1 thousand TJ of heat was produced.

Detailed data on heat generation by licensed companies, as well as the quantities of heat supplied to the networks and end users, are illustrated in Figure 1.

Figure 1 Heat generation in Poland in 2022[5]



4. "Heat power engineering in numbers – 2022", Energy Regulatory Office, Warsaw, October 2023

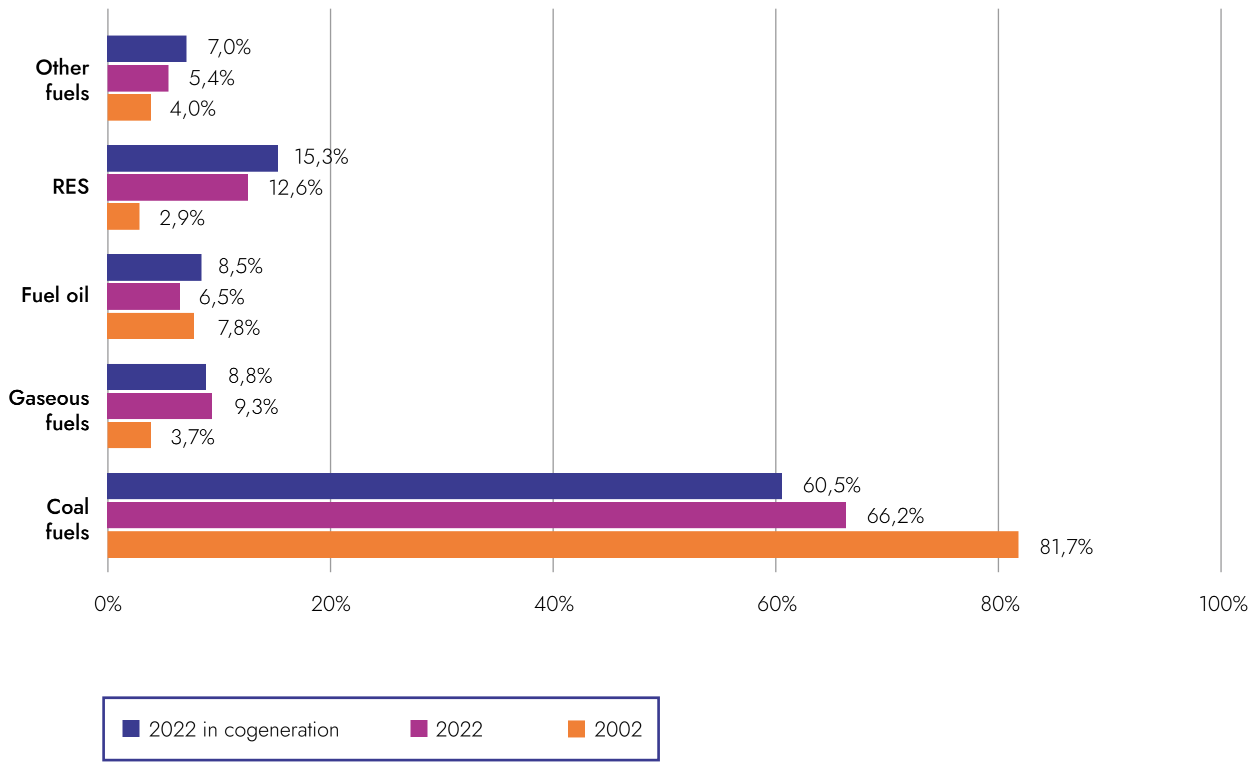
5. Own study based on "Heat power engineering in numbers – 2022", Warsaw, October 2023

In 2022, heat production in cogeneration accounted for 62.1% of total heat generation by licensed energy undertakings. It is a slight decrease by 1.1 percentage points compared to 2021. Of the 355 enterprises generating heat in 2022, 133 of them (i.e. 36.9%) also generated heat in cogeneration.

Analyzing the structure of fuels used for heat generation, one can see slow but systematic diversification of energy sources. Nevertheless, coal fuels continue to dominate licensed district heating. In 2022, their share was 66.2% of all fuels used in heat sources. This is a continuation of the downward trend observed in recent years: 69.5% in 2021, 68.9% in 2020, 71% in 2019, 72.5% in 2018, and 74.0% in 2017. Since 2002, the share of coal fuels has decreased by 15.5 percentage points.

It is worth noting that there has been a significant increase in the share of fuels from renewable energy sources (RES) in the energy mix, indicating progressing changes in the fuel structure of the district heating sector. The structure of fuels in 2002 and 2022 is shown in Chart 1.

Chart 1. Structure of fuels according to energy content, consumed for heat generation in 2002 and in 2022, and for heat production in cogeneration in 2022.[6]



6. Ibid.

In enterprises producing heat in cogeneration, a slightly greater variety of fuels used is noticeable. Although coal fuels still prevail, about a third of the fuels consumed comes from other sources. This group includes renewable energy sources (RES) accounting for 15.3%, gaseous fuels with a share of 8.8%, and fuel oil which accounts for 8.5%.

What needs to be emphasized is the share of RES in heat generation at 12.6% in 2022, which is in 97% due to the use of biomass for energy, as shown in Chart 2. Achieving the European Union's climate-policy ambitions will require further increases in the share of RES in district heating and cooling. National targets have not been defined definitively – but the share should be estimated at 32.1% to 35.4%, depending on a country's ambitions. This means that the share of RES in district heating and cooling should be increased by at least 19.5 percentage points by 2030.

Analyzing heat prices in 2022, a significant increase has been observed. The average single-component price of heat from all licensed sources reached PLN 64.03/GJ, which is an increase by 34.38% compared to 2021. Differences in prices are worth noting, depending on generation technology:

- Average price of heat from sources without cogeneration: PLN 76.39/GJ
- Average price of heat from sources with cogeneration: PLN 55.15/GJ

This major price increase was mainly due to higher costs of heat production, in particular: increase in fuel prices, which is associated with high inflation, and increased costs of CO_2 emission allowances.

It should be emphasized that heat generation costs, and, consequently, the price level, are closely related to the type of fuel used in production. A detailed summary of this dynamic is shown in Table 2.

Table 2. Prices for heat generated from various types of fuels[7]

Specification	2019 [PLN/GJ]	2020 [PLN/GJ]	2021 [PLN/GJ]	2022 [PLN/GJ]
Average price of heat generation	40,97	44,33	47,65	64,03
Hard coal	40,34	43,88	47,27	63,88
Brown coal	25,09	28,03	31,58	37,09
Light fuel oil	73,75	58,4	56,57	78,22
Heavy fuel oil	34,95	37,16	39,58	44,60
High-methane natural gas	52,17	53,64	57,53	79,39
High nitrogen natural gas	43,34	46,06	53,79	75,13
Biomass	42,65	45,77	47,44	58,31
Other renewable energy sources	36,53	37,71	33,49	39,51
Other fuels	37,84	44,08	47,42	57,75

7. Ibid.

The revenue of district heating enterprises depends mainly on the volume of heat sales, which is determined by the heat needs of consumers and the type of fuel used in generation. These factors influence average heat prices and the scope of services provided. However, there is an observable tendency to reduce the demand for heat, which affects companies' revenue. The reasons for this are, in particular:

- Thermal modernization measures taken by consumers;
- Higher average temperatures in the winter months;
- Growing awareness and energy saving by consumers.

It is worth emphasizing that despite the increase in heat prices, the economic situation of the district heating sector has not improved. Since 2019, the profitability of sources generating heat in cogeneration has been negative.

In 2022, there was a significant increase in costs in the district heating sector: total costs of district heating operations increased by 36.94%, while the cost of running district heating operations increased by 36.99%. The main factors contributing to the cost increase are:

- Higher cost of greenhouse gas emission allowances;
- Instability in the fuel market, especially that of natural gas;
- Increase in costs of electricity purchases.

These factors significantly affect the economics of district heating enterprises' operations, presenting them with new financial and operational challenges.

It can be pointed out that both fixed costs (up 8.84%) and variable costs (up 56.8%) increased in 2022. Among fixed costs, the highest increase applied to "Materials and energy" (by 13.11%). Among variable costs, the highest increase also applied to the generation volume-dependent item of "Materials and energy" (by 58.22%), including costs of process fuels together with their transport costs (by 98.93%).

It should be noted that since 2019, total gross profitability (year after year) has remained negative, and the reason for this is the low gross profitability of cogeneration sources. On the other hand, gross profitability of heat sources without cogeneration has been positive for 13 years.

In 2022, total gross profitability (for all licensed enterprises participating in the survey) was minus 22%, with gross profitability for heat-generating sources without cogeneration at plus 0.25% and gross profitability for sources generating heat with cogeneration at minus 38.11%.

The pre-tax financial result was at minus PLN 6.24 billion in 2022 (in 2021: minus PLN 1.5 billion, in 2020: minus PLN 473.8 million, in 2019: minus PLN 543 million). At the same time, 2022 is the first year in which even the "financial surplus" turned negative at minus PLN 2.68 billion. The financial result on sales was minus 5.9 billion zloty, while profitability on sales was minus 21.48%.

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Table 3. Aggregate result on energy activities (electricity and heat) at power plants and combined heat and power plants (2022)[8]

Details	[TPLN]
Revenues from sales of electricity and heat	94 545 048,00
Costs of own operations	46 934 979,20
Costs of purchasing energy for resale, costs of remitted property rights, compensatory payment	15 773 087,00
Selling costs	1 488 589,70
Management costs	1 207 824,00
Total cost of revenue from the sale of electricity and heat	65 445 842,30
Result on sales of electricity and heat	29 099 205,70
Other revenues	4 567 876,90
including revenue from the sale of CO_2 emission allowances	1 070 875,00
Other costs	36 844 003,50
including costs of purchasing CO_2 emission allowances	35 566 188,50
Result including other revenues and costs	-3 176 920,90
Financial revenues	280 065,70
Financial costs	1 457 822,80
Result including financial revenues and costs	-4 354 678,00

2.2. Polish centralized district heating sector in comparison with other European countries

The centralized district heating accounts for a smaller share of the heat market in the European Union (EU). Approximately 10,000 European district heating systems satisfy about 12% of the EU total heat demand (data as of 2021).[9] However, this is above the global average of 8.5% in 2021, according to data published by the International Energy Agency. This clearly shows how much more developed the European centralized district heating is.[10]

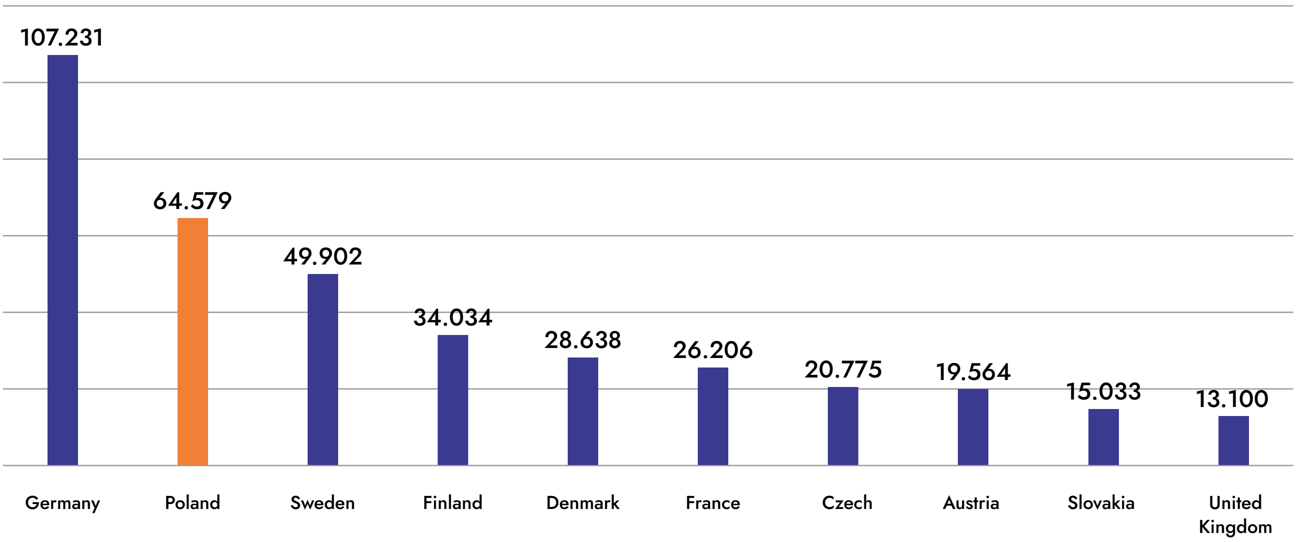
The share of district heating is not evenly distributed across Europe. The importance of district heating networks varies significantly from region to region. District heating systems are by far the most common heating solution in northern and eastern European countries (Nordic countries, Baltic states, Poland, etc.), while in the south and parts of western European countries this method of heat supply plays a minor role (e.g. the Netherlands, the UK, France).

8. Own study based on the Energy Regulatory Office data and G.10.2 reports of the Energy Market Agency
9. DHC Market Outlook 2024, EuroHeat&Power
10. Ibid.

Approximately 77.3 million EU residents use heat supplied by district heating networks, and research indicates that there are more than 19,000 district heating systems in Europe. According to data from national district heating associations and authorities, district heating supply in Europe stands at 608 TWh, reflecting a more comprehensive view of the European market.

One of the key indicators determining the size and potential of district heating systems is the amount of heat sold. Poland ranks among the top countries in this list, as shown in Chart 2. District heating sales, i.e., the amount of heat actually supplied to end users, is an important business indicator that determines the size of the sector.

Chart 2. District heating sales in Europe, 2022[11]

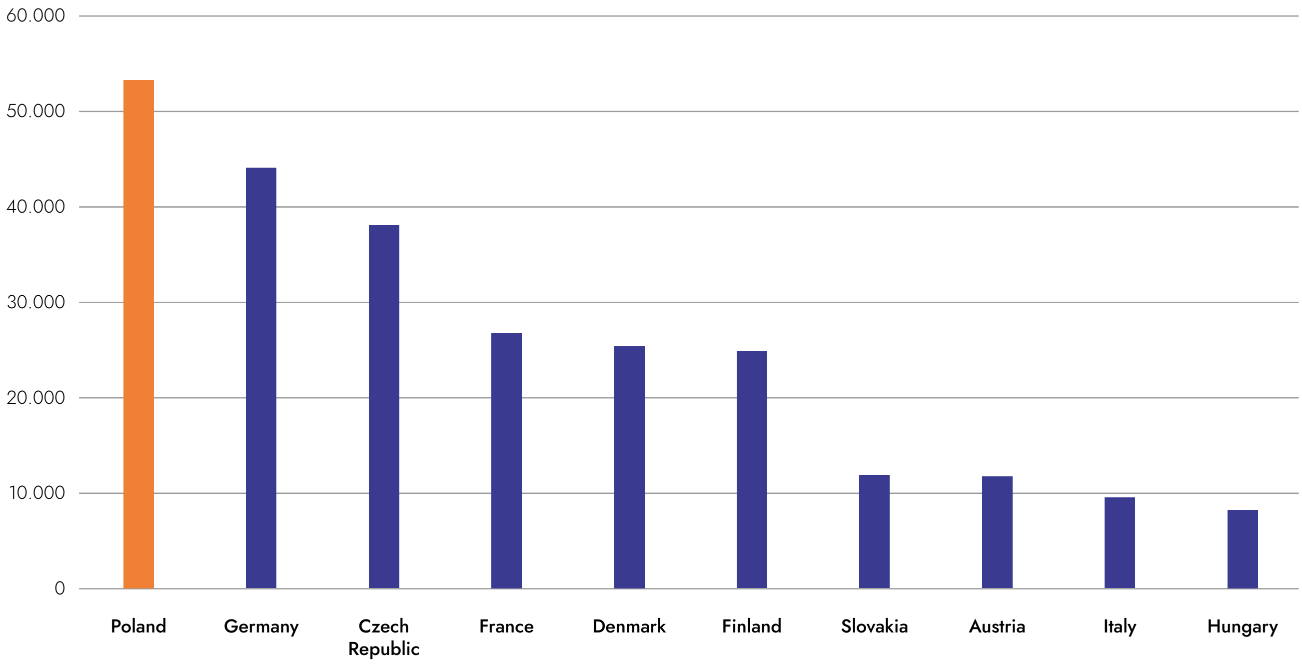


The total installed capacity in the European district heating sector reaches approx. 333.4 GWt in 2022. As illustrated in Chart 3, Poland (53.1 GWt) and Germany (44 GWt) are the countries with the largest installed capacity, followed by the Czech Republic (38.1 GWt), Sweden (27.9 GWt), France (26.8 GWt), Denmark (25.3 GWt), Finland (24.7 GWt), and Austria (11.2 GWt).

A comparison based on the same countries shows that the capacity decreases slightly (by 0.6%) from 2021. While installed capacity increased in some markets (Austria, Belgium, Denmark, Finland, France, Hungary, Portugal, Spain, and the United Kingdom), a minor decrease was recorded in some markets in Central and Eastern Europe, such as Croatia, the Czech Republic, Latvia, Lithuania, Poland, and Romania. This trend is rather due to effectiveness and successful strategies optimizing the use of generation assets than the abandonment of generation sources.

11. Own study based on the Energy Regulatory Office data (for Poland) and DHC Market Outlook, Euroheat & Power, 2024 (for other countries)

Chart 3. Installed capacity by country in Europe, 2022[12]



An additional indicator indicating the size and potential of the sector is the total length of district heating networks (Chart 4). The district heating networks in the analyzed European countries have a total length of 194,845 kilometers, and the data shows that this number has been steadily growing from year to year (2021: 186,590 km[13], 2014: 149,820 km[14]). New connections of consumers to district heating networks in big cities with more than 500,000 residents are approx 20–40 MW per year, an exception being the district heating system in Warsaw, where in the recent years more than 100 MW of new consumers have been connected annually.[15]

The energy mix of district heating systems varies greatly from country to country. This is due to national peculiarities, including with regard to fuel availability at the local level, as well as regulatory conditions. The local aspect, which is particularly important in centralized district heating, is worth noting here. Chart 5 illustrates the centralized district heating energy mix in Poland and neighboring countries compared to the mix in the EU. District heating in Poland, the Czech Republic, Slovakia, and Germany is mainly produced in fossil fuel plants, whereas centralized district heating in Lithuania, Latvia, and Estonia is based on natural gas, biomass and biofuels.

12. Ibid.

13. DHC Market Outlook 2023, EuroHeat&Power

14. D1.1 Report on classification of DHC networks and control strategies August 2015

15. Surma, T., Leśniak, A. "Prospects for the development of high-efficiency cogeneration in Poland in light of the Fit for 55 regulatory package." Rynek Energii 2023, No. 3 (166).

Chart 4. Length of district heating networks, 2022[16]

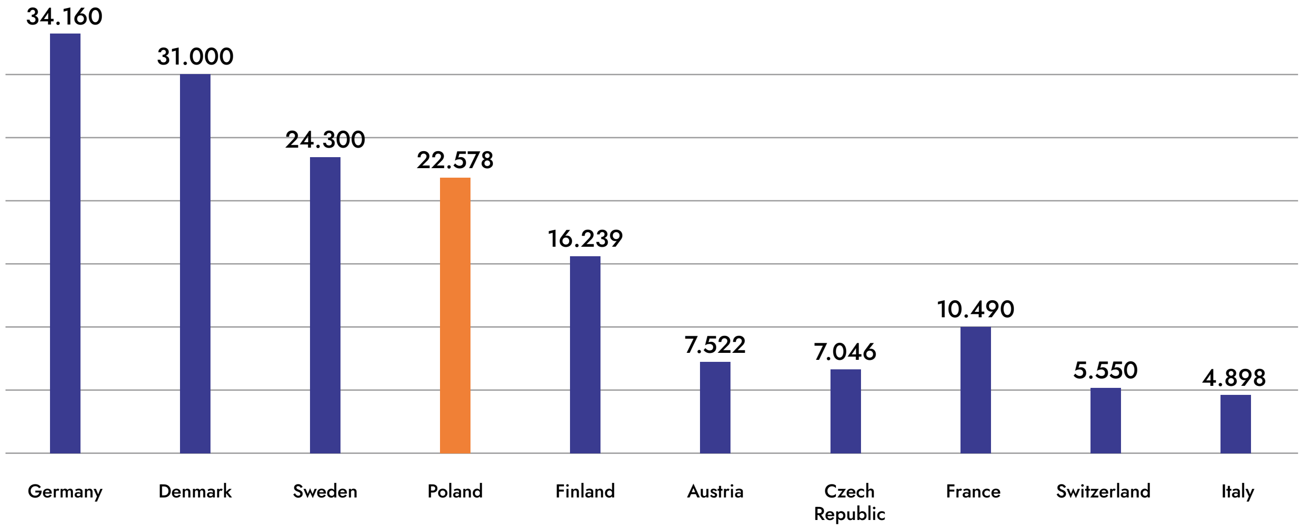
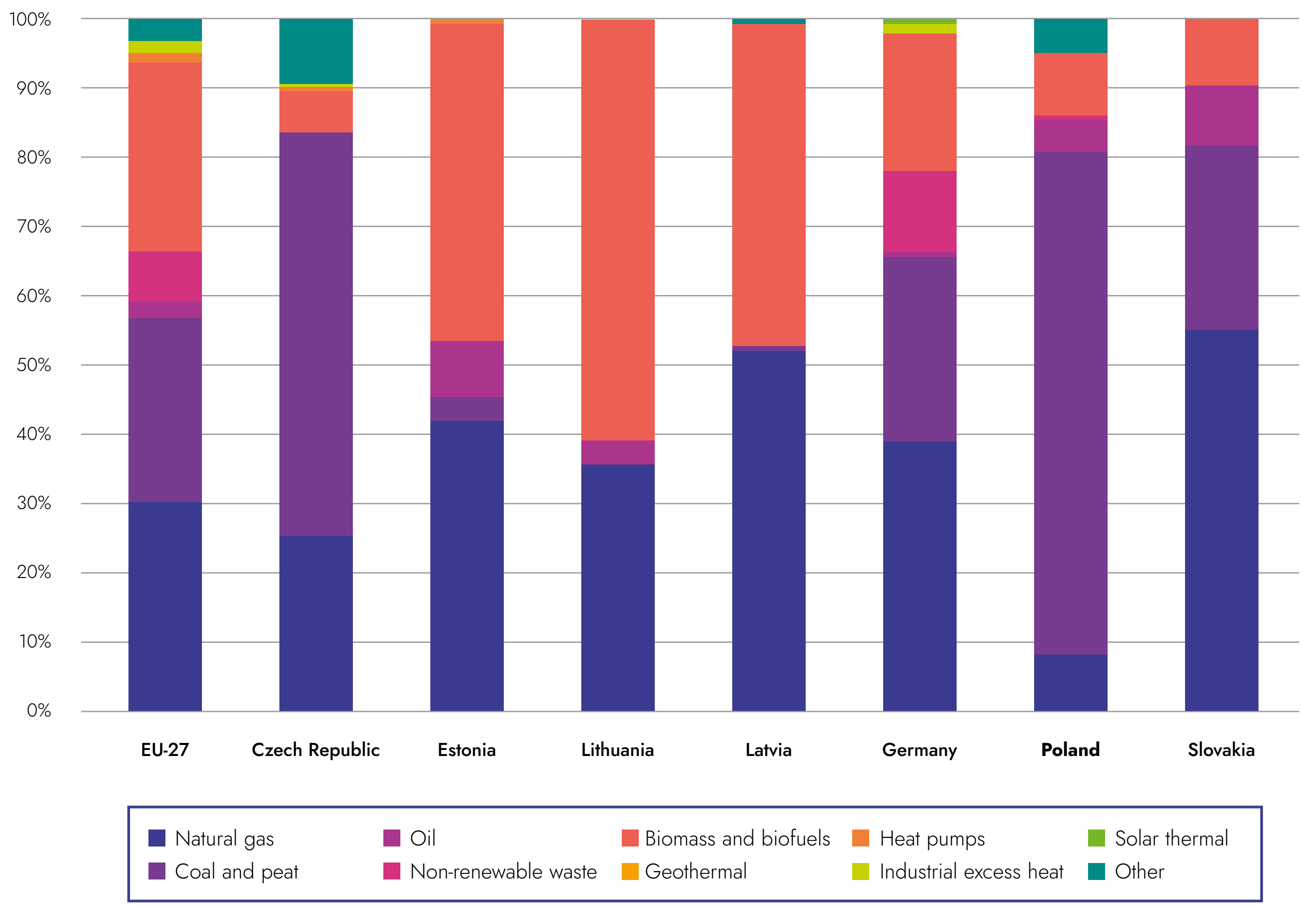


Chart 5. Energy mix in centralized district heating in Poland and neighboring countries in comparison to the mix in the EU[17]



16. Ibid.

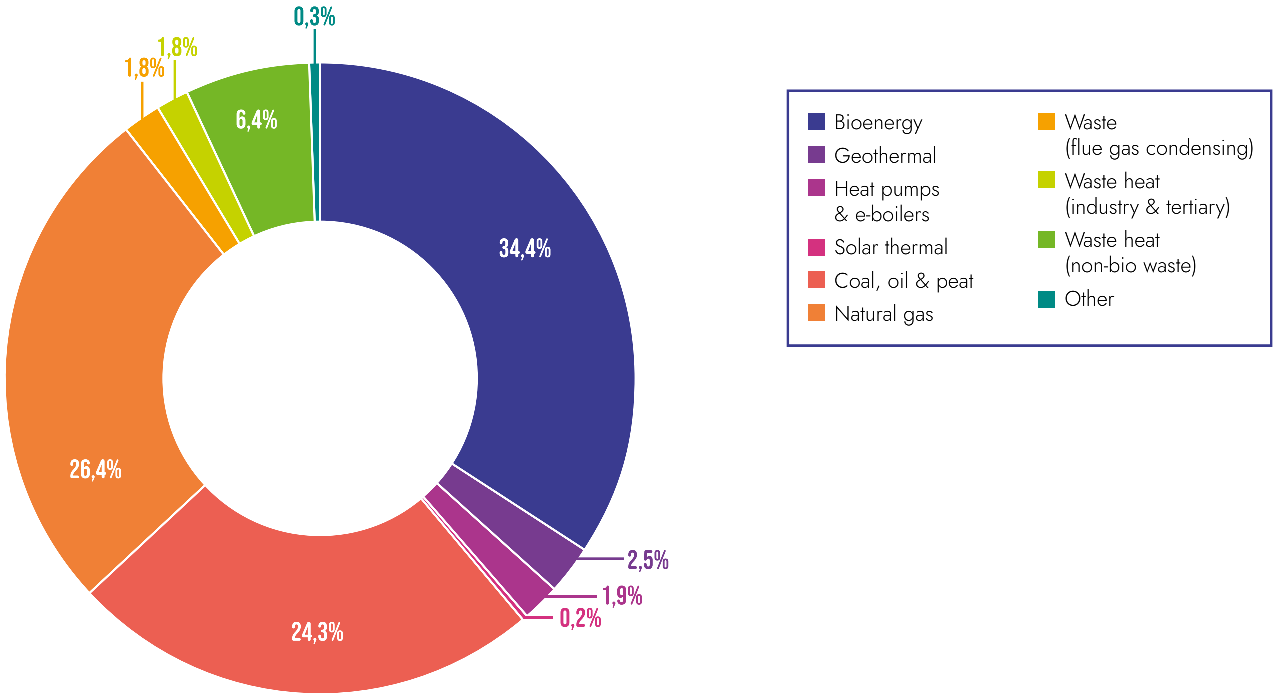
17. „Comparative analysis of district heating markets: examining recent prices, regulatory frameworks, and pricing control mechanisms in Poland and selected neighbouring countries", A. Komorowska, T. Surma, POLITYKA ENERGETYCZNA – ENERGY POLICY JOURNAL, 2024

At the same time, a growing trend toward further integration of renewable energy sources and waste heat can be observed in Europe. Chart 6 shows a breakdown of fuels used in the centralized district heating sector in Europe[18]. The climate crisis and the instability in the energy commodity market as a result of Russia's full-scale aggression against Ukraine have highlighted the urgent need to accelerate the decarbonization of the district heating sector, at the same time having to take into account local conditions and characteristics of individual district heating systems. Striving at more ambitious climate goals – i.e., achieving climate neutrality by 2050 – requires a faster transition in the area of thermal energy production and distribution. Implementing local, sustainable heating solutions is key to providing more renewable heat.

The shares of renewable energy sources vary considerably from country to country. In Iceland, renewable (geothermal) sources account for more than 90% of district heating supply, while Sweden relies mainly (68%) on the supply of sustainable bioenergy sources. In total, the share of bioenergy sources, geothermal energy, solar heat, and heat pumps (including electric boilers) accounted for 39% of the energy mix in 2022, which is an increase of 0.2 percentage points on an annual basis.

Cogeneration has always played a key role in the portfolio of generation assets in the district heating sector in Europe. Although the economics of cogeneration units have suffered due to low wholesale energy prices over the past decade, the solution still plays an important role in heat generation, covering between 17% (France) and 86% (Germany) of district heating production in the largest markets. Cogeneration units will be able to maintain a leading role in meeting the definition of an effective system as required by the EED when the fuel used is decarbonized and natural gas is replaced by decarbonized gases – biomethane and renewable hydrogen.

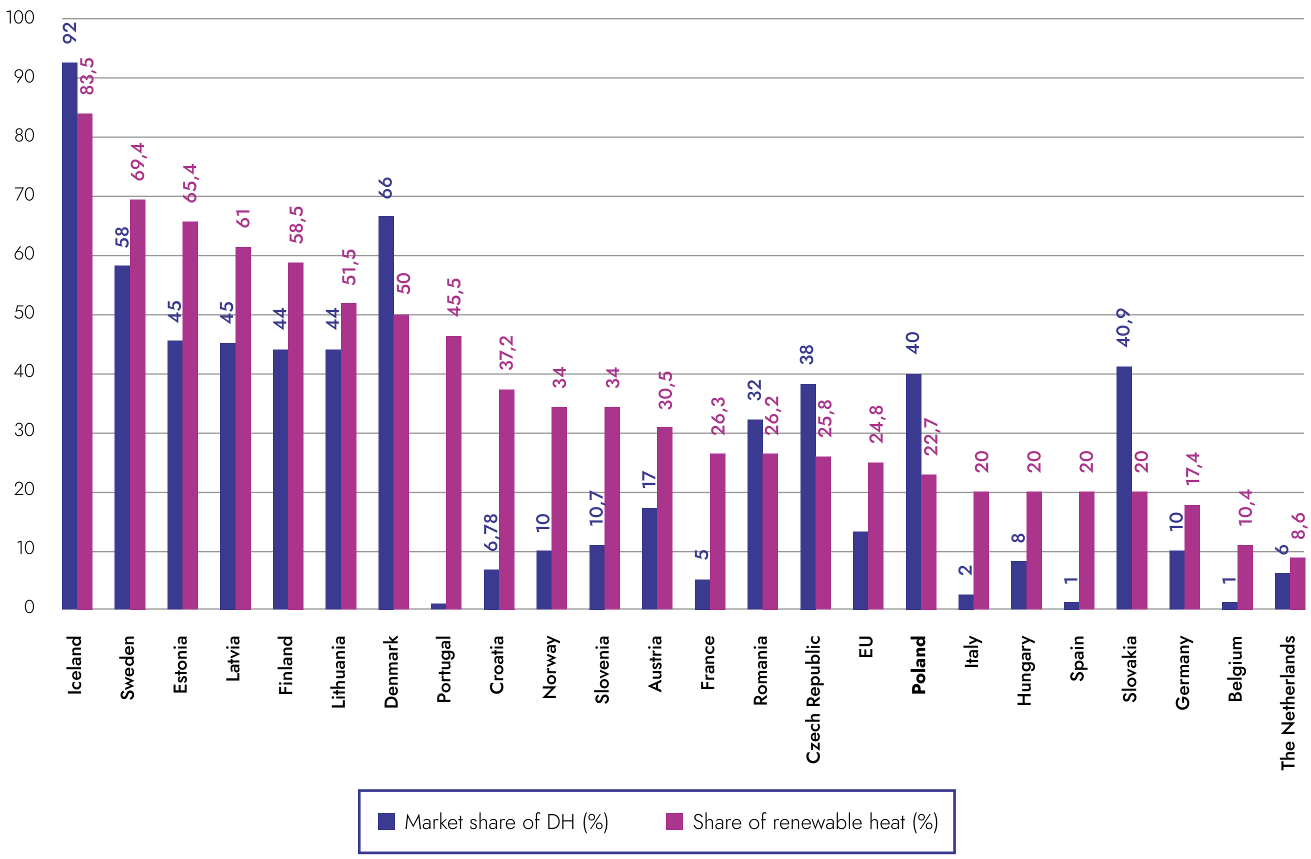
Chart 6. Heat sources in the European centralized district heating sector in 2022[19]



18. DHC Market Outlook 2024, EuroHeat&Power
19. Ibid.

It is worth noting that in Poland cogeneration units have been built or are under construction thanks to support under various support schemes. Large units with capacity of several hundred MW are being built mainly due to the possibility of support under the capacity market. Approximately 1.5 GW of capacity in 12 cogeneration units was contracted in the capacity market auctions in the years 2018–2022, of which nearly 900 MW (4 units) were commissioned before 2021. The support scheme under the dedicated Act on promotion of electricity from high-efficiency cogeneration has ensured, since 2019, the construction of approx. 500 MW of installed electrical capacity in 68 new high-efficiency cogeneration units. These results show that cogeneration capacity is not increasing at the rate that was assumed when the support scheme was introduced. The support scheme for renewable energy sources ensured the construction of a maximum of 85 MW of installed capacity in 124 new cogeneration units using renewable energy resources. It is worth noting that support is mainly received by biogas units under the FIT and FIP systems, i.e. plants with a capacity of up to 1 MW. Poland's power system and district heating sector need new cogeneration capacity, especially in renewable energy sources.[20]

Chart 7. Shares of district heating (in energy sources for satisfying heating needs of the residential/commercial sector) and renewable energy in gross final energy consumption for heating and cooling (2022)[21]



20. Leśniak, A., Surma, T., Zamasz, K. "Evaluation of support schemes for new high-efficiency cogeneration units in Poland." Rynek Energii 2023, No. 5 (168), pp. 22–30.

21. Ibid.

The evolution of technology, particularly the development of efficient large heat pumps, has also expanded the range of available sources, including new urban waste heat sources. The ReUseHeat project has identified the potential for utilizing low-temperature waste heat by means of heat pumps. It focused particularly on wastewater treatment plants, data centers, and residential and commercial buildings. It was estimated as part of the project that "available" sources of low-temperature waste heat, located "inside or within 10 kilometers" of existing district heating systems areas, could account for more than 300 TWh/year, or about 12% of total heat demand of buildings in Europe. Large heat pumps can extract energy from a variety of sources, including: geothermal ones, ambient energy (such as lakes, rivers, seawater, and sewage), waste heat from industrial processes, urban excess heat (e.g., from the commercial/residential sector — supermarkets, subways, data centers, etc.).

Waste heat accounts for 3.6% of Europe's total district heating supply in 2022, including the share of heat recovered from the industrial and commercial sectors as well as flue gas condensation. The value mentioned was determined in a highly conservative manner as some countries do not report waste heat use in district heating.[22] The highest shares of waste heat occur in markets where district heating is well developed and heat planning and/or taxation schemes ensure favorable conditions for those projects.

There is huge untapped potential for waste heat in Europe. It is estimated[23] that waste heat from power generation, industrial systems, and waste-to-energy conversion amounts to 2,860 TWh/year in the EU, which is almost equivalent to the region's total energy demand for room and water heating in residential and commercial buildings.

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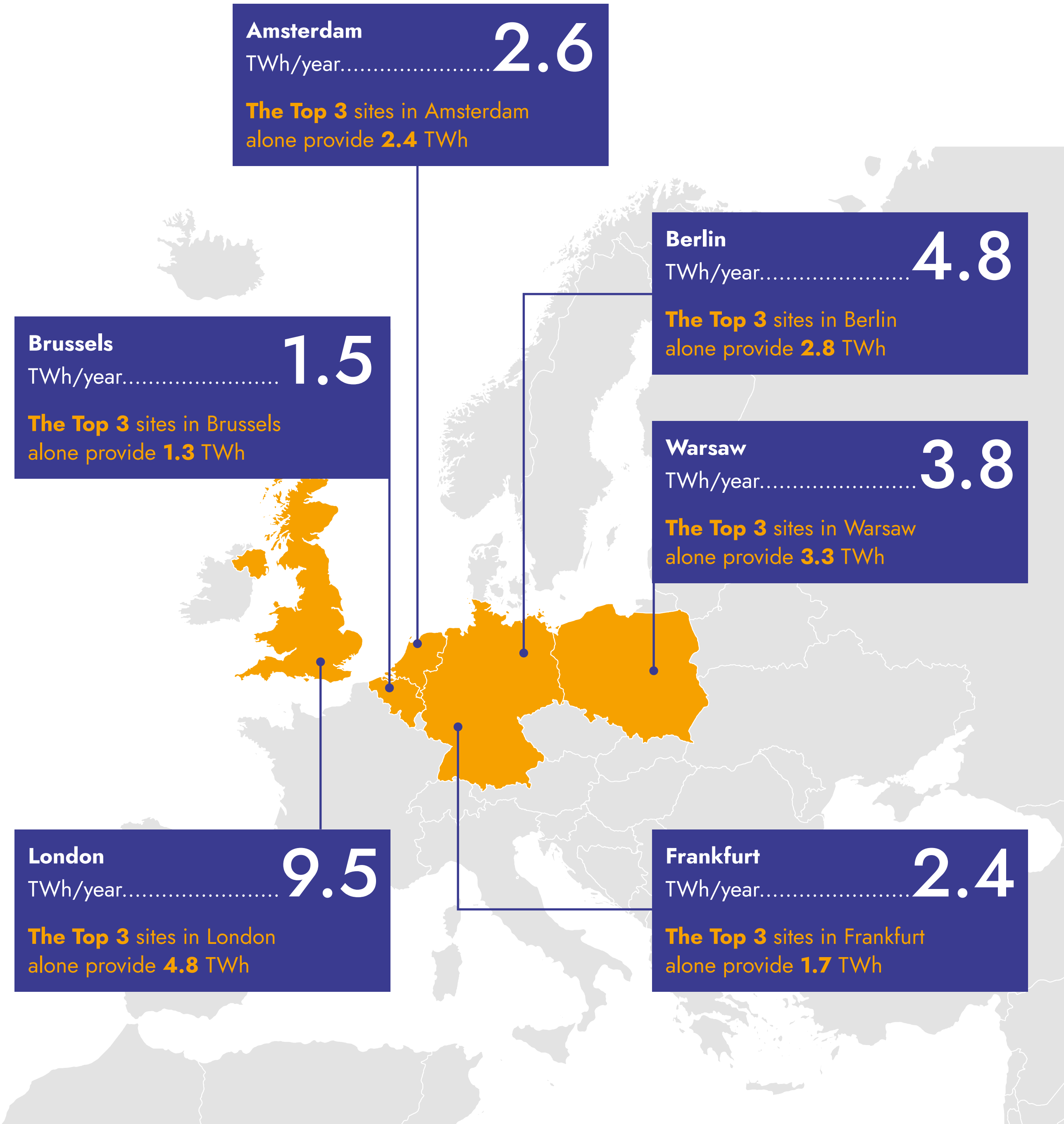
22. DHC Market Outlook 2024, EuroHeat&Power

23. The world largest untapped energy source - Excess heat, Danfoss, February 2023

Figure 2. Waste heat potential in selected cities in Europe[24]



24. "Danfoss waste heat white paper", EuroHeat&Power

The centralized district heating is increasingly interested in capturing waste heat that is a byproduct of industrial processes. The sector where high potential for waste heat recovery is identified is the industrial one: the manufacturing of steel, cement, paper, glass, and chemicals. There is also significant potential for waste heat capture in data centers and hydrogen production. It is worth pointing out that waste heat sources are still underutilized due to regulatory uncertainty as well as fragmented practices in the EU markets.[25]

One should also point out the significance of the impact of regulation on the district heating sector and the varied approaches of countries to shaping the regulatory environment. The regulated nature of the district heating sector is due to the existence of the so-called natural monopolies in the area of heat distribution and transmission. Due to the risk of distortion of competition in the district heating sector, there are a number of legal acts aimed at protecting consumers – heat consumers – from unreasonable price increases. Poland, along with Bulgaria, Denmark, Lithuania, Slovakia, and the Netherlands, is one of the countries where centralized district heating prices are regulated by law, both ex-ante, i.e., by means of tariff approval, and ex-post, i.e. control of their application. It should also be borne in mind that while it is true that to a high extent sectoral domestic law is shaped on the basis of EU acts, the way it is implemented may highlight differences in countries' approaches to heat development.

2.3. Key regulations in the "Fit for 55" package from the perspective of centralized district heating

The European Union's climate and energy policy will shape further development and transformation of centralized district heating in Poland. The EU's key legislative tool is the "Fit for 55" regulatory package, supplemented by the "RePowerEU" package, whose overarching goal is to reduce greenhouse gas emissions by at least 55% by 2030 from the 1990 emission levels, and ultimately achieve climate neutrality by 2050 for the entire EU economy. The directions and pace of change in the regulatory environment for centralized district heating are influenced the most by the solutions adopted in the following revised directives of the package, as well as their targeted implementation into domestic law:

- Energy Efficiency Directive (EU)[26] (EED);
- Energy Performance of Buildings Directive (EU)[27] (EPBD);
- Renewable Energy Directive (EU)[28] (RED);
- EU Emissions Trading System Directive (EU)[29] (EU ETS).

25. DHC Market Outlook 2024, EuroHeat&Power

26. Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September 2023 on energy efficiency and amending Regulation (EU) 2023/955 (recast) (OJ L, 2023/231, p. 1).

27. Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 on the energy performance of buildings (recast) (OJ L, 2024/1275).

28. In its version that takes into account the amendments arising from Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652 (OJ L, 2023/2413, as amended).

29. In its version that takes into account the amendments by Directive (EU) 2023/959 of the European Parliament and of the Council of 10 May 2023 amending Directive 2003/87/EC establishing a system for greenhouse gas emission allowance trading within the Union and Decision (EU) 2015/1814 concerning the establishment and operation of a market stability reserve for the Union greenhouse gas emission trading system (OJ L 130, 2023, p. 134, as amended).

2.3.1. Energy Efficiency Directive (EED)

Scope of regulation	Solutions adopted
The EU's 2030 energy reduction target in relation to the projections in the 2020 Reference Scenario.	11.7% – in relation to the projections in the 2020 Reference Scenario.
The factor of new annual final energy savings as from 2024.	1.3% for 2024–2025, 1.5% for 2026–2027 and 1.9% for 2028–2030, and 1.9% after 2030.
The emission criterion for high-efficiency cogeneration (EPS 270).	270 g CO_2/kWh of direct emissions from fossil fuels for production for new and substantially retrofitted units after the transposition of the provision (October 11, 2025). The possibility to derogate from the application of the emission criterion until January 1, 2034, subject to the development of an emission reduction plan to achieve the threshold of 270 g CO_2/kWh by January 1, 2034.
The eligibility of energy savings from direct combustion of fossil fuels.	Not possible to accept as from 2024. A derogation until the end of 2030 for energy-intensive enterprises upon meeting specific conditions.
The use of fossil fuels other than natural gas.	The member states will ensure that, in the case of either the construction of new district heating systems or substantial retrofit of generating units supplying a given system, there is no increase in the use of fossil fuels other than natural gas in existing sources compared to the average consumption of the previous 3 years, and that no new source in the system uses fossil fuels, except for units using natural gas that could be built or substantially retrofitted by 2030.
The scope of primary contractual rights concerning heat, cooling, and hot water.	New requirements with respect to primary contractual rights concerning heating, cooling, and hot water – the content of such an agreement should include provisions on, among other things: **1.** services being provided and service quality levels stipulated in the agreement; **2.** types of maintenance services offered that are covered by the agreement at no additional charge; **3.** methods of obtaining up-to-date information on all the applicable tariffs, maintenance fees and bundled products or services; **4.** term of the agreement, terms and conditions for renewal and termination of the agreement and the termination of services; **5.** compensation and fee reimbursement arrangements that apply if the service quality standards guaranteed in the agreement are not met; **6.** methods for initiating out-of-court dispute resolution. Under the directive provisions, final consumers and end users must also be provided with a summary of the key contractual terms and conditions, including prices and tariffs, in a clear and concise form, phrased in straightforward language. Consumers must also receive appropriate notices of any intention to amend the agreement.
Classifying the whole stream of heat generated in heat pumps as heat from RES (for the purposes of compliance with the definition of an efficient district heating system).[30]	Taking into account the need to ensure a level playing field in district heating systems for all renewable energy supply variants, the European Commission has issued recommendations according to which all heat supplies from heat pumps should be taken into account when assessing compliance with efficient district heating system criteria: ■ heat coming entirely from a heat pump should be accounted for as energy from renewable sources, provided that the heat pump in question meets the minimum efficiency conditions of Annex VII to the Renewable Energy Directive at the time of installation.

30. Commission Recommendation (EU) 2024/2395 of 2 September 2024 setting out guidelines for the interpretation of Article 26 of Directive (EU) 2023/1791 of the European Parliament and of the Council as regards the heating and cooling supply (europa.eu)

Scope of regulation	Solutions adopted
The plan to improve the efficiency of primary energy use.	A responsibility imposed on operators of existing district heating systems (with a contracted capacity of more than 5 MW), that do not meet the criteria for an efficient system, to prepare a plan every five years (starting from January 1, 2025) to improve the efficiency of primary energy use, reduce transmission losses, and increase the share of heat supply from renewable sources, as well as including measures for these systems to achieve an efficient status.
The planning framework for heating and cooling.	The member states will submit a comprehensive heating and cooling assessment to the European Commission, to be developed in cooperation with key stakeholders. As part of this assessment, solutions based on efficient district heating and cooling systems are to be promoted, and a cost and benefit analysis is to be carried outs (details in this regard are provided in Annex XI to the Directive in question). The authorities of municipalities with a population of over 45,000 will develop, in cooperation with key market participants, local heating and cooling plans, which will focus on, among other things: an assessment of the condition of infrastructure, an analysis of heating equipment and systems in buildings, the path to achieving the targets set out in the aforementioned plans, in accordance with the principle of climate neutrality, as well as an assessment of the way and possibility of financing policies and measures on the subject in question. Local heating and cooling plans can be implemented jointly by a group of several neighboring local authorities, provided that the geographic and administrative context and district heating infrastructure make this approach possible.
Facilitating the connection of high-efficiency cogeneration units.	The possibility for a member state to facilitate the connection of high-efficiency cogeneration units to the grid by indicating that national authorities may obligate transmission/distribution system operators to apply reduced levels of connection fees. The process of connecting a high-efficiency cogeneration unit to the grid should not take more than 24 months.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As far as the future of centralized district heating is concerned, in particular the definition of the directions and pace of the sector transformation, new regulations for recognizing district heating and cooling systems as efficient ones are crucial (Article 26 of the EED). These criteria are shown in Figure 3.

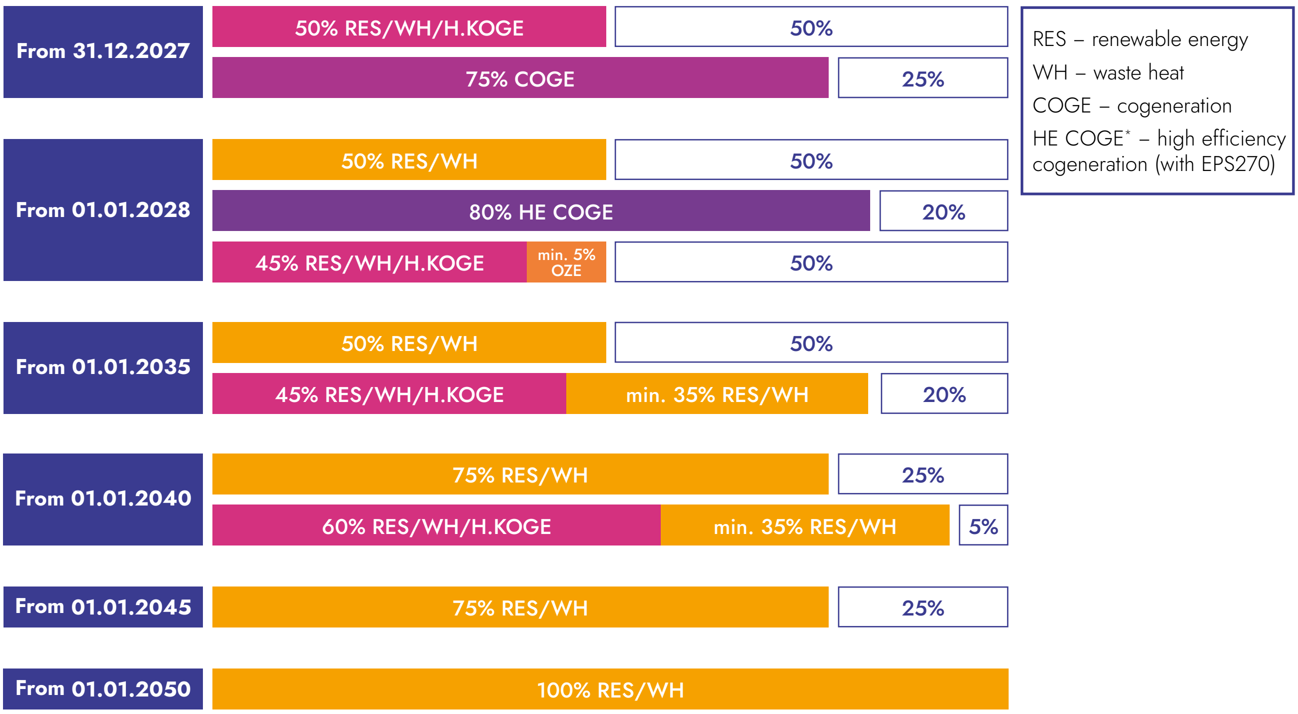
The Directive also provides for the choice of an alternative definition of an efficient district heating and cooling system in terms of sustainability criteria, based on the maximum level of greenhouse gas emissions from a district heating and cooling system per unit of heat or cold supplied to consumers:

- by December 31, 2025: 200 grams/kWh;
- from January 1, 2026: 150 grams/kWh;
- from January 1, 2035: 100 grams/kWh;
- from January 1, 2045: 50 grams/kWh;
- from January 1, 2050: 0 grams/kWh.

The alternative definition is to apply at the request of a member state which shall notify the European Commission in due time.

The time limit for the EED transposition into the domestic law of the member states is October 11, 2025.

Figure 3. Change of the criteria for an efficient district heating and cooling system



2.3.2. EPBD revision

The EPBD revision introduces regulations that are to enable the achievement of zero emissions by 2050 in principle for the entire EU building stock which is currently responsible for 36% of the EU greenhouse gas emissions[31].

31. COM(2020) 662 final, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions: A Renovation Wave for Europe – greening our buildings, creating jobs, improving lives, Brussels, October 14, 2020.

Scope of regulation	Solutions adopted
National building renovation plans	The member states will develop national building renovation plans (subject to public consultation) which will set milestones leading to zero-emission buildings. The draft national building renovation plans will be submitted to the European Commission every five years and will replace the current long-term renovation strategies. The member states are required to submit the first draft to the EC by December 31, 2025, and the first national building renovation plan by December 31, 2026. For residential buildings, the member states are required to develop trajectories for progressive renovation of the domestic building stock with a view to achieving zero emissions of the building stock by 2050.
Primary energy consumption reduction	The member states should ensure that the average primary energy consumption (calculated in kWh/(m^2/year) of the entire residential building stock decreases compared to 2020: by at least 16% by 2030 and by at least 20–22% by 2035, whereas by 2040 and 5 years thereafter, it is at least equal to, or lower than the value determined on the national level, resulting from a gradual reduction in average primary energy consumption in the years 2030–2050, in accordance with national targets for zero-carbon building stock.
Individual heat sources	As from January 1, 2025, the member states may not provide financial incentives for the installation of individual boilers running on fossil fuels, including natural gas (excluding those already agreed under the 2021–2027 Multiannual Financial Framework and so-called hybrid systems). Phasing out individual fossil-fuel boilers latest by 2040
Zero-emission building	The Directive stipulates that new residential buildings will meet zero-emission criteria as from 2030 (and new buildings owned by public institutions as from 2028). The energy demand of zero-emission buildings, both new and those undergoing renovation, can be met with energy from renewable sources: ■ generated on site or nearby ■ supplied by energy communities ■ energy from an efficient district heating and cooling system within the meaning of Article 26 of the recast EED ■ energy from emission-free sources. If it is not technically or economically feasible to meet the aforementioned requirements for how buildings are going to be supplied, the total annual primary energy consumption can also be covered by other energy coming from the grid, that meets the criteria established at the national level.
Energy performance certificates of buildings	By May 29, 2026, energy performance certificates for buildings must comply with the model specified in Annex V to the EPBD. The certificate is to specify the energy class of a building on a closed scale from A to G. Class A corresponds to zero-emission buildings, whereas class G corresponds to buildings with the worst energy performance at the moment the scale was introduced. The energy performance certificate is to include recommendations for cost-effective improvement of the energy performance of a building or a building module, the reduction of its operational greenhouse gas emissions, and the improvement of its indoor environment quality, unless the building or building module has already achieved class A energy performance. Energy performance certificates and reviews of heating systems should assess the feasibility of the heating system to operate at more efficient temperature settings, e.g. as a low-temperature one.
Providing space on buildings for photovoltaic systems	Buildings should gradually, depending on the usable floor area, be equipped with solar energy systems (photovoltaics or solar collectors), and this requirement applies to both new (public, non-residential and residential) buildings and existing (public and non-residential) buildings, providing that the installation of this kind of systems should be technically suitable and economically and functionally feasible.

The time limit for the EPBD transposition into the domestic law of the member states: May 29, 2026, in the scope of: Articles 1, 2 and 3, 5–29 and 32, and Annexes I, II and III, and V–X; May 1, 2025, in the scope of: Article 17 section 15 (Articles 30, 31, 33, and 34 shall apply as from May 30, 2026).

2.3.3. RED revision

Scope of regulation	Solutions adopted
The target share of RES in gross final energy consumption in the EU in 2030	42.5% binding on the EU + 2.5% indicative target (reaching it will enable the achievement of 45% at the EU level). A higher overall target will consequently translate into increased sectoral targets and the establishment of those for new sectors e.g. industry.
The RES target for heat and cold	0.8 pp. in 2021–2025 and 1.1 pp. in 2026–2030 (binding on the state).
The RES target for centralized district heat and cold	2.2 p.p. per annum in the period 2021–2030 (indicative target).
Including electricity from RES in targets for centralized district heating	The possibility of including electricity from renewable energy sources in centralized district heating targets has been introduced. The member states concerned will inform the European Commission and report data on energy volumes as part of integrated national energy and climate plans.
RES Acceleration Areas	According to the Directive, accelerating the development of RES systems is to be achieved through: ■ introduction of so-called "acceleration areas" to be designated on the basis of mapping by the member states that identifies domestic RES potential and the onshore areas, subsurface, sea or inland water areas available for the construction of systems and related infrastructure; ■ reducing the time limits for issuing permits for the construction, extension, and operation of RES systems, with the following assumptions: • in acceleration areas, the time limits for issuing permits for the construction, extension, and operation of RES systems are to be shortened to 12 months, • apart from acceleration areas, the time limit for issuing permits is to be 24 months. Among the systems subject to regulation, there are heat pumps and heat storage. This is an issue relevant to the development of sector coupling between district heating with electric power engineering.
Biomass sustainability criteria	The reduction of the threshold for the total thermal capacity of generating plants, from which the criteria will be applied: from 20 to 7.5 MW_t (for solid biomass fuels).
Cascading principle	The sustainability criteria for the use of biomass for energy purposes have been tightened, including by making the cascading principle mandatory with respect to forest biomass. The member states may use a derogation if it is related to ensuring energy security or the characteristics of the local market with respect to the use of forest biomass which does not meet the requirements that enable the use of forest biomass from the quantitative or technical point of view for obtaining an economic and environmental added value higher than energy generation.
Support for electricity from biomass	The ban on providing new direct support or renewal of existing support schemes for the generation of electricity from biomass fuels only. The Directive provides for a conditional deviation. The ban on providing direct financial support for the energy use of wholesome wood and waste collected on a non-selective basis.

The time limit for the Directive transposition into the domestic law of the member states has been set for May 21, 2025 (with exceptions set out in the provisions of the Directive).

2.3.4. Amended EU ETS Directive

Scope of regulation	Solutions adopted
Increasing the GHG reduction target in the ETS to 62% relative to 2005 (including maritime transport)	The Linear Reduction Factor (LRF), affecting the reduction of the volume of greenhouse gas emission allowances entering the market each year, will increase from the existing 2.2% to 4.3% from 2024, and then to 4.4% from 2028. The volume of greenhouse gas emission allowances will be reduced once by 90 million in 2024 and by 27 million in 2026. In the market stability reserve, which is responsible for preventing a surplus of allowances on the market, the factor will be 24% until 2030, and allowances accumulated in the reserve exceeding 400 million will be automatically deleted.
Funds from the sale of allowances for the transition of the economy towards zero emission	Member states must allocate their entire proceeds from the sale of allowances to finance climate protection measures (so far 50%), such as RES, energy efficiency, modernization and development of energy systems, including district heating networks, and electromobility among other things.
Modernization Fund	In the case of Poland, up to 20% of the funds may be used to finance non-priority activities, including those related to the construction of natural gas units, as long as they comply with the "do no significant harm" principle, in accordance with Regulation (EU) 2020/852 on establishing a framework to facilitate sustainable investment, amending Regulation (EU) 2019/2088. In addition, funds from the Modernization Fund for the construction of sources using natural gas must be dictated by considerations of ensuring energy security. Decisions on financing these investments can be made by the end of 2027 at the latest.
Allocation of free allowances for the district heating sector	■ the pool of free allowances in 2026–2030 will be reduced based on the corresponding size of the benchmark reduction; ■ in addition, receiving the full pool of allowances will be subject to the implementation of energy audit recommendations by the system (a reduction in allowances by 20% if the recommendations have not been implemented); ■ the amended directive also stipulates that the values of the indicators for the allocation of free emission allowances for the 2026–2030 period are determined by reference to 2021–2022 and the annual reduction rate, with the values of the indicators decreasing in the range of 0.3% to 2.5% per year. This represents a reduction in the current volumes in the range of 6% to 50% for BMs used between 2026 and 2030. ■ for the systems with cogeneration units, the Linear Reduction Factor (LRF) will not be used to calculate the allocation of allowances, leading to a higher number of free allowances received by these systems the possibility of obtaining an additional allocation of allowances (30% of the number determined in accordance with Article 10a, provided that a climate neutrality plan is developed by May 1, 2024, which assumes that a significant emission reduction is achieved by 2030, and investment costs equal to at least the value of the additional allowances are incurred) ■ the allocation of free allowances was introduced for heat generation from electricity (e.g., from electrode boilers), or hydrogen production with a production capacity of more than 5 tons per day, including from zero-emission methods.
Extension of the EU ETS to WTE plants	Verification and reporting of greenhouse gas emission from plants from January 1, 2024; full inclusion in the EU ETS from 2028 with a possible derogation until December 31, 2030 (the decision on the full inclusion of WTE plants in the EU ETS after the EC report presentation).
Mechanism to counteract an excessive increase in the prices of the EU ETS 2 emission allowances	If the average price of allowances remains above EUR 45 per ton for a period of 2 months, additional 20 million of allowances released from the market stability reserve will enter the market. The mechanism will be able to be applied once a year and will remain in effect until the end of 2029, when a review of the average price level enabling this measure is scheduled.
Introduction of the EU ETS 2 system	The EU ETS 2 system will cover the use of fuels for heating buildings (outside the EU ETS so far) and transportation. Launching the system is planned for 2027, with the possibility of postponement until 2028 in case of exceptionally high energy (oil and gas) prices. Covering buildings with the system will involve the necessity to have allowances surrendered against emissions verified by entities that grant authorizations to market fuels used for combustion in the building sector, i.e., also combined heat and power plants and heating plants with a fuel capacity of less than 20 MW_t (not covered by the current scope of the EU ETS system).

The deadline for transposition of the EU ETS Directive into domestic law of member states was set for December 31, 2023. The EU ETS 2 solutions were supposed to be implemented by June 30, 2024.

2.4. Technologies to support decarbonization of medium and large district heating systems

	POWER RANGE OF A TYPICAL UNIT	TYPICAL EFFICIENCIES
OCGT unit	several hundred kWe to several hundred MW_e (on the average 60–70 MW_e for a single unit)	total 82–90%; electrical efficiency up to 41%
CCGT unit	from a few to a few hundred MW_e (for district heating applications, a typical unit with an extraction back-pressure turbine from 50 to 200 MW_e, with a condensing turbine the power can even exceed 200 MW_e)	total 82–90%; electrical efficiency 50–60%
Gas-fired water boilers	typical from a few to 38 MW_t in a single unit for flame and smoke-tube boiler technology, in the case of water-tube boilers even above 100 MW_t for a single unit	total above 95%
Oil-fired water boiler (conversion to bio-oil)	typical from a few to 38 MW_t in a single unit for flame and smoke-tube technology	total above 95%
Co-generation power generators (Gas engines)	from a few kWt to 20 MW_t for a single generator (typically between 1–10 MW_t for a single engine	total 82–90%; electrical efficiency 42–46%
Biomass water boilers	from a few hundred kWt to units over 100 MW_t for grateless water-tube boilers (20–40 MW_t typically for a single unit)	for grate boilers 70–85% for fluidized bed boilers 80–92%
Biomass co-generation (co-firing)	from a few MW_e to several hundred MW_e (typically 20–50 MW_e)	for the combined production of electricity and heat, the efficiency of co-generation units can exceed 90%, in the case of the example unit it is assumed to amount to 90.5%
Heat pumps	from a few kW to over a dozen MW_t (typically large-scale pumps from 0.5 MW_t to 25 MW_t)	for heat pumps we define the COP coefficient of performance, usually in the range of 2.5–4 for typical applications for district heating
Geothermal energy	On the average, 3–10 MW_t (geothermal alone) and 8–20 MW_t with additional heating. Currently, the highest power in Poland is about 80 MW_t (Podhale)	Depending on the parameters of geothermal waters and the technology of additional heating equipment ■ in the case of the use of heat pumps above 500% ■ In the case of a boiler: 100–220% (T geoth.w.=60°C); 150–600% (T geoth.w.=75°C)
Electrode boilers	Typically, from 1 MW_t to 60 MW_t	efficiency of about 99%.
WTE plant	Typical units from 5 MW_t to 80 MW_t	up to 25% electrical efficiency total efficiency in co-generation 74–87%
TTES heat storage facilities	Thermal capacity averages about 50 kWh/m^3. Typical units have several to tens of thousands of cubic meters of capacity (~6,000–60,000 m^3)	>90%
PTES heat storage facilities	Energy storage potential from 0.5 GWh for small facilities to as much as 500 GWh for very large facilities (availability of large area of vacant land is necessary), typically 5–25 GWh	70–95% depending on the heat accumulation time for a single cycle
Solar collectors	Depending on the area and topography of the land for the solar farm approx. 2.5–3.0 MW_t/ha	50–70%, but strongly dependent on sunshine and ambient temperature
Flue gas heat recovery system	Depends on the available flue gas stream, its composition and parameters of the receiving medium, as well as the technology of the system itself. Typically, from a few even up to more than 20% of the thermal output of the generating device downstream of which it is installed	Increases the overall efficiency of the system

	ENERGY SOURCE/FUEL	AVAILABILITY OF POWER/FUEL
OCGT unit	natural gas	dependent on the gas network
CCGT unit	natural gas	dependent on the gas network
Gas-fired water boilers	natural gas	dependent on the gas network
Oil-fired water boiler (conversion to bio-oil)	light fuel oil	for primary fuel high, with conversion to bio-oil depending on the development of the market for biofuels
Co-generation power generators (Gas engines)	natural gas	dependent on the gas network
Biomass water boilers	biomass: forest, agricultural, waste (industrial and municipal)	For the time being, biomass is available as a fuel. Entry into force of regulations developed under the RED III Directive applies to units above 7.5 MW in fuel, resulting in stricter fuel certification requirements
Biomass co-generation (co-firing)	biomass from products, waste and residues from forestry production and from industries that process its products, including: wood chips, wood pellets, energy wood	For the time being, biomass is available as a fuel. Entry into force of regulations developed under the RED III Directive applies to units above 7.5 MW in fuel, resulting in stricter fuel certification requirements
Heat pumps	Heat sources: air, water (surface, marine), wastewater (both treated and untreated), ground, geothermal energy, waste heat (industry, data centers). Fuel: electricity	Very wide range of availability of low-temperature sources, however, finding a convenient location near the district heating system may constitute a limitation. Fuel — electricity — available, depending on the connection capacity of the power system
Geothermal energy	primarily geothermal energy+additional heating with other fuel (usually gas or electricity)	dependent on the area of presence of deposits and their parameters (mainly western and central part of the country)
Electrode boilers	electricity	dependent on the available connection capacity of the power system or the possibility of using installed generation sources in the vicinity. Large potential for the use of surplus energy from the NPS, possibility of local balancing of power supply areas of the power system
WTE plant	waste (including mixed substances and objects) from mechanical treatment of waste — customarily pre-RDF	With the introduction of circular economy and regulatory requirements for the share of recycled waste, the supply of fuels will decrease.
TTES heat storage facilities	A TTES storage facility is supplied with heat produced by any generating device or directly with heat from a district heating network. Its typical use is to flatten the heat production curve, optimize the use of generating units and store surplus heat from RES installations in the short term.	excess heat
PTES heat storage facilities	Similar as for TTES, with the assumption of long-term use	excess heat
Solar collectors	solar radiation energy	dependent on insolation conditions for the location
Flue gas heat recovery system	energy contained in the flue gases	dependent on availability of energy source/flue gas generator

	CO_2 EMISSIONS	POSSIBILITY OF FUEL CONVERSION OR CO-FIRING WITH GREEN FUEL	RES SOURCE (YES/NO)
OCGT unit	under conditions of high-efficiency co-generation: low-carbon source	yes in the case of biomethane, partially in the case of hydrogen	yes, depending on the possibility of burning/co-firing green fuel — currently no detailed legal regulations
CCGT unit	under conditions of high-efficiency co-generation: low-carbon source	yes in the case of biomethane, partially in the case of hydrogen	yes, depending on the possibility of burning/co-firing green fuel — currently no detailed legal regulations
Gas-fired water boilers	low carbon source, less than 270 kg CO_2/MWh	yes in the case of biomethane, yes in the case of hydrogen	yes, depending on the possibility of burning/co-firing green fuel — currently no detailed legal regulations
Oil-fired water boiler (conversion to bio-oil)	source with emissions above 270 kg/kWh	yes, very wide for other liquid or gas fuel	yes, depending on the possibility of burning/co-firing green fuel — currently no detailed legal regulations
Co-generation power generators (Gas engines)	under conditions of high-efficiency co-generation: low-carbon source	Possibility of using biogas, bio-oil as well as hydrogen	yes, depending on the possibility of burning/co-firing green fuel — currently no detailed legal regulations
Biomass water boilers	zero-emissions source due to RED II Directive regulations	not applicable, biomass itself is used to convert coal assets to zero- and low-carbon facilities	yes, provided the sustainability criteria are met
Biomass co-generation (co-firing)	zero-emissions source due to RED II Directive regulations	not applicable, biomass itself is used to convert coal units to zero- and low-carbon facilities	yes, provided the sustainability criteria are met
Heat pumps	no direct CO_2 emissions	depends on the source of electricity (ensuring the origin of electricity)	yes — in the case the low-temperature source uses, for example, ambient or aerothermal energy. When the low-temperature source uses, for example, exhaust air, the heat treated as waste heat
Geothermal energy	zero-emission technology when using a zero-emission additional heating source	yes for additional heating equipment	yes, partially, depending on the additional energy used
Electrode boilers	no direct CO_2 emissions	depends on the source of electricity (ensuring the origin of electricity)	no (regulatory changes required)
WTE plant	zero-emission source based on what and until when	yes, through a share of biodegradable fuel	yes (depending on the biodegradable fraction share)
TTES heat storage facilities	no direct CO_2 emissions	Directly not applicable, indirectly dependent on heat sources	yes, provided that RES heat is stored
PTES heat storage facilities	no direct CO_2 emissions	Directly not applicable, indirectly dependent on heat sources	yes, provided that RES heat is stored, and heat pumps are powered by RES sources
Solar collectors	zero-emissions	not applicable — the RES source.	yes
Flue gas heat recovery system	depending on the primary unit, the technology does not generate additional emissions, by improving the efficiency of the whole system lowers the emission factor	directly not applicable, indirectly dependent on heat sources	yes (the use of waste heat)

	TECHNICAL MINIMUM	DEPENDENCE OF ACHIEVABLE PARAMETERS ON UNCONTROLLABLE FACTORS (INCLUDING WEATHER DEPENDENCE)
OCGT unit	approximately 75% of thermal output at the environmental minimum for a single turbine without the use of a hot stack	Strong dependence of the achievable electric power on the value of the gas turbine's inlet air temperature
CCGT unit	If an extraction-condensing turbine is used, it is possible to operate without heat extraction	Strong dependence of the achievable electric power on the value of the gas turbine's inlet air temperature
Gas-fired water boilers	10–20% of rated power	virtually no dependence
Oil-fired water boiler (conversion to bio-oil)	10–20% of rated power	virtually no dependence
Co-generation power generators (Gas engines)	approximately 50% of electric power — usually the cooling system and the flue gas by-pass allow complete heat dissipation, if used	In case of extreme temperatures above 35°C
Biomass water boilers	20–25% of rated capacity	independent
Biomass co-generation (co-firing)	30–50% of maximum load	relatively independent of uncontrollable factors
Heat pumps	Operation at different loads is possible. The technical minimum can go even below 20% of nominal power (depending on the type and power of the pump)	The type of the low-temperature source has a significant impact: in the case of heat pumps powered by atmospheric air or surface waters — high dependence on atmospheric conditions, in the case of heat pumps using sewage — more stable operation, less dependent on weather conditions — pumps powered by ground or geothermal waters and the operation of which is based on waste heat
Geothermal energy	80% for a single borehole, periodic shutdown of boreholes is practiced	low dependence
Electrode boilers	0–100%	independent
WTE plant	60% of the boiler's load	low dependence in the case of pre-RDF (191212), higher in the case of variation in the quality of fuel using directly untreated waste due to its moisture absorbed from the environment (waste code 200301)
TTES heat storage facilities	depending on design solutions the storage facility has a minimum charging or discharging level, for example, in the ECB the charging minimum is 100 m3/h, and the discharging minimum 250 m3/h	independent
PTES heat storage facilities	the discharge technical minimum depends on the technical minimum of the installed heat pumps.	a PTES system should not be constructed in areas where there is groundwater at shallow depths. The existence of swift groundwater would result in an additional significant heat loss to the ground, and thus a deterioration in efficiency. Therefore, for this type of investment project, it is necessary to first drill boreholes and thoroughly examine the quality of the soil in the area of the planned investment project.
Solar collectors	not applicable	Strong dependence on weather conditions
Flue gas heat recovery system	Depending on the technical minimum of the base unit	To the same extent as the base unit

	COMBINED HEAT AND POWER (CO-GENERATION)	COMPLIANCE WITH THE DEFINITION OF AN EFFICIENT DISTRICT HEATING SYSTEM (APPLICABILITY AT A GIVEN TIME)	TIME TO REACH NOMINAL PARAMETERS FROM COMMISSIONING/ FIRST FEED-IN OF HEAT TO THE NETWORK
OCGT unit	yes	yes until high-efficiency co-generation is relevant, in case of fuel conversion the possibility to treat as a RES source	30–60 minutes/5–30 minutes first feed-in of heat
CCGT unit	yes	yes until high-efficiency co-generation is relevant, in case of fuel conversion the possibility to treat as a RES source	1–5 hours depending on the thermal condition/15–60 minutes first feed-in of heat
Gas-fired water boilers	no	yes, in case of fuel conversion the possibility to treat as a RES source	30–60 minutes/15–30 minutes first feed-in of heat
Oil-fired water boiler (conversion to bio-oil)	no	yes, in case of fuel conversion the possibility to treat as a RES source	up to 30–60 minutes/first feed-in of heat possible up to 15–30 minutes
Co-generation power generators (Gas engines)	yes	yes until high-efficiency co-generation is relevant, in case of fuel conversion the possibility to treat as a RES source	up to 30 minutes/first feed-in of heat possible from 5 to 10 minutes
Biomass water boilers	yes	yes	4–6 hours/first feed-in of heat to the network 2–4 h
Biomass co-generation (co-firing)	yes	yes	commissioning time to the steam turbine's minimum is about 8 hours/to full speed +10–12 hours/first feed-in of heat to the network 2–4 h
Heat pumps	no	yes	15–60 minutes/first feed-in of heat possible from 5 to 10 minutes
Geothermal energy	marginal potential	yes – the RES source	continuous operation – if the borehole has to be started-up at least 4 hours
Electrode boilers	no	no (regulatory changes required)	commissioning time 20–45 minutes/first feed-in of the heat to the network after 5–10 minutes
WTE plant	yes	no – heat is not treated as the RES source	from 2 to 6 h
TTES heat storage facilities	optimization of the heat production process in systems with high variability of consumption	depending on the origin of the heat	not more than a few minutes – time to start the heat output systems
PTES heat storage facilities	can optimize the operation of a co-generation system in the short term, or store excess thermal energy from co-generation in the summer.	depending on the origin of the heat	not more than a few minutes – time to start the heat output systems
Solar collectors	possible in the case of hybrid PV panels	yes – the RES source	operation dependent on weather conditions
Flue gas heat recovery system	yes	does not apply directly, considered jointly with the base unit	approx. 15 minutes

	AVERAGE OVERHAUL CYCLE	TYPICAL DESIGN LIFE	AVERAGE DURATION OF THE INVESTMENT PROCESS — ON-SITE IMPLEMENTATION PHASE (FROM FID TO TOC)
OCGT unit	an inspection every 3,000–12,000 h; a medium overhaul every 25,000–35,000 h; a general overhaul of the turbine generator unit every 45,000–60,000 h of operation	20–25 years	3 years
CCGT unit	gas turbine generator unit: an inspection every 3,000–12,000 h; a medium overhaul every 25,000–35,000 h; a general overhaul every 45,000–60,000 h; steam turbine generator unit: a medium overhaul every 25,000–30,000 h; a general overhaul every 50,000–60,000 h	20–25 years	4–5 years
Gas-fired water boilers	No major overhaul is assumed, only inspections, revisions and other activities in accordance with the requirements of the Office of Technical Inspection	20–25 years	2–2.5 years
Oil-fired water boiler (conversion to bio-oil)	No major overhaul is assumed, only inspections, revisions and other activities in accordance with the requirements of the Office of Technical Inspection	20–25 years	2–2.5 years
Co-generation power generators (Gas engines)	Inspection every 2,000 engine hours on average, medium overhaul every 18,000–22,000 engine hours, major overhaul 55,000–80,000 engine hours;	20–25 years	2–3 years
Biomass water boilers	Inspection once a year/a medium overhaul every 3 years/a major overhaul every 6 years (scope dependent on needs)	20–25 years	2 years
Biomass co-generation (co-firing)	The overhaul life of the unit dictates the overhaul cycle of the steam turbine generator unit: a medium overhaul every 20,000–30,000 h; a general overhaul every 50,000–60,000 h	20–25 years	3–5 years
Heat pumps	Inspection once a year; a major overhaul every 40,000–50,000 h	20–25 years	2–3 years
Geothermal energy	2 weeks per year for additional heating equipment, periodic maintenance between one and three years, 2 weeks of downtime for borehole maintenance	long – 30 years on average	2–3 years (borehole plus the heat generation plant)
Electrode boilers	3 days of downtime per year	>20 years	1 year
WTE plant	Required inspection of the boiler once a year, a medium overhaul of the steam turbine generator unit every 20,000–30,000 h, a general overhaul of the steam turbine generator unit every 50,000–60,000 h	15–20 years	3 years
TTES heat storage facilities	Typical overhauls of the storage facilities themselves are not assumed, only inspections, other systems by standard as needed	>25 years	2–3 years
PTES heat storage facilities	Typical overhauls of the storage facilities themselves are not assumed, only inspections, other systems by standard as needed	>25 years	2–3 years
Solar collectors	Maintenance inspections 1–2 times a year	15–25 years	1.5–2 years
Flue gas heat recovery system	adapted to the overhaul plans of the base unit	not shorter than the base unit	2 years

	AVAILABILITY PER YEAR	THE NECESSITY TO INTERACT WITH LOW-TEMPERATURE NETWORKS
OCGT unit	approx. 8,000 h	no
CCGT unit	approx. 8,000 h	no
Gas-fired water boilers	approx. 8,000 h	no
Oil-fired water boiler (conversion to bio-oil)	approx. 8,000 h	no
Co-generation power generators (Gas engines)	approx. 8,000 h	no
Biomass water boilers	available all year	not applicable
Biomass co-generation (co-firing)	approx. 8,000 h	no
Heat pumps	high reliability (no need for long-term maintenance outages) and availability (usually they can operate all year round), in the case of some types of low-temperature source (e.g., atmospheric air or surface water) there is a limit to the possibility of heat generation due to the temperature of the low-temperature source and the risk of freezing; a major overhaul requires downtime for about 1 month	no, although it would significantly increase the efficiency of heat pumps
Geothermal energy	virtually available all year round	yes (in the absence of the possibility of using additional heating)
Electrode boilers	virtually all year round	no
WTE plant	emphasis on high availability, limited retention above 8200 h	no
TTES heat storage facilities	available all year round, depending on the amount of stored energy	can interact with both low- and high-temperature networks
PTES heat storage facilities	available most of the year	can interact with both low- and high-temperature networks
Solar collectors	highly dependent on weather conditions, time of day and season	yes (in the absence of the possibility of using additional heating)
Flue gas heat recovery system	according to the availability of the base unit	can interact

	TECHNICAL/TECHNOLOGICAL BARRIERS (AVAILABILITY OF LOW-TEMPERATURE SOURCE, AVAILABILITY OF POWER FROM NPS, AVAILABILITY OF SPACE)	THE POSSIBILITY OF DIRECT INTERACTION WITH THE DISTRICT HEATING NETWORK (HIGH-TEMPERATURE NETWORKS)
OCGT unit	the necessity to ensure the supply of fuel (gas availability) and the ability to feed the electricity out	yes
CCGT unit	the necessity to ensure the supply of fuel (gas availability) and the ability to feed the electricity out	yes
Gas-fired water boilers	fuel availability	yes
Oil-fired water boiler (conversion to bio-oil)	fuel availability	yes
Co-generation power generators (Gas engines)	fuel availability and the ability to feed the electricity out	yes, additional heating required above 105–110°C
Biomass water boilers	■ required appropriate selection of boiler capacity to heat demand, ■ depending on the biomass planned to be burned, materials with a higher corrosion resistance may need to be used, ■ space and storage facilities are needed for temporary storage of biomass.	yes
Biomass co-generation (co-firing)	limited biomass storage capacity, in the case of large units – logistical difficulties with delivering an adequate amount of biomass	yes
Heat pumps	Limited availability of electrical connection capacity. Possible problems with appropriate location of the low-temperature source in relation to the district heating network. Maximum additional heating temperature at 80–90°C, in addition, in the period of low temperatures there is a risk of reducing heat production	yes, although temperatures reached in the winter period may be insufficient
Geothermal energy	local geological and legal conditions, availability of land	no
Electrode boilers	there may be local limitations on available connection capacity, relatively low demand for land availability	yes
WTE plant	no significant, location outside city centers	yes
TTES heat storage facilities	operating temperature range up to 98°C – for pressureless tanks	yes
PTES heat storage facilities	**a.** necessary accessibility of a large area of undeveloped land **b.** no occurrence of groundwater at shallow depths **c.** maximum temperature range of operation in the range of 10–95°C **d.** in the case of interaction with compressor heat pumps – availability of power from the NPS to supply them is needed	yes
Solar collectors	availability of land, no objects that shade the installation, no objects that shade the collectors	no
Flue gas heat recovery system	for installations built on existing equipment, the required space for installation can be problematic	no, usually used as preheating of district network return water

	COMPATIBILITY WITH THE TAXONOMY	THE POSSIBILITY OF OBTAINING EXTERNAL FINANCING (GRANTS AND LOANS, E.G. "RES FOR DISTRICT HEATING", "CHP FOR DISTRICT HEATING"/"DISTRICT CO-GENERATION").
OCGT unit	yes, technically feasible (the necessity to prove, among other things, a min. 55% reduction in emissions compared to the unit being replaced and others). Achieving an EPS index of 270 and the ability to perform a fuel conversion on the unit to "green or low-carbon gases" by the end of 2035.	yes
CCGT unit	yes, technically feasible (the necessity to prove, among other things, a min. 55% reduction in emissions compared to the unit being replaced and others). Achieving an EPS index of 270 and the ability to perform a fuel conversion on the unit to "green or low-carbon gases" by the end of 2035.	yes
Gas-fired water boilers	yes, technically feasible (the necessity to prove, among other things, a min. 55% reduction in emissions compared to the unit being replaced and others). Achieving an EPS index of 270 and the ability to perform a fuel conversion on the unit to "green or low-carbon gases" by the end of 2035.	no
Oil-fired water boiler (conversion to bio-oil)	yes, technically feasible (the necessity to prove, among other things, a min. 55% reduction in emissions compared to the unit being replaced and others). Achieving an EPS index of 270 and the ability to perform a fuel conversion on the unit to "green or low-carbon gases" by the end of 2035.	no
Co-generation power generators (Gas engines)	yes, technically feasible (the necessity to prove, among other things, a min. 55% reduction in emissions compared to the unit being replaced and others). Achieving an EPS index of 270 and the ability to perform a fuel conversion on the unit to "green or low-carbon gases" by the end of 2035.	yes
Biomass water boilers	yes, provided the sustainability criteria are met	yes
Biomass co-generation (co-firing)	yes	yes
Heat pumps	yes	yes
Geothermal energy	yes	yes — local governments only
Electrode boilers	no	no (aid funds)
WTE plant	no	yes, Modernization Fund (for co-generation units) under the "Use of Alternative Fuels for Energy Purposes" Programme — Part 3)
TTES heat storage facilities	yes	yes, only in combination with a RES source
PTES heat storage facilities	yes	yes, mainly in combination with a RES source. As part of the programs for co-generation from the Modernisation Fund, it is possible to include a heat storage facility.
Solar collectors	yes	yes
Flue gas heat recovery system	yes	yes

	POSSIBLE SUPPORT SCHEMES (E.G., CHP PREMIUM, CAPACITY MARKET)	AVAILABILITY OF THE TECHNOLOGY ON THE MARKET (ENSURING COMPETITIVENESS OF SUPPLIERS)	THE ROLE OF TECHNOLOGY (PEAKING/SUB-PEAKING/ BASELOAD)
OCGT unit	yes	medium	baseload/sub-peaking
CCGT unit	yes	medium	baseload
Gas-fired water boilers	no	high	peaking
Oil-fired water boiler (conversion to bio-oil)	no	high	peaking
Co-generation power generators (Gas engines)	yes	high for units under 5 MW_e, medium for units over 5 MW_e	baseload/peaking/sub-peaking
Biomass water boilers	yes	high	baseload
Biomass co-generation (co-firing)	yes	high	baseload
Heat pumps	no, partly as DSR in the capacity market	medium for high power heat pumps	baseload
Geothermal energy	no dedicated; assisting heat pump can be reported to DSR	limited availability of companies with drilling rigs	baseload, peaking operation not possible due to specifics of borehole exploration
Electrode boilers	no	high	peaking/sub-peaking/baseload
WTE plant	yes	high	baseload — heat consumption availability is required
TTES heat storage facilities	not applicable	high	discharging the storage facility at peak heat demand, charging off-peak heat demand
PTES heat storage facilities	not applicable	medium due to little experience on the Polish market	discharging at peak heat demand, charging off-peak heat demand
Solar collectors	none — no	medium	baseload (battery required) + another backup source
Flue gas heat recovery system	none	medium	baseload/peaking/sub-peaking depending on heat power demand.

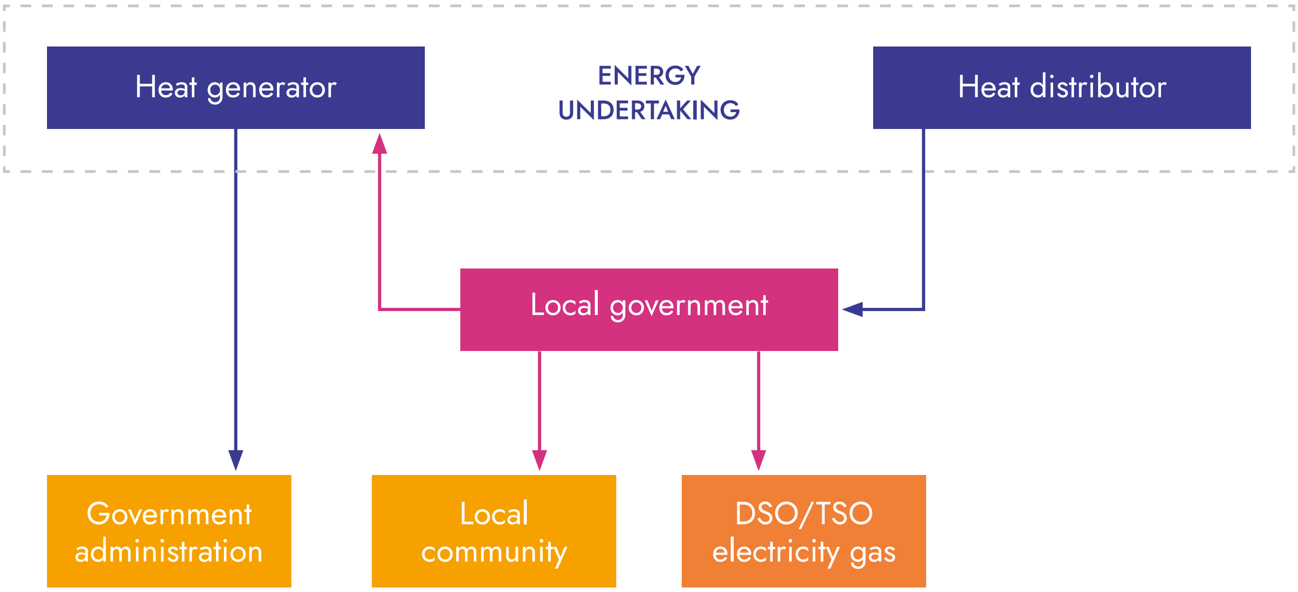
	ADMINISTRATIVE BARRIERS
OCGT unit	Potentially lengthy process of obtaining required administrative approvals and permits.
CCGT unit	Potentially lengthy process of obtaining required administrative approvals and permits.
Gas-fired water boilers	The necessity to obtain administrative approvals and permits
Oil-fired water boiler (conversion to bio-oil)	The necessity to obtain administrative approvals and permits
Co-generation power generators (Gas engines)	The necessity to obtain administrative approvals and permits
Biomass water boilers	The necessity to obtain building and environmental permits and additional testing and certification.
Biomass co-generation (co-firing)	The duration of the investment and administrative process, the necessity to obtain further permits — significantly increasing the duration of investment project. Tightening criteria for the feasibility of biomass use — sustainability criteria. In the case of conversion of coal-fired units to biomass (or multi-fuel — biomass and waste), it is not possible to amend the energy generation/heat generation license (WEE/WCC) and to include these units as RES installations, due to the fact that equipment will not always be installed. Under the current definition of a dedicated multi-fuel combustion plant and a multi-fuel combustion plant (the RES Act), it is not possible to perform co-combustion of RDF and biomass and to treat the entire stream from the biodegradable part of RDF and biomass as emissions-free in the EU ETS.
Heat pumps	■ No operational support system for heat pumps. ■ The complicated process of including heat from heat pumps in the tariff. ■ Problems related to the classification of heat from heat pumps as RES heat and waste heat.
Geothermal energy	A geothermal heating plant is a mining facility according to regulations, and from this follows the obligation to employ, in addition to the primary staff: a mining facility manager (with the appropriate licenses), a geologist and a mining surveyor. They can be part-time or contract workers
Electrode boilers	none
WTE plant	The necessity to obtain building and environmental permits
TTES heat storage facilities	due to dimensions, the need to obtain building and environmental permits
PTES heat storage facilities	building and environmental permits required – Any unusual solutions, such as groundwater protection, increase the building costs.
Solar collectors	The necessity of obtaining an environmental decision if the footprint area is not less than: ■ 0.5 ha in areas covered by forms of nature protection, ■ 1 ha in areas other than those listed above.
Flue gas heat recovery system	The necessity to obtain building and environmental permits

	UNIQUE FEATURES
OCGT unit	the possibility of a significant reduction in the number of operating personnel
CCGT unit	
Gas-fired water boilers	the possibility of a significant reduction in the number of operating personnel
Oil-fired water boiler (conversion to bio-oil)	the possibility of a significant reduction in the number of operating personnel
Co-generation power generators (Gas engines)	fuel flexibility, the ability to self-start quickly in blackout conditions
Biomass water boilers	■ the use of renewable energy sources; ■ a reduction of CO_2 emissions; ■ the ability to run on a variety of biomass types, which gives great flexibility in fuel selection; ■ the ability to store fuel; ■ have the potential for heat recovery.
Biomass co-generation (co-firing)	independent of weather conditions and can operate in the baseload all year round, flexible approach and choice of fuel (in the case of co-combustion) in terms of economic impact on the operation of the unit or in terms of its availability
Heat pumps	no pollutant emissions and CO_2 emissions, very high energy efficiency, high reliability, it is possible to use heat pumps for both heating and cooling
Geothermal energy	stable source of energy
Electrode boilers	a low-cost, highly flexible heat source capable of utilizing surplus production from RES
WTE plant	conversion of non-recyclable waste to energy
TTES heat storage facilities	key solution when interacting with heat pumps and electrode boilers ■ reducing the load imbalance of the power unit, ■ increasing the degree of combined production, ■ increasing the degree of flexibility and total efficiency, ■ increasing electric power generation at times with higher electricity prices, ■ the possibility of eliminating pseudo-condensation operation in the summer, ■ the possibility of eliminating peak load boiler operation during transitional periods, ■ providing heat supply in case of unit failure, ■ ensuring longer life of operating equipment and reducing its failure rate by ensuring a constant (unchanging) load on the equipment
PTES heat storage facilities	**a.** Under a short-term buffer operation mode — the same advantages that have been mentioned for TTES storage **b.** Under a seasonal heat accumulator operation mode ■ the possibility of eliminating the most expensive peak load boilers (or a maximum reduction of production from them) during winter periods, with the highest demand for heat ■ limitation of operation of co-generation units in pseudo-condensation ■ apparently, there is already a technology for an upper cover of the PTES tank on which floating PV farms could be built.
Solar collectors	an automated source, producing green heat in a non-linear manner — heat accumulation is perceived as good,
Flue gas heat recovery system	■ the use of waste heat, ■ a reduction of CO_2 emissions; ■ the ability to operate according to heat demand.

3. Conditions of the transition connected with the cooperation between heat market participants

The transition of district heating systems (district heating network, generating units and demand facilities) is necessary to achieve the goals of the climate and energy policy of the EU, but at the same time it requires the involvement of many stakeholders in this process. In view of the above, it is becoming more important than ever to strengthen cooperation between all heat market participants. Only mutual understanding of the needs and perspectives of all stakeholders will make it possible to find the synergy and successfully carry out the energy transition of district heating systems. The mutual relationships between the heat market participants are illustrated in Figure 4.

Figure 4. Heat market participants



The pace and directions of the necessary transition are defined by the directives adopted by the European Parliament and the Council in 2023 as part of the "Fit for 55" package (the key legal acts within this package are presented in Chapter 4 of this Report). These documents, together with the National Energy and Climate Plan, the Polish Energy Policy and the Strategy for the District Heating Sector, will provide a road map for municipalities, district heating enterprises, heat consumers and other entities to implement their investment projects. In this context, it is

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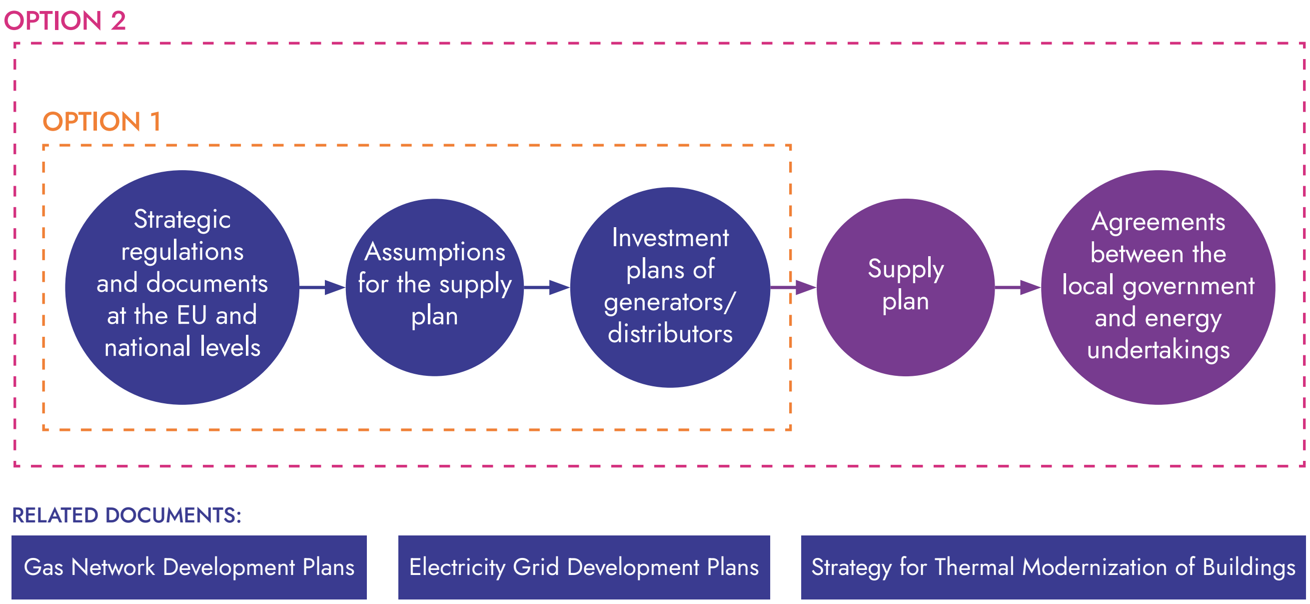
crucial to involve all heat market participants (government administration and local government administration, the regulator, energy undertakings) in the creation of long-term strategies, as they will significantly influence the directions of the transition and investment decisions made in individual district heating systems, which in turn will have a decisive impact on heat prices for final consumers.

Securing the financing for investment projects will be necessary for achieving the goals set forth in the referenced documents. Given their financial standing and the weight of the challenges posed, district heating enterprises should be among the main beneficiaries of the EU funds provided for the energy transition and at the disposal of state institutions or under government administration control.

The creation of a transparent regulatory framework to support the achievement of the goals set and the simplification of administrative processes remains particularly important. Uncertainty in the regulatory environment is today one of the key constraints on enterprises making investment decisions and smooth implementation of projects. What is also important is both the timely and proper implementation of the EU regulations into domestic law, which is the responsibility of government administration, and the subsequent proper application of these regulations by regulatory authorities. With regard to currently applicable regulations, especially in the area of tariffs, it is necessary to make them more flexible and adapt them to new market trends (e.g., dispersed generation sources) and technological trends (e.g., heat storages). The mechanism for approving heat tariffs also needs to be modified in order to introduce stronger incentives leading to energy efficiency improvements across the value chain and reduced CO_2 emission reduction. The current tariff system insufficiently stimulates development in this area, focusing mainly on controlling the unit price of heat; without any changes in this area, it will be difficult to implement the next steps on the way to climate neutrality (specific proposals for legislative changes are presented in the recommendation section of the Report)

In addition to the increasing time pressure, the key challenges of the transition are issues related to the optimum choice of the capacity, location and technology for the new sources. It is therefore important to ensure that the planning process is properly conducted, in close cooperation between the local government administration which plays a crucial role in the heat supply planning process, a district heating enterprise(s) operating in a given location (the district heating network operator, the heat generator – if these are separate entities) and final consumers. The local government, playing a coordinating role, should cooperate with all market participants whose complementary knowledge of the network segment, as well as the generation segment, will allow the preparation of assumptions for the heat supply plan, taking into account the fulfillment of requirements for an efficient district heating system and the implementation of provisions arising from the air protection plan. The coordinating role of the local government is crucial, especially in markets where the district heating system is supplied from multiple heat sources and the distributor is a separate entity. The possible options of the heat supply planning process are illustrated in Figure 5.

Figure 5. Heat supply planning process



In the case of some district heating systems in Poland (including those operating in the largest cities), the ownership structure of their main elements is varied, which means that separate entities own the generation source and district heating networks. Thus, enterprises with roles that have been separated for years in terms of responsibility for heat generation and transmission as well as distribution operate within these systems, which, given the often divergent business plans among energy undertakings, can hinder the process of planning and implementing investment projects. The above conditions may also cause the risk of implementing investments in generating capacity on a scale that does not correspond to actual demand on the side of final consumers in a given district heating system.

Given the scale of the investment challenges and the process of shaping tariffs for these enterprises, the division of responsibilities between market participants and optimum planning of the capacity level in new decarbonized generating units become even desirable, in order to limit the impact of the transition and secure the interests of all stakeholders, including final consumers. It is also important to size the level of peak capacities in an optimum way. Uncoordinated oversizing of generation capacity will not contribute to the occurrence of competition in the heat market and will have a negative impact on the situation of final consumers. Cooperation between stakeholders is also necessary to determine the locations of investment projects, which will be optimum in terms of the network hydraulics, access to power or gas infrastructure. The entities with the best knowledge of the purpose of the real properties located in a given municipality are local governments. Long-term guarantees in terms of power take-off and heat volume (especially for sub-peak and peak sources), adjustments of heating water losses, economic load distribution, modernization and reconstruction of the network allowing new connections, are some of the elements of a possible partnership between the generator and the distributor that can ensure broad development of the district heating system.

Effective decarbonization of the district heating system in a given location should start with the transition on the side of the final consumer who is often directly accessed/contacted by the heat supplier (a district heating network operator). Generating units produce energy for specific customer needs, hence proper management of the demand side is important in terms of the level of capacity to which generating units need to be restored. This refers to measures to optimize heat consumption by consumers. It includes the implementation of strategies and technologies that help control and reduce heat demand, which can bring tangible benefits in terms of energy and financial savings. Developing a long-term forecast of demand for district heat on the basis of, among other things, hydraulic analyses of the transmission infrastructure, urban development strategies and plans (especially with regard to residential areas), or the implications of the implementation of the EPBD should be an essential element to begin the process of the transition of district heating systems.

The result of the above is an opportunity to optimize the level of capital expenditures necessary to cover the level of capacity contracted by final consumers. Contracted thermal capacity is the highest capacity that will occur in a given facility under design conditions, necessary to ensure the coverage of heat losses, maintain heat comfort and air exchange in the premises, maintain the normative temperature of domestic hot water, ensure proper operation of other equipment or systems. In other words, contracted capacity is the reserve of thermal capacity that a consumer

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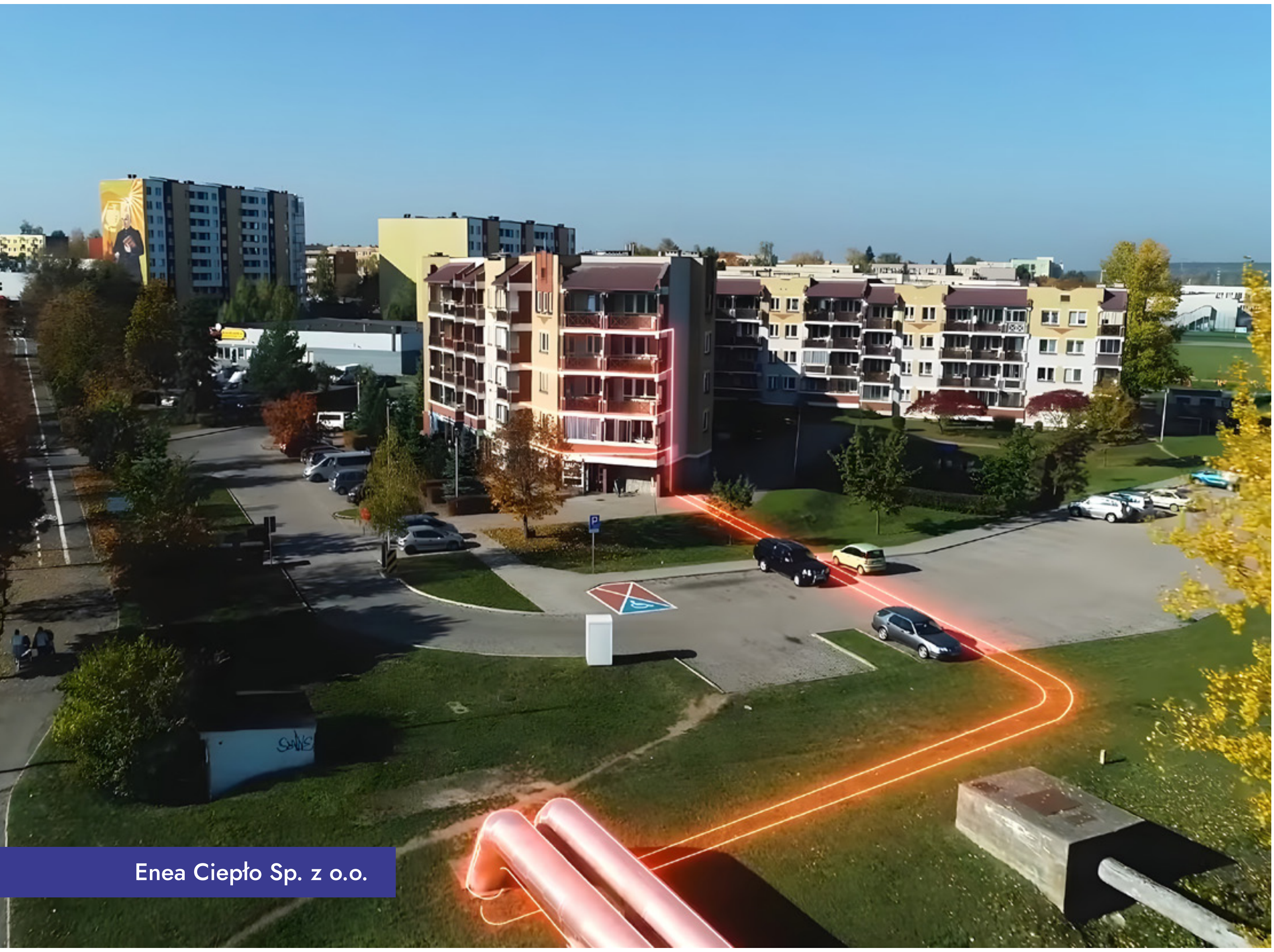
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must receive in order to heat the premises to the normative temperature (which is 21°Cfor residential spaces) at an outdoor air temperature from -24°C to -16°C, depending on the climate zone. Batch data and assumptions play an important role in the design of modern heating systems for buildings. Design engineers in Poland rely on climate design data from the 2006 PN-EN 12831:2006 standard, which explicitly cites the 1982 division into 5 climate zones with design temperatures from -24°C to -16°C. The design temperatures of the latter one are averaged values from meteorological stations from the period of 20 years, meaning that the applicable division into climate zones is derived from data for 1962–1981. When designing a demand facility, design engineers use the assumption of the need for additional heating in buildings under extreme conditions from the design temperature to the heat comfort temperature (21°C). Currently, a trend of climate change is observed as well as the resulting increase in the level of the minimum ambient temperature. When design engineers rely on outdated data, this leads to the selection of oversized heating equipment. This exposes final consumers and investors (for buildings, the distribution network, as well as the generation equipment) to unnecessary capital expenditures and makes it difficult to optimize equipment operation, as well as hampers the efforts to increase the efficiency of district heating systems.

Most district heating systems in Poland were designed assuming a supply pipeline temperature of 150°C under design conditions. Each district heating system is characterized by its design parameters, which consist of adjustment tables on the source side and on the side of consumer nodes, supply and return pressures, heating water flow. Introduction of the pre-insulated pipe technology a dozen or so years ago resulted in the possibility of lowering the heating medium supply temperature to the level of 120–135°C. According to the data included in the report by Forum Energii titled "Low-Temperature District Heating Networks," lowering the temperature by 10°C will save 10% of lost heat. The aforementioned climate change and the development of low-temperature technologies, supported by thermal modernization activities, such as the replacement of district heating stations, make it reasonable to consider further lowering the supply temperature. Further lowering of heating water parameters will not in every case be associated with an increase in the flow rate in district heating networks proportional to lowering the network temperature. This process does not have to be capital-intensive and in many cases can be limited to reconstruction of key sections of mains to improve hydraulic conditions. The condition necessary for the implementation of the next generation district heating networks is the change of the adjustment of district heating stations and adaptation of indoor systems for operation under low temperature regime. The scale and scope of the works required to adjust indoor systems should be evaluated on a case-by-case basis, taking into account the fact that demand facilities are generally oversized. Coordination of planned investment activities by the local government between energy undertakings and thermal modernization activities as well as investments in new construction will allow the technological mix to be better matched to changes occurring in heat markets.

One of the instruments that can help develop a coherent vision of the heat market to ensure the security of supply for residents in the long term is the development of the "Draft Assumptions of the Heat, Electricity and Gaseous Fuel Supply Plan," resulting from the obligation imposed on local governments in Article 19 of the Energy Law. The local government, playing a coordinating role, should cooperate with all market participants whose complementary knowledge of the network segment, as well as the generation segment, will allow the preparation of assumptions of the heat supply plan, taking into account the criteria for the efficient district heating system and the implementation of provisions arising from the strategic documents, including the air protection plans. The coordinating role of the local government is crucial, especially in markets where the district heating system is fed from multiple heat sources and the distributor is an entity separate from the generator(s).

It is attributable to the government and the local government to define the role of system heat in the long term, in the context of mechanisms to support the development of dispersed and individual heating sector.

The role of the local government in the process of planning and organizing heat supply, taking into account the development of efficient district heating systems, as well as the effectiveness of measures aimed at the transition of district heating systems, is addressed in detail by the Supreme Audit Office (hereinafter referred to as "Supreme Audit Office") in the information on the results of the "Development of Efficient District Heating Systems" audit of 2022. According to the report of the Supreme Audit Office, municipalities do not adequately fulfill their obligations under the Energy Law. The experience of district heating companies in cooperation with local governments, at the stage of creating and implementing the provisions of the supply plan assumptions, indicates areas for improvement, such as:

- the actual implementation of the obligation to update the "Assumptions of the Heat Supply Plan,"
- reliable estimation of the heat demand level,
- taking into account and coordinating investment plans of market participants,
- proper estimation of the scale and material scope of the feasible potential for electricity generation from high-efficiency cogeneration and increasing energy efficiency.

Failure to meet basic own responsibilities by a municipality often prevents the correct identification of needs and the implementation of optimum solutions in the energy transition process. The Supreme Audit Office also pointed out the low level of implementation of tasks connected with the transition of district heating systems towards energy efficiency in the case of the systems operated by enterprises not related to each other. It should be emphasized that even the correct planning and implementation of modernization activities at the source, due to the lack of parallel works on the district heating network modernization, thermal modernization and replacement of individual heat sources, reduced the efficiency of the entire system.

Respecting the responsibilities of municipalities to monitor the compliance of the works carried out by electricity companies with the assumptions of the supply plan is also important for the success of the energy transition process. The lack of such monitoring makes it impossible to assess reliably whether there are prerequisites for the adoption of heat supply plans. If the distributor does not agree to implement the generator's plans, this role should be taken over by a municipality through signing appropriate agreements with the generator. While a municipality is authorized to do so under the provisions of Article 20 of the Energy Law, these provisions have never been applied in Poland.

Planning the transition of district heating systems, in line with the idea of sector coupling, should be integrated with investment plans and strategies of other branches of the energy sector, particularly the production and distribution of natural gas and electricity. The structure of heat generation will be changing in future years due to the requirements set forth in Article 26 of the EED.

From 2035, the status of an efficient district heating system, in principle, will be achievable through:

1. Maximizing the use of renewable energy to supply Power-to-Heat systems;
2. Increasing the use of waste heat;
3. Supplying gas-fired generating units with decarbonized gases.

Coal-fired cogeneration units will be gradually replaced by high-efficiency cogeneration units based on natural gas, Power-to-Heat systems and, depending on the availability of resources, systems with renewable energy sources. The operation regime of cogeneration units will change from operation at the base of district heating systems to sub-peak and peak operation, depending on the contingency needs in terms of balancing electricity shortages in the National Power System. Cooperation between the district heating and power sectors in this regard should therefore focus on creating conditions that allow new units to be connected to the electricity grid and enable the use of district heating systems as a tool to counteract electricity grid instability caused by the increase in the share of electricity from renewable energy sources. In addition, one way to ensure the efficiency of systems is to work on hybridization of district heating stations in cooperation with RES units, such as heat pumps and PV systems. At the same time, the development of technologies that allow the "greening" of gas infrastructure will be carried out in order to meet regulatory obligations to ensure the volume of heat of sufficient quality. Also, there may be much more interest in this type of fuel from the district heating sector, especially after 2035. Coordinating the plans and needs of both sectors in this regard will allow optimum planning of the schedule of necessary investment projects. Enterprises that are producers of waste heat that can be used in the district heating system (e.g., industrial plants, data centers, large-format stores, hotels) may play an important role in ensuring energy efficiency in the future.

The effective use of modern technologies and the process of integrating them into the distribution assets will be possible with parallel investments in upgrading and digitizing them. The ability to respond dynamically to changes in the level of heat demand with dynamic changes in primary energy vectors, including electricity for Power-to-Heat systems, will become a key factor in managing the balance of the district heating network.

An element that should not be forgotten is the cooperation of the heat market participants in educational and promotional activities. In recent years, there has been a gradual increase observed in the interest in reducing the carbon footprint of households and institutional customers. A strategy for building climate and environmental awareness among final customers will help determine their willingness to bear the costs of the transition.

4. Assumptions for the analysis

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This chapter presents the macroeconomic and market assumptions as well as technical assumptions adopted for the multi-option economic model that determines the most cost-optimum options for implementing the "Fit for 55" package (in terms of achieving or maintaining the status of an efficient district heating system by a given district heating system) for individual heat markets (district heating systems) that differ in size and demand structure. The technology options were selected in such a way that a one-time investment process would have the potential to meet the regulatory requirements, especially with regard to completing subsequent milestones of the criterion of the efficient district heating and cooling system looking ahead to 2050. The various technologies in the stack are selected prioritizing both the lowest cost of heat generation and the achievement of at least the minimum volumes of heat from high-efficiency cogeneration, RES and waste heat, as specified in the definition of an efficient district heating and cooling system. The heat markets were divided according to the contracted thermal capacity:

- up to 20 MW_t;
- from 20 to 50 MW_t;
- from 50 to 100 MW_t;
- from 100 to 300 MW_t;
- from 300 to 500 MW_t;
- above 500 MW_t.

Four options of technological combinations are proposed for each heat market, which allow a given district heating system to meet the criterion of an efficient district heating system in successive time frames, as defined by Article 26 section 1 of the EED.

The analysis was performed for the period 2024–2050.

The model in each year recalculates the most cost-effective heat sources, taking into account not only the fulfillment of the requirements of an efficient district heating system, but also the variable costs of production, and – for each year – arranges the stack of generating units writing them into the demand resulting from the heat profile for a given option of the district heating system. This means that the heat production of each generating unit is based on the demand of a given market and the margin situation in a given year. The generating units with the lowest variable cost operate at the base of the district heating system.

4.1. Macroeconomic and market assumptions

The key factors influencing the selection of optimum technologies for heat generation are macroeconomic and market assumptions. This analysis adopts the most current set of assumptions, which were prepared by PTEC members in May 2024 and which are presented in Charts 8–14.

Chart 8. EUR/PLN exchange rate, source: PTEC's own study based on the Guidelines of the Ministry of Finance on the use of uniform macroeconomic indicators, October 2023, and average quotations of the National Bank of Poland.

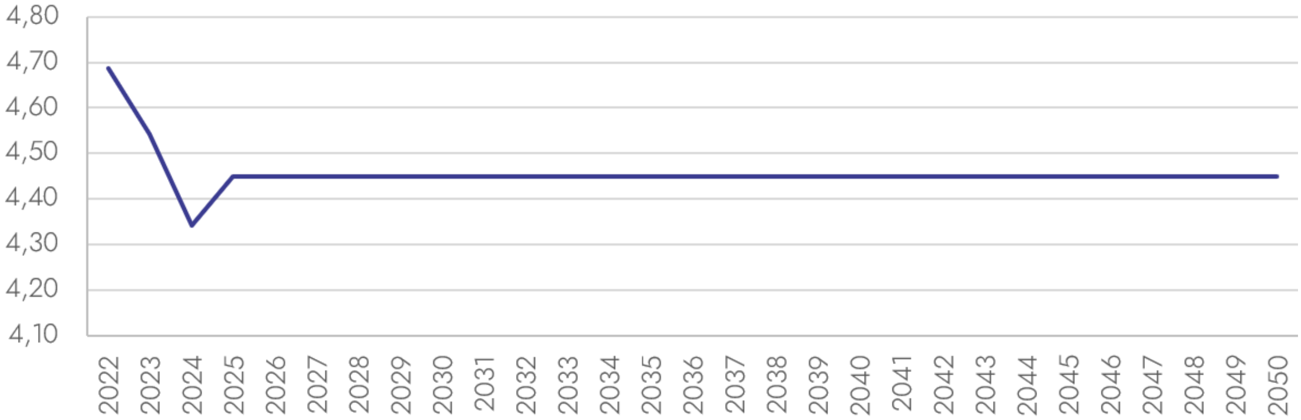


Chart 9. CPI inflation forecast Poland, source: PTEC's own study based on data from the National Bank of Poland – Current projection of inflation and GDP (published on March 11, 2024) and the Guidelines of the Ministry of Finance on the use of uniform macroeconomic indicators, October 2023.

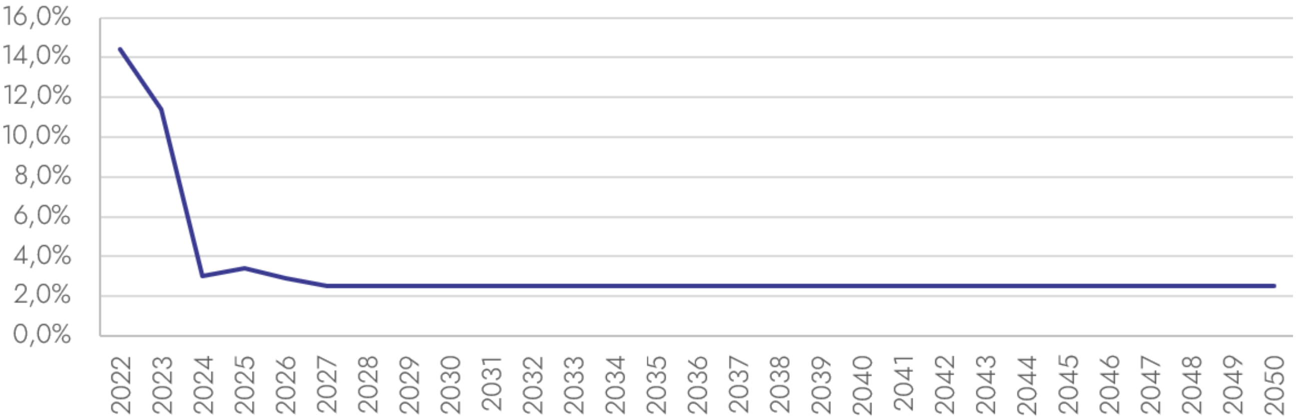


Chart 10. Coal price forecast [PLN/GJ], source: PTEC's own study – based on current quotations and the World Energy Outlook October 2023 – European Union; Announced Pledges Scenario report.

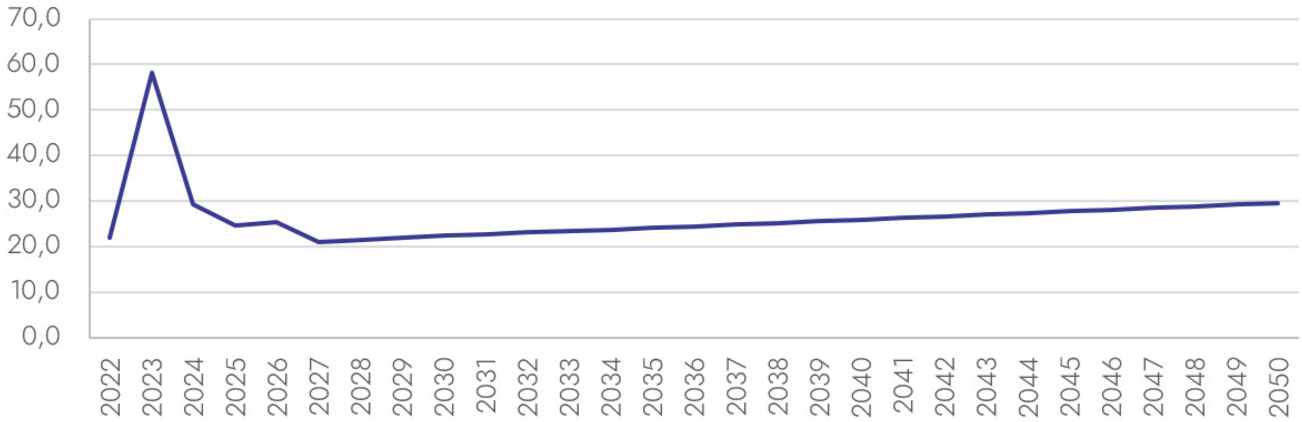


Chart 11. Natural gas price forecast [PLN/GJ], source: PTEC's own study based on current quotations and World Energy Outlook October 2023 – European Union; Announced Pledges Scenario report

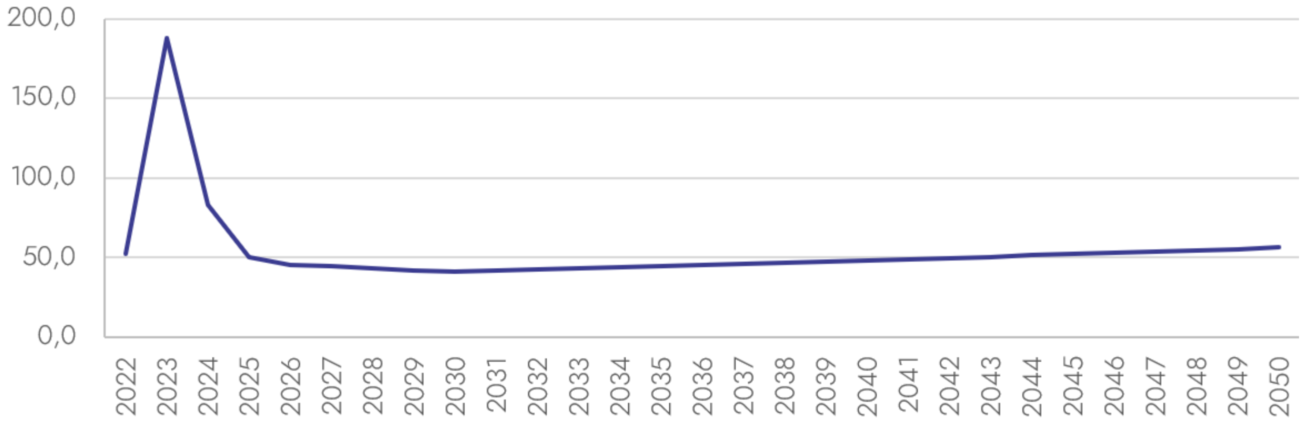


Chart 12. Biomass price forecast [PLN/GJ], source: PTEC's own study based on contracted data and PTEC Members' biomass price forecasts.

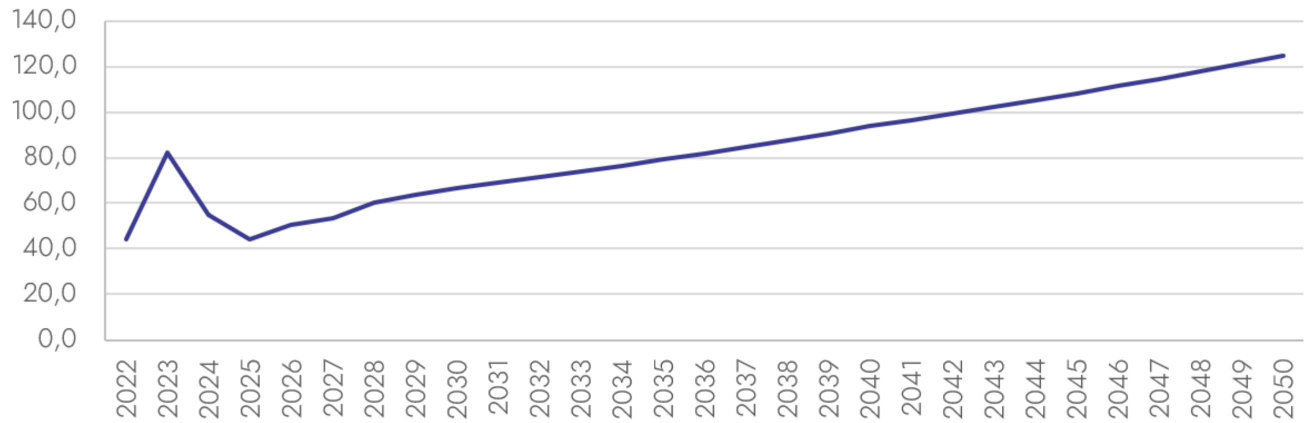


Chart 13. Price of greenhouse gas emission allowances [PLN/t], source: PTEC's own study based on current quotations and analysis of WEO October 2023 – European Union; Announced Pledges Scenario CO_2 prices for electricity, industry and energy production.

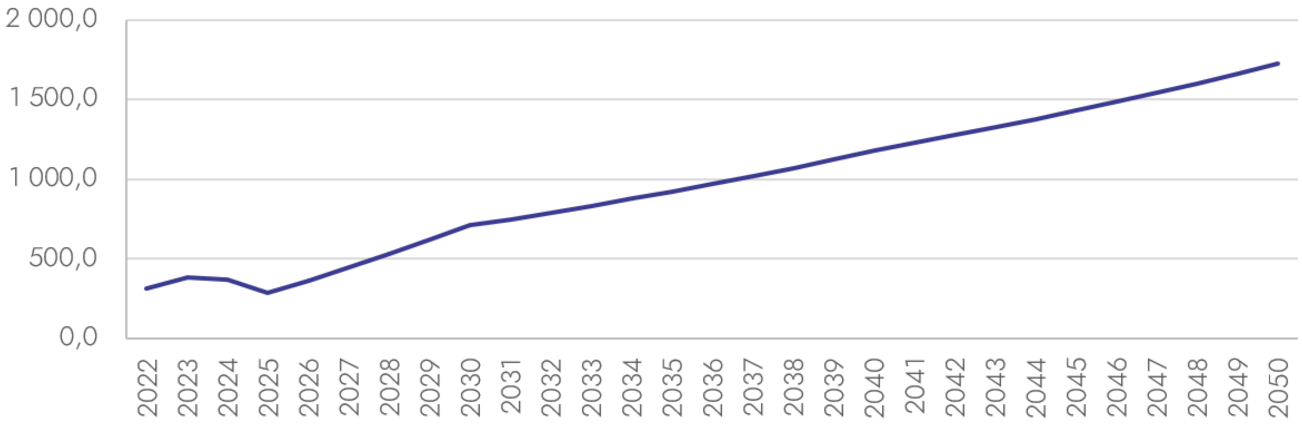
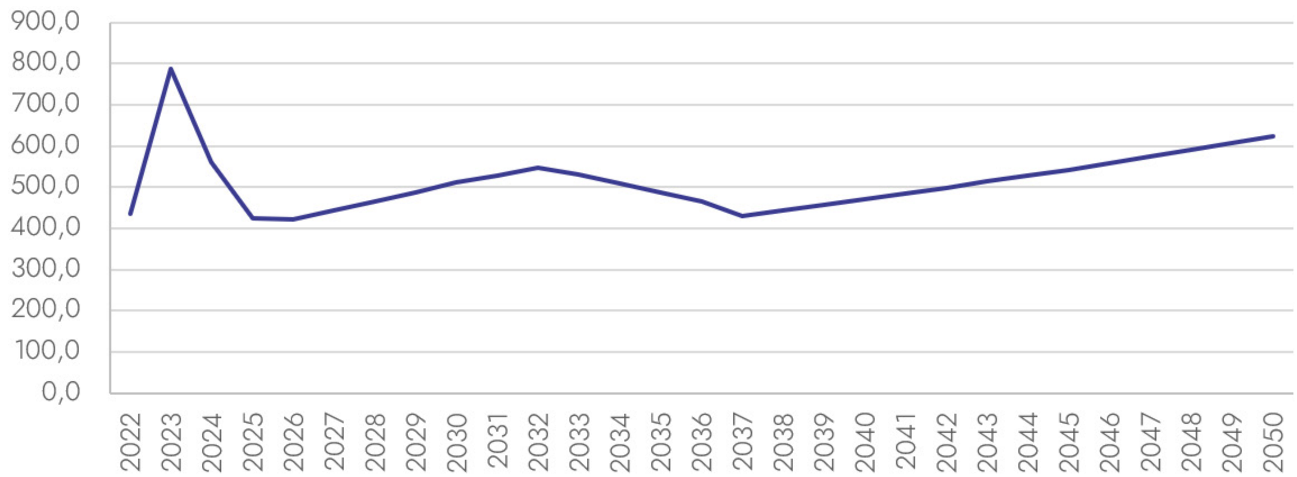


Chart 14. Forecast of electricity prices in the wholesale energy market [PLN/MWh]: PTEC's own study based on the adopted cost assumptions and the assumption of a fixed electricity market margin for the more profitable technology among condensing coal-fired units and new CCGT gas units. The electricity price forecast shown in the chart in the long term takes into account anticipated changes in the fuel mix due to, among other things, the development of nuclear power and offshore wind power, as well as the gradual reduction in the operation of conventional units.



4.2. Technical and economic assumptions

Table 5 includes the key technical and economic assumptions for each type of technology.

Table 5. Technical and economic assumptions, source: PTEC's own study on the basis of experience from its operations

Technology	Fuel	Overall efficiency %	CAPEX mPLN'23/MWₑ	CAPEX mPLN'23/MWₜ	OPEX % CAPEX
Coal-fired cogeneration	hard coal	85%	15	N.A.	5%
Coal-fired boilers (WR)	hard coal	85%	N.A.	1.8	5%
Gas-fired boilers	high methane natural gas	95%	N.A.	0.93	1%
OCGT	high methane natural gas	82%	8.4	N.A.	3%
CCGT	high methane natural gas	86%	9	N.A.	3%
Gas engines	high methane natural gas	85%	8.15	N.A.	5%
Oil-fired boilers	high methane natural gas	95%	N.A.	0.8	0.5%
Biomass-fired boilers	biomass	85%	N.A.	3.8	5%
Biomass-fired cogen-eration	biomass	85%	15	N.A.	5%
Heat pumps	ambient energy and electricity	320%	N.A.	5.5	0,65%
Geothermal energy	ambient energy	N.A.	N.A.	11.4	2%
Electrode boilers	electricity	99%	N.A.	0.7	0.5%
WTE plant	waste	85%	90	N.A.	5%

Proven technologies for which there is now operational experience in Europe were adopted for the analysis. In addition, taking into account the need to adapt district heating systems to the criteria of the efficient district heating system definition which will be applicable from 2028, no consideration was given to technologies for which manufacturers are at the stage of obtaining licenses and it is not viable to commission these sources within the specified time frame in accordance with the requirements of the "Fit for 55" package, such as SMR.

Other assumptions included:

- Remuneration costs at the level of PLN 12.7 thousand in 2023 per month / FTE; the number of FTEs was varied depending on the technological mix in a given option;
- Weighted average cost of capital (WACC) of 8%;
- Corporate income tax (CIT) of 19%.

4.3. Assumptions for benchmark heat markets

The regulations of the "Fit for 55" package resulting from the goals of the EU's climate and energy policy (including the EPBD) will affect the long-term prospects for the development of district heating systems. The adopted legal solutions (especially in the area of energy efficiency of buildings) will cause:

1. Increased pace of thermal retrofit of existing buildings to reduce final and primary energy demand;
2. Tightening technical guidelines for new residential construction toward high energy efficient and passive houses.

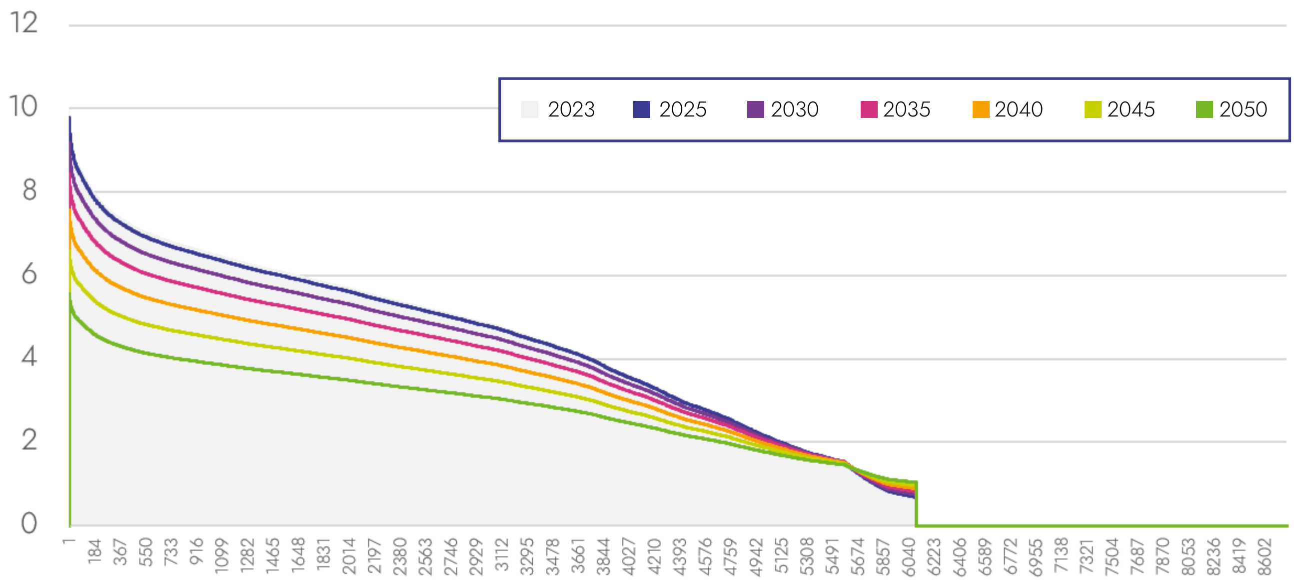
This will result in a degradation of the heat market, understood as a reduction in heat demand for the existing mass of buildings and lower demand from new connections of buildings from the primary and secondary markets (with reduced demand for central heating), which will have a significant impact on the structure of individual heat markets. The effect of the above conditions on the level of heat demand will depend on the initial state of thermal retrofit of buildings currently connected to the district heating system. Changes in demand resulting from the introduction of savings due to rising heat prices are already being observed in district heating systems. For the purposes of the analysis, it was assumed that the buildings connected to the district heating system had mostly undergone at least partial thermal retrofit in the past.

Ultimately, a decrease in heat demand is projected, which will not be able to be fully compensated for by new central heating connections.

The rate of degradation of heat markets will depend on the duration of the validity of new regulations (including transition mechanisms) and the potential for new connections. Currently, volume losses of 30% to 40% are expected by 2050 (in smaller markets with limited contracted capacity for hot water heating).

Chart 15 presents the heat market for contracted thermal capacity between 0 and 20 MW_t (a market currently outside the EU ETS). In Poland, more than 90% of such markets have no hot water and the district heating network is used for central heating. In these cases, domestic hot water is provided by local heaters in the buildings.

Chart 15. Heat market with contracted capacity of 10 MW_t, source: PTEC's own study



Charts 16 and 17 present examples of heat markets in the capacity ranges of 20 to 50 MW_t and 50 to 100 MW_t. These markets are characterized by a relatively low share of hot water demand relative to larger cities and systems. This demand can be noticed in particular in the summer period.

Chart 16. Heat market with a contracted capacity of 35 MW_t, source: PTEC's own study

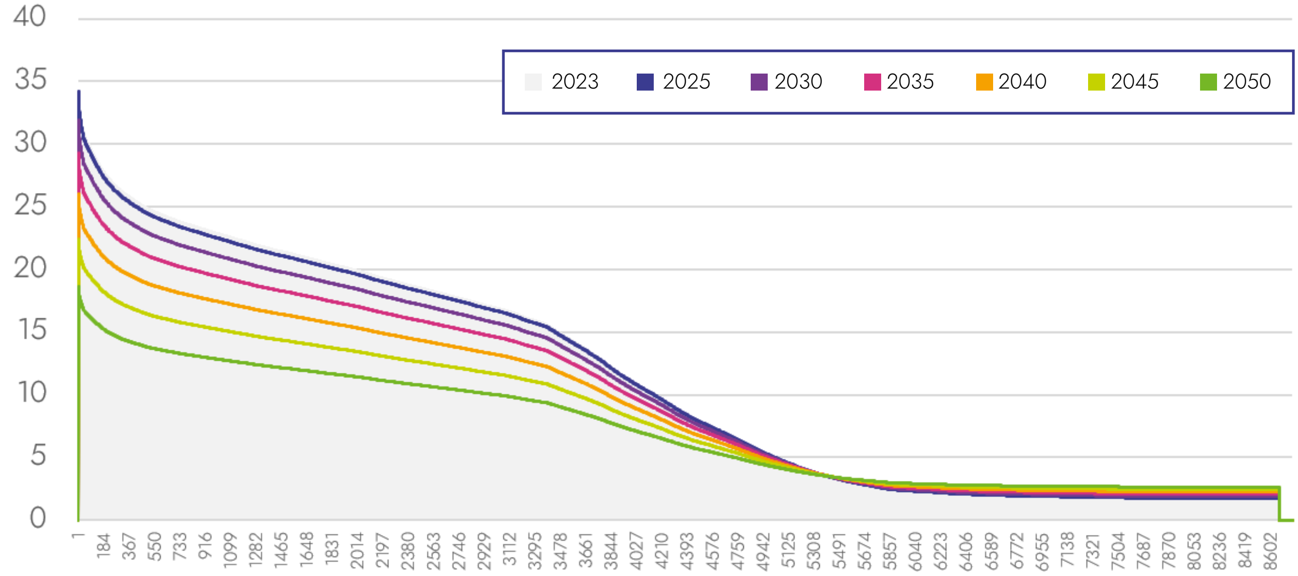
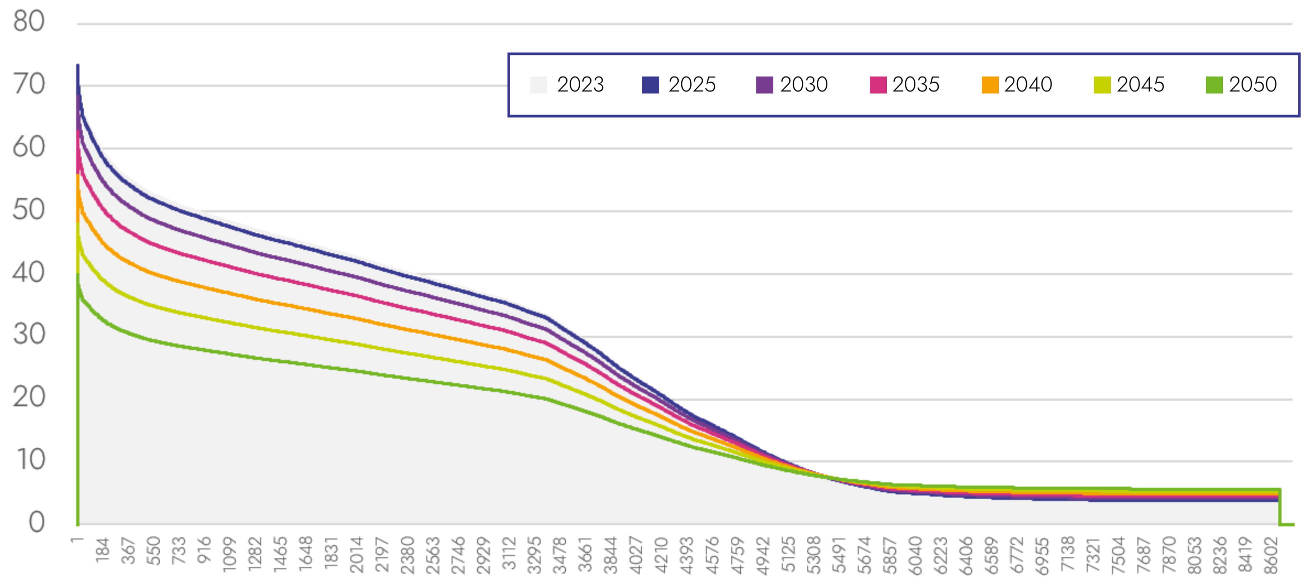


Chart 17. Heat market with a contracted capacity of 75 MW_t, source: PTEC's own study



Charts 18 through 20 present the heat demand of Poland's largest district heating systems, which are located in cities of more than 200,000 people.
Four different technology options were analyzed for each market, which are technically feasible and will enable the requirements of an efficient district heating system to be met over successive time frames, as defined in the EED. In order to keep the results comparable, these options are analogous to the 2023 PTEC analysis.

Chart 18. Heat market with a contracted capacity of 200 MWt, source: PTEC's own study

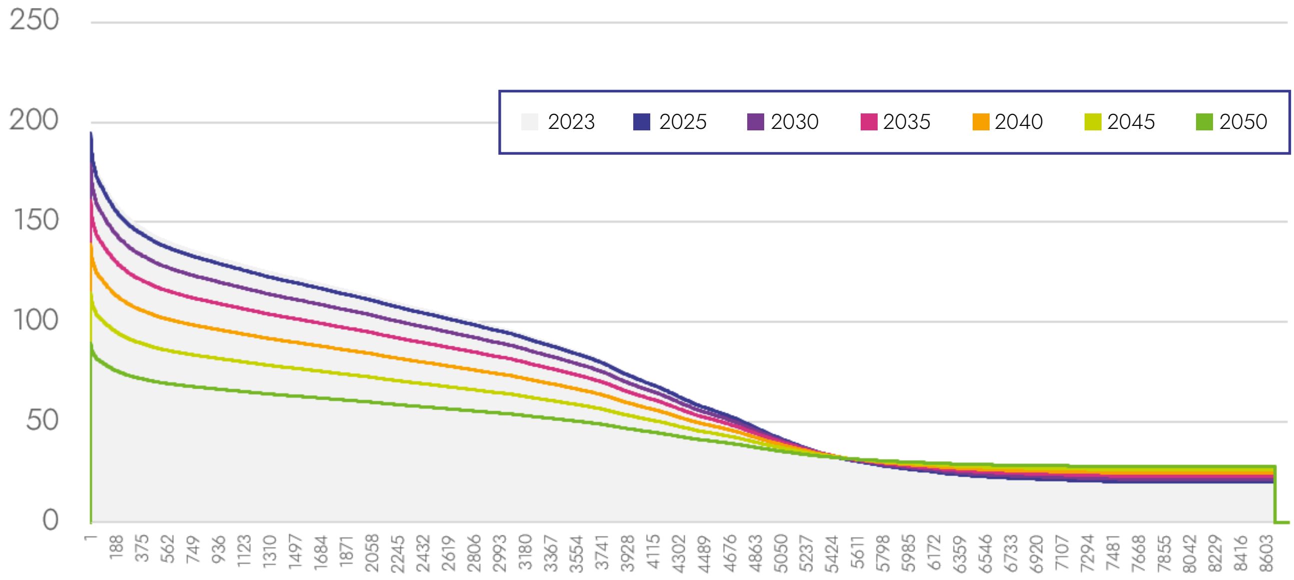


Chart 19. Heat market with a contracted capacity of 400 MWt, source: PTEC's own study

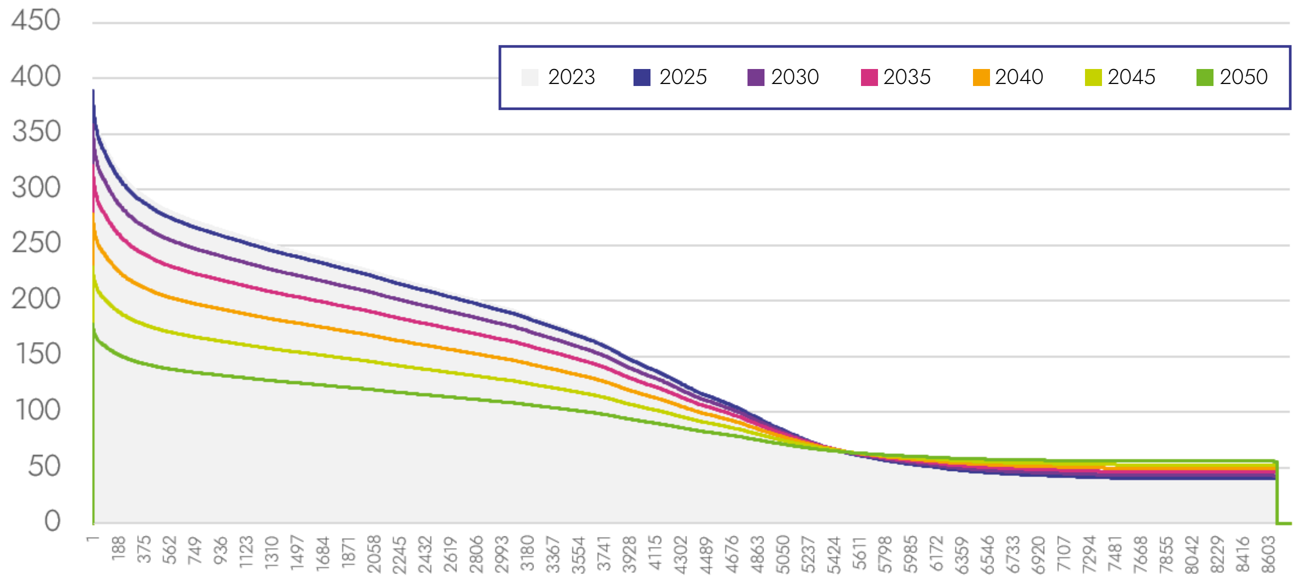
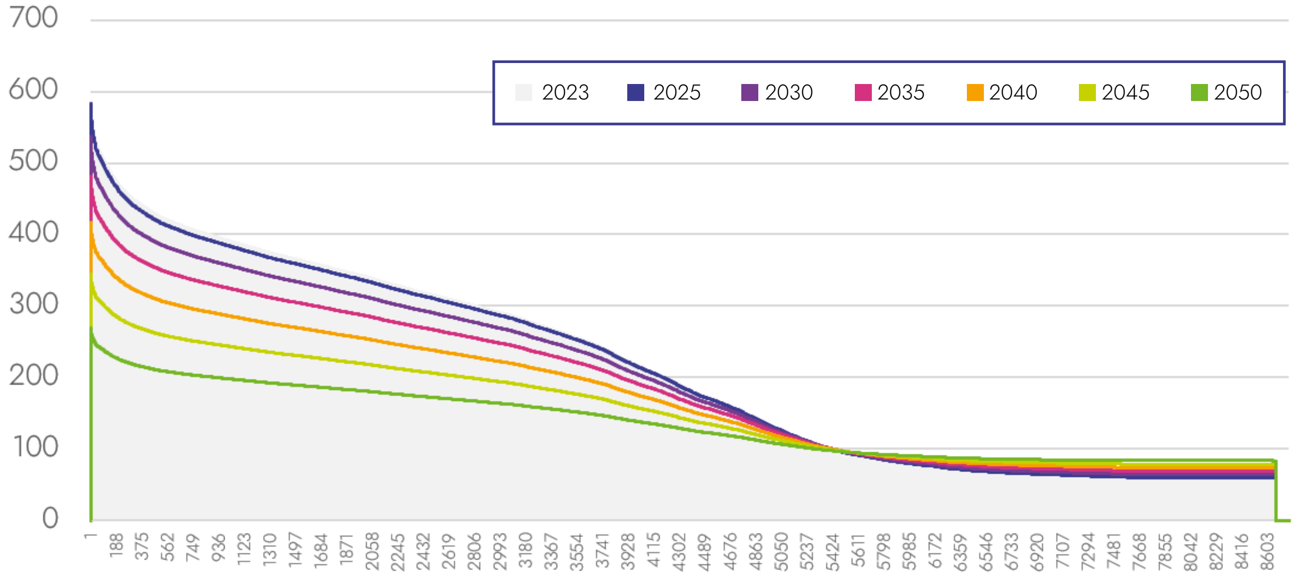


Chart 20. Heat market with a contracted capacity of 600 MW_t, source: PTEC's own study



4.4. Technology options

The analysis was prepared on the basis of technological options, which were developed for each heat market from each power range, taking into account forecasts of the development of heat demand. A detailed summary of technology options is presented below. It should be noted that the installed thermal capacity assumed for the source is about 120% of the network's peak demand. Options that include heat pumps include additional power in peak units, due to the limited capacity of this technology during periods of low temperatures, in order to secure power during peak heat demand.

It is important to note that globally the proposed options do not include biomass cogeneration units. This is due to the following conditions, among others:

- definitely higher capital expenditures compared to biomass boilers which are not cogeneration units with a similar effect to meet the criteria relating to the definition of an efficient district heating system;
- higher demand for biomass fuel for cogeneration units, which will be important under conditions of shortage of supply of this fuel on the market;
- technology options with biomass cogeneration units generate higher LCOH values due to high levels of capital expenditures and limited profitability of biomass-fueled electricity generation over the long projection period;
- considerations related to participation in operational support systems for biomass-fired cogeneration units. Participation in RES auctions is hampered by the unpredictability of the biomass market resulting in the inability to secure contracts with suppliers for the period of generation of electricity sold as a result of the auction and, consequently, the inability to size a reasonable bid. In the case of the cogeneration bonus auction, the problem stems from a common basket for all types of fuels, of which biomass has the highest generation costs.

Waste combustion systems were also omitted from the options presented. It is possible that these units will be included in the EU ETS system in 2031, and the share of waste available on the market for combustion will gradually decrease.

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At the same time, it should be emphasized that the above barriers do not preclude the use of the aforementioned technologies when planning new investments. The decision to launch an investment should be considered on a case-by-case basis, taking into account local conditions (including fuel availability), regulatory conditions and the financial capabilities of the investor.

Heat market from 0 to 20 MW_t

OPTION 1

- WR-type (coal-fired) water grate boilers are in operation until 2027
- As of 2028, 1.5 MW_t gas engines, 7 MW_t gas water boilers and 3.5 MW_t biomass water boilers are in operation

OPTION 2

- WR-type (coal-fired) water grate boilers are in operation until 2027
- As of 2028, 10 MW_t biomass water boilers and 2 MW_t gas water boilers are in operation

OPTION 3

- WR-type (coal-fired) water grate boilers are in operation until 2027
- As of 2028, 2 MW_t heat pumps and 11.5 MW_t biomass boilers are in operation; the district heating network is supplied with 0.5 MW_t waste heat

OPTION 4

- WR-type (coal-fired) water grate boilers are in operation until 2027
- As of 2028, 5 MW_t gas engines and 6.5 MW_t biomass boilers are in operation; the district heating network is supplied with 0.5 MW_t waste heat

Heat market from 20 to 50 MW_t

OPTION 5

- WR-type (coal-fired) water grate boilers are in operation until 2027
- As of 2028, the district heating network is supplied with 0.5 MW_t waste heat, 15 MW_t gas engines are in operation, 25 MW_t biomass water boilers and 4.5 MW_t gas water boilers are installed

OPTION 6

- WR-type (coal-fired) water grate boilers are in operation until 2027
- As of 2028, the district heating network is supplied with 0.5 MW_t waste heat, a 14 MW_t OCGT system is in operation, 30.5 MW_t biomass boilers are installed,

OPTION 7

- WR-type (coal-fired) water grate boilers are in operation until 2027
- As of 2028, the district heating network is supplied with 0.5 MW_t waste heat, a 15 MW_t CCGT system is in operation, 9.5 MW_t electrode boilers and 20 MW_t biomass boilers are installed

OPTION 8

- WR-type (coal-fired) water grate boilers are in operation until 2027
- As of 2028, the district heating network is supplied with 0.5 MW_t waste heat, 44.5 MW_t biomass boilers are in operation, 4 MW_t heat pumps are installed,

Heat market from 50 to 100 MW_t

OPTION 9

- WR-type (coal-fired) water grate boilers are in operation until 2027
- As of 2028, the district heating network is supplied with 1.0 MW_t waste heat, 30 MW_t gas engines, 49 MW_t biomass boilers and 10 MW_t gas water boilers are in operation

OPTION 10

- WR-type (coal-fired) water grate boilers are in operation until 2027
- As of 2028, the district heating network is supplied with 1.0 MW_t waste heat, a 30 MW_t CCGT system, 59 MW_t electrode boilers and 10 MW_t heat pumps are in operation

OPTION 11

- WR-type (coal-fired) water grate boilers are in operation until 2027
- As of 2028, the district heating network is supplied with 1.0 MW_t waste heat, a 30 MW_t OCGT system, 19 MW gas boilers and 40 MW_t biomass water boilers are in operation

OPTION 12

- WR-type (coal-fired) water grate boilers are in operation until 2027
- As of 2028, the district heating network is supplied with 1.0 MW_t waste heat, 89 MW_t biomass boilers and 4 MW_t heat pumps are in operation

Heat market from 100 to 300 MW_t

OPTION 13

- Until 2027, coal-fired cogeneration and coal-fired water boilers are in operation
- As of 2028, the district heating network is supplied with 3.0 MW_t waste heat, 50 MW_t gas engines, 60 MW_t biomass boilers, 70 MW_t gas boilers and 57 MW_t electrode boilers are in operation

OPTION 14

- Until 2027, coal-fired cogeneration and coal-fired water boilers are in operation
- As of 2028, the district heating network is supplied with 3.0 MW_t waste heat, a 70 MW_t CCGT system, 50 MW_t heat pumps, 50 MW_t biomass boilers and 117 MW_t electrode boilers are in operation

OPTION 15

- Until 2027, coal-fired cogeneration and coal-fired water boilers are in operation
- As of 2028, the district heating network is supplied with 3.0 MW_t waste heat, a 70 MW_t OCGT system, 95 MW_t biomass boilers and 72 MW_t electrode boilers are in operation.

OPTION 16

- Until 2027, coal-fired cogeneration and coal-fired water boilers are in operation
- As of 2028, the district heating network is supplied with 3.0 MW_t waste heat, 70 MW_t biomass boilers, 30 MW_t gas engines and 137 MW_t gas boilers are in operation

Heat market from 300 to 500 MW_t

OPTION 17

- By 2027, coal-fired cogeneration and WP water boilers are in operation
- As of 2028, the district heating network is supplied with 6.0 MW_t waste heat, 115 MW_t biomass boilers, 145 MW_t gas boilers, 50 MW_t gas engines and 164 MW_t electrode boilers are in operation

OPTION 18

- By 2027, coal-fired cogeneration and WP water boilers are in operation
- As of 2028, the district heating network is supplied with 6.0 MW_t waste heat, a 100 MW_t CCGT system, 95 MW_t biomass boilers, 20 MW_t ground source and 259 MW_t gas boilers are in operation

OPTION 19

- By 2027, coal-fired cogeneration and WP water boilers are in operation
- As of 2028, the district heating network is supplied with 6.0 MW_t waste heat, 80 MW_t gas engines, 50 MW_t heat pumps, 110 MW_t biomass boilers and 284 MW_t electrode boilers are in operation

OPTION 20

- By 2027, coal-fired cogeneration and WP water boilers are in operation
- As of 2028, the district heating network is supplied with 6.0 MW_t waste heat, 110 MW_t biomass boilers, 50 MW_t heat pumps, 80 MW_t gas engines and 284 MW_t gas boilers are in operation

Heat market above 500 MW_t

OPTION 21

- By 2027, coal-fired cogeneration and WP water boilers are in operation
- As of 2028, the district heating network is supplied with 10.0 MW_t waste heat, a 200 MW_t CCGT system, 180 MW_t biomass boilers, 330 MW_t gas boilers

OPTION 22

- By 2027, coal-fired cogeneration and WP water boilers are in operation
- As of 2028, the district heating network is supplied with 10.0 MW_t waste heat, 600 MW_t biomass boilers and 110 MW_t electrode boilers are in operation,

OPTION 23

- By 2027, coal-fired cogeneration and WP water boilers are in operation
- As of 2028, the district heating network is supplied with 10.0 MW_t waste heat, 170 MW_t biomass boilers, 20 MW_t ground source and 520 MW_t gas boilers are in operation,

OPTION 24

- By 2027, coal-fired cogeneration and WP water boilers are in operation
- As of 2028, the district heating network is supplied with 10.0 MW_t waste heat, 200 MW_t gas engines, 150 MW_t biomass boilers, 50 MW_t heat pumps and 360 MW_t electrode boilers are in operation

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4.5. Data on system heat markets in Poland

Table 6 describes the actual large-scale heat markets in Poland which were divided by contracted thermal capacity in the following ranges:

- up to 20 MW_t;
- from 20 to 50 MW_t;
- from 50 to 100 MW_t;
- from 100 to 300 MW_t;
- from 300 to 500 MW_t;
- above 500 MW_t (the analysis adopted a 600 MW_t heat market model).

In order to estimate the scale of capital expenditures, the amount of fuel required and the impact on final heat prices for final customers, this analysis uses a benchmark calculated on the basis of heat generation in heat markets by capacity range, as presented in Table 7.

Table 6. Division of system heat markets in Poland into benchmark markets, source: PTEC's own study based on data from the National Center for Emission Balancing and Management

Capacity range [MW]	Total installed capacity [MW]	Total available capacity [MW]	Heat generation [GJ]	Share of installed capacity in total market [%]	Share of achievable capacity in total market [%]	Share of heat generation in total market [%]
0 - 20	1 992	1 593	12 229 197	4,2%	4,1%	4,6%
20 - 50	4 402	3 587	23 668 458	9,3%	9,1%	8,9%
50 - 100	5 876	4 750	32 182 001	12,4%	12,1%	12,0%
100 - 300	9 062	7 269	47 491 829	19,2%	18,5%	17,8%
300 - 500	6 035	5 235	25 315 476	12,8%	13,3%	9,5%
500 +	19 903	16 797	126 335 239	42,1%	42,8%	47,3%
Total	**47 270**	**39 231**	**267 222 200**	**100%**	**100%**	**100%**

Table 7. Summary of analyzed system heat markets – analysis scaling, source: PTEC's own study based on data from the National Center for Emission Balancing and Management

Capacity range [MW]	Heat generation in actual heat markets in Poland [GJ]	Example heat markets for analysis [GJ]	Number of heat markets in given capacity ranges [#]
0 – 20	12 229 197	99 387	123
20 – 50	23 668 458	348 774	68
50 – 100	32 182 001	747 372	43
100 - 300	47 491 829	2 203 239	22
300 - 500	25 315 476	4 406 478	6
500 +	126 335 239	6 609 718	19

5. Analysis results

5.1. Key results

This section presents the results of an economic analysis to determine the capital expenditures that need to be incurred to bring Poland's district heating sector into compliance with the key decisions of the "Fit for 55" package. The overarching assumption of the analysis is that, as a result of the implemented investment projects, district heating systems will meet the criteria for an efficient district heating system contained in the new EED.

In the analysis, the technology options were selected in such a way that a one-time investment process would have the potential to meet regulatory requirements in the run up to 2050 (in relation to an efficient district heating system). The various technologies in the stack are selected prioritizing both the lowest cost of heat generation and the achievement of at least the minimum volumes of heat from high-efficiency cogeneration, RES and waste heat, as specified in the definition of an efficient district heating system.

It should also be noted that there may be new opportunities around 2040 related to the option of converting existing gas generating units to allow the use of green hydrogen, biomethane or biogas, which should further increase the potential to accelerate the decarbonization of the district heating sector.

The adoption as a boundary condition of a given modeled district heating system's fulfillment of the "efficient district heating system" criterion is due to the crucial importance of this status for the operation of a given system. Its loss is associated with serious consequences for both energy companies engaged in heat generation and heat transmission and distribution, including, among others:

- a significant restriction on the possibility of obtaining investment support for the construction or modernization of the district heating network and investment support for generation units;

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- the actual lack of market development opportunities for connecting new consumers and buildings (due to the requirements of the EPBD);
- destabilizing the operation of the district heating network resulting from the need to connect RES plants, particularly to connect a large number of small RES plants (which will not equate to a large volume of heat from RES);
- the emergence of stranded costs resulting from the construction of generating units that guarantee energy security;
- easier possibility for final customers to disconnect from the district heating network;
- the emergence of more individual heat sources (not only using RES),

but also it has an impact on air quality, as emissions of harmful substances and greenhouse gases will increase due to the aforementioned effects, and the phenomenon of low emissions will worsen. Thus, it has important implications for all parties involved in local heat markets.

The mathematical optimization model used in the analysis aims to minimize the total cost of heat generation in district heating systems. It comprises the following components:

- CAPEX – which includes capital expenditures;
- OPEX – which includes costs of overhauls;
- Costs – which include the cost of fuel, the cost of greenhouse gas emission allowances and fixed operating costs;
- Period of analysis – 2024–2050.

The model, based on a typical ordered heat demand curve, calculates the used thermal capacity of the sources. Based on the thermal efficiency of the sources, a work stack is established in order from the most efficient (i.e. the cheapest) source after the variable cost of generation. The model

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takes into account regulatory requirements, i.e. the need to meet the criterion of an efficient district heating system, which involves taking into account the required shares of heat from RES or waste heat or heat from high-efficiency cogeneration in a given district heating system. Such a stack of units fills the demand of the heating market in each of the options. As a consequence of the above, there are years where heat from RES installations is not the cheapest, but must be produced for regulatory reasons, or a surplus of RES is obtained in relation to the requirements to meet the criterion of an efficient district heating system, when it is cheaper than other generating units. The analysis assumes that heat generation based on RES electricity supplied from the national power system and documented, for example, by a PPA contract, is 100% considered RES heat, according to the revised RED.

The model is intended to calculate the average discounted unit heat price on generation, which ensures the profitability of a given option at IRR = 8% over the period 2024–2050. The model discounts all expenditures (CAPEX, OPEX), takes into account revenues from the sale of electricity, and assumes that electricity from high-efficiency cogeneration is supported by the high-efficiency cogeneration support mechanism at PLN 127'23/MWh for units with a capacity of more than 50 MW_e and PLN 305.86'23/MWh for units with a capacity of 1–50 MW_e, and then determines a heat price that results in NPV = 0 over the entire forecast period. Nominal capital expenditures for each technology option are shown in Chart 21.

Taking the results of the analysis into account, it should be assumed that in individual heat markets, depending on the contracted capacity and the option of development of generation sources, it will be necessary to invest between PLN 41 million and PLN 4,146 million in a single market (for a market with a capacity of 600 MW_t, in the case of larger heat markets, it should be expected to incur more expenditures than those described in options 21–24). The level of capital expenditures to bring individual system heat markets in line with the requirements of an efficient district heating system is summarized in Table 8.

Chart 21. Nominal capital expenditures for individual technology options [mPLN], source: PTEC's own study based on the analytical model

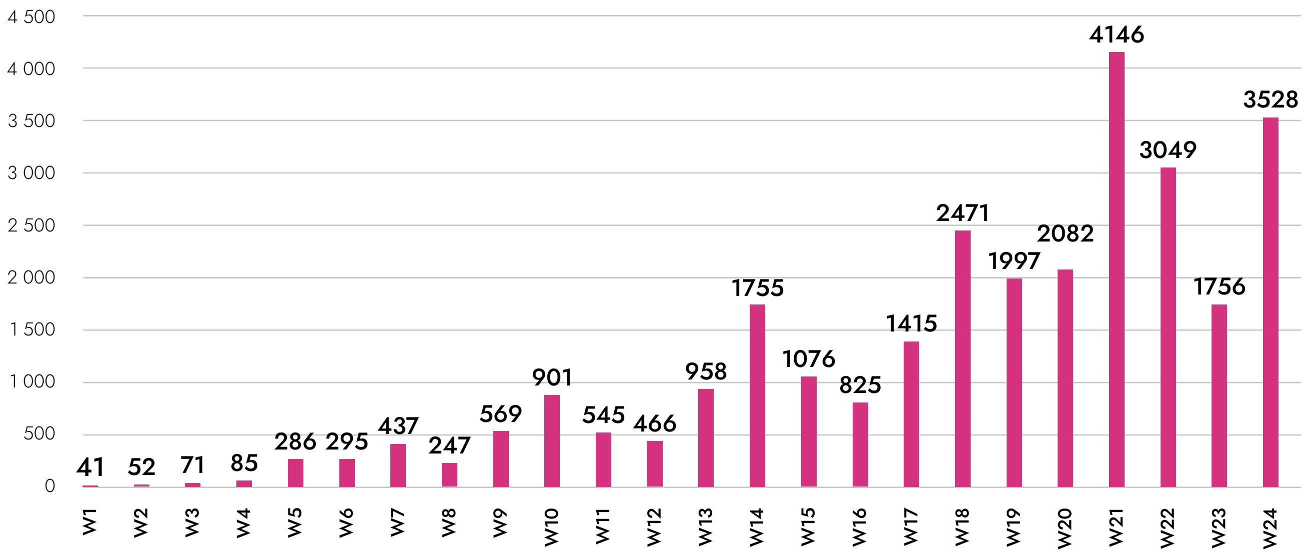


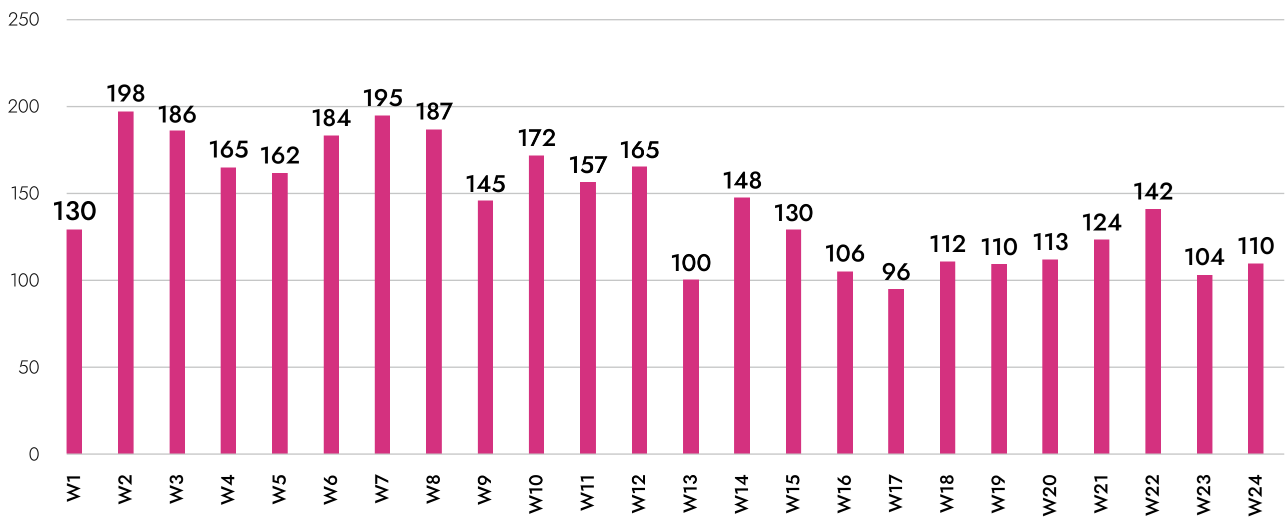
Table 8. The level of capital expenditures to bring individual system heat markets in line with the requirements of an efficient district heating system, source: PTEC's own study

Capacity range [MW]	Minimum expenditures [million PLN]	Average expenditures [million PLN]	Maximum expenditures [million PLN]
0 – 20	41	62	85
20 – 50	247	316	437
50 – 100	466	620	901
100 – 300	825	1 154	1 755
300 – 500	1 415	1 991	2 471
500+	1 756	3 120	4 146

Taking into account the number of heat markets in Poland in the proposed capacity ranges, it should be concluded that it will cost from PLN 102 billion in the minimum capital expenditures option to PLN 211 billion in the maximum capital expenditures option, additionally taking into account the capital expenditures related to the implementation of the relevant connection infrastructure (to the electricity grid, to the gas network) for the gas options, to meet the requirements set out in the "Fit for 55" package. However, it is important to point out the likelihood of a non-inflationary increase in capital expenditures due to as follows: the need to modernize the entire segment at the same time (the opening of a large work site), the saturation of the contractors' market, the interruption of the supply chain due to the geopolitical situation. These aspects are important given the assumed time schedule and evolutionary shape of the definition of an efficient system. The capital expenditures shown above are for generation sources and do not include expenditures related to retrofit of district heating networks and consumer facilities. Capital expenditures for this segment, mentioned in subsection 5.3, were estimated at between PLN 82 billion and PLN 106 billion and between PLN 115 billion and PLN 149 billion, respectively.

The effect of development and retrofit of the district heating sector is an integral part of the increase in the price of heat for end users. The single-component heat price, through which investors will be able to allocate funds for the development of generating units and ensure the profitability of their enterprises, is shown in Chart 22. The prices shown are the prices of heat generation, and, thus, do not include the costs of heat distribution and transmission.

Chart 22. Single-component heat prices for final customers [PLN'23/GJ], source: PTEC's own study

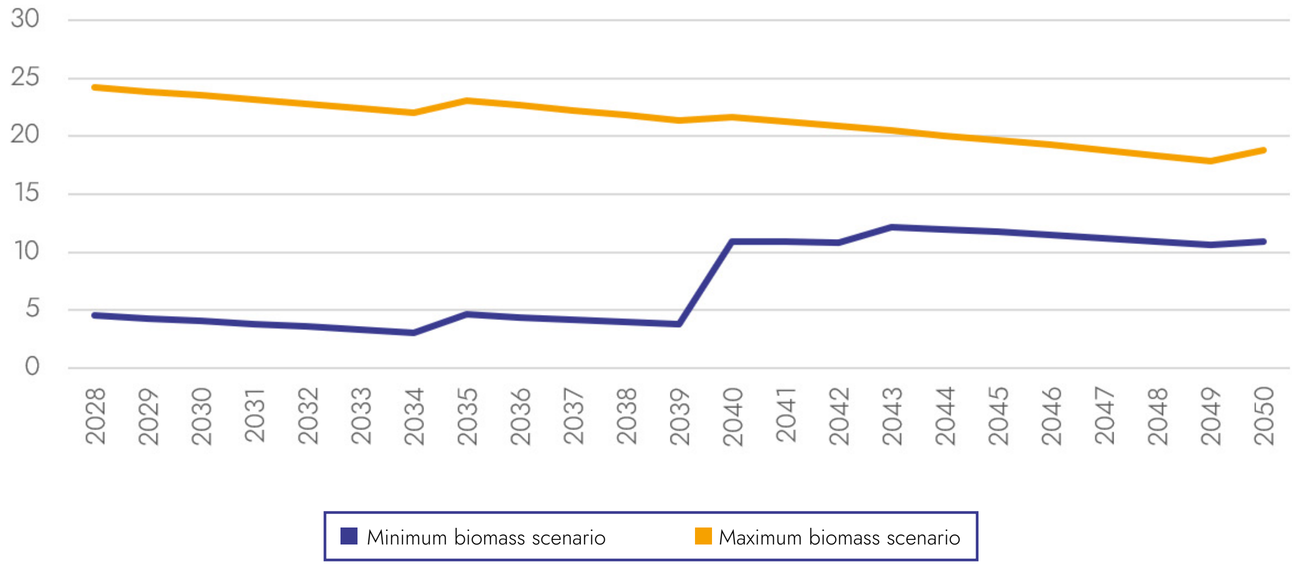


5.2. Fuel demand considerations

5.2.1. Availability of biomass

If investors are willing to implement technology options with the maximization of the share of biomass in heat generation, the demand for this fuel in the first period would be approx. 25 million tons per year, which, given the conditions of the biomass market, is an unrealistic option. In the scenario of minimizing the share of biomass in the district heating sector by 2040, the demand would be about 5 million tons per year, after which it jumps to about 11 million tons per year due to the tightening of the criteria of an efficient district heating system. A necessary condition for enabling such a volume of biomass is the gradual expansion of the biomass market, which is not feasible from the standpoint of demand and the logistics of fuel supply. For comparison – during one of the best years for the biomass market in Poland, 6.5 million tons of biomass were burned across the electricity and district heating sectors, followed by problems with lack of availability. Biomass fuel demand is shown in Chart 23.

Chart 23. Biomass demand [million tons], source: PTEC's own study based on model results



In the case of biomass fuel demand, it should be noted that in Poland CHP and heating plants are located in cities, which further creates logistical problems. This causes numerous protests from residents due to significant inconvenience on the side of congested streets and social unrest, which ultimately translates into the inability to implement scenarios with high biomass use in CHP plants.

In addition, it should be noted that the maximum potential for biomass use in the sector is approx. 5 million tons per year (currently less than 4 million tons per year are burned in the sector), assuming a developed and secure biomass market. This results in the fact that only small heat markets with a contracted thermal capacity of less than 50 MW_t can meet the requirements of the "Fit for 55" package settlements in such a way, in terms of the required amount (increment) of heat from RES in the district heating system (allowing to meet the criterion of an efficient district heating system). In the case of large district heating systems, operating in locations such as Wrocław, Kraków, Warsaw, Gdańsk, the Śląsko-Dąbrowska Agglomeration, for example, where there is no available generation technology on an appropriate scale, an adequate volume of fuel (albeit biomass) is not available to meet the targets for the incremental share of heat from RES should it be implemented into national legislation in the form of a mandatory increment in each district heating system. For example, in order to obtain a 20% share of heat from RES in Warsaw's district heating system, approx. 1.2 million tons of biomass would have to be obtained annually, which is impossible due to both demand and logistical considerations. The maximum share of RES heat generated from biomass in these heat markets could be 5%, assuming that the difficulties associated with the unstable market for this fuel are overcome. This is because it is characterized by very little predictability, with the vast majority of fuel contracted on a month-to-month basis, and market tools such as long-term contracts, the stock market or price indexes do not function.

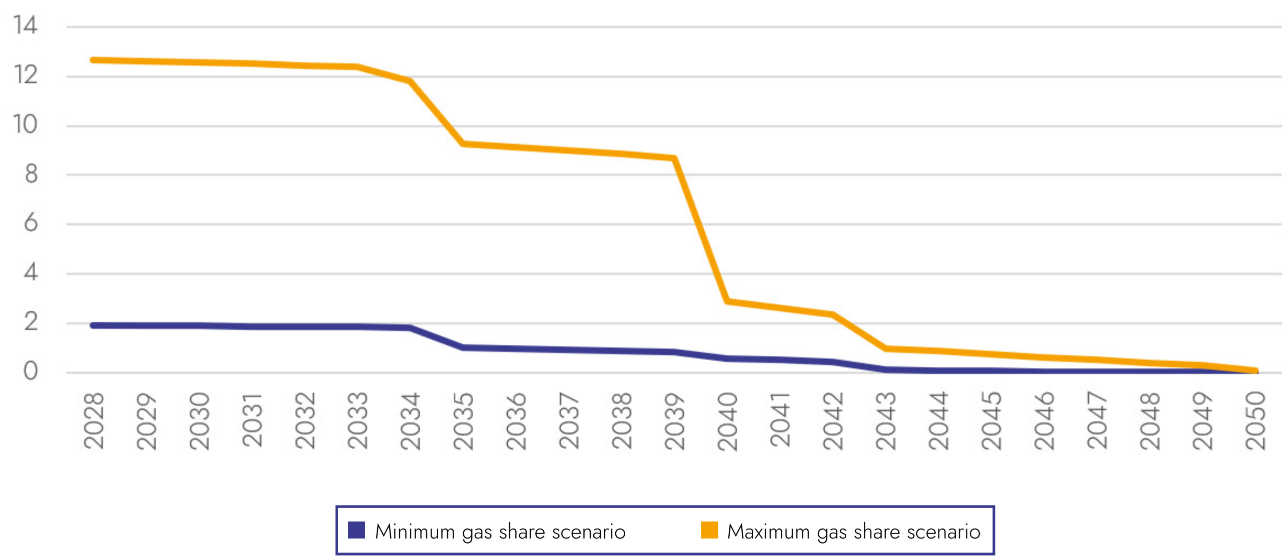
To a significant extent, this is due to the fact that the biomass supply market faces significant logistical, regulatory and geopolitical barriers. As indicated above, especially in large cities, the transportation and storage of biomass poses a major logistical challenge. Another factor that significantly limits the use of biomass is the requirement to certify the entire production chain of these fuels against constantly tightening sustainability criteria (SDC). The certification system affects the supply and price of biomass fuels, and applies from the stage of raw material acquisition to the stage of final use, taking into account all links in the supply chain. Poland's geopolitical location is also not without influence on the biomass market. The armed conflict in Ukraine has significantly reduced the supply of fuel, as it has resulted in the blocking of Belarus and Ukraine, the two main import destinations (Poland currently imports approx. half of the needed fuel). It should be mentioned that further tightening of the requirements for biomass (especially forest biomass), contained in the amended RED, as well as the planned introduction of a national regulation on energy wood may further limit the availability of this raw material for energy purposes. In conclusion, the biomass market will face deepening constraints over the next few years, which may have a negative impact on investment decisions in this type of generation source.

5.2.2. Availability of gas

Chart 24 shows gas demand under two scenarios: with the selection of options with the largest share of gas sources and the minimum share of gas sources. Based on ERO data for 2021[32],gas use in the centralized district heating sector is approx. 3 billion cubic meters. This data, compared to Chart 24, illustrates the scale of the technological and investment challenges facing Poland's district heating sector and associated infrastructure. It is also important to point out the considerations related to the network gas market and the overall shape of the investments carried out, related, among other things, to the need for energy companies to cover the full costs associated with the construction of connection pipelines.

The possible availability of decarbonized gases (biogas, green hydrogen or others), would allow conversion of gas units (low cost to about 30% share) and possible extension of their use to achieve further requirements to meet climate and energy policy goals.

Chart 24. Gas demand [bcm], source: PTEC's own study based on model results



32. Heat power engineering in numbers – 2021, Energy Regulatory Office, Warsaw, December 2022.

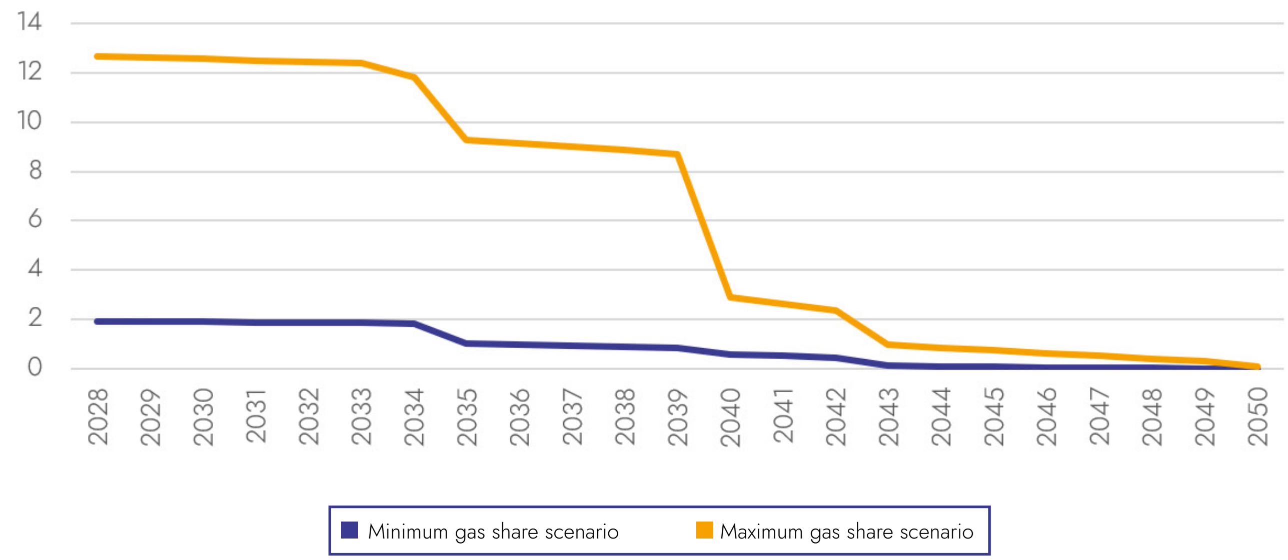
5.2.3. The impact of changing the generation mix on the carbon performance of the centralized district heating sector

The analyses also included an assessment of the impact of implementing investments to meet the requirements of the "Fit for 55" package on the carbon performance of the centralized district heating sector in Poland. The results in the two scenarios are presented in Chart 25, which shows that if the most ambitious scenarios for the use of RES in the centralized district heating sector in Poland are to be pursued, the sector's carbon performance will be marginal, but at this point it should be noted that there will be a logistical and technical problem related to the lack of fuel availability.

In a scenario in which gas is used to a greater extent in cogeneration units, the sector's carbon performance will also be significantly reduced and the requirements of the "Fit for 55" package will be met, but gas demand will increase nearly 4-fold from year to year, which is also technically unfeasible in terms of securing sufficient supplies of the fuel. This may also be hampered by the scope of planned investments specified by the gas transmission system operator in Poland (i.e. GAZ-SYSTEM) in the National Ten-Year Transmission System Development Plan for 2022–2031[33] which, despite its high level of ambition in terms of the investments to be made, did not foresee the need to switch to gas as an intermediate fuel in such a short timeframe as is implied by the definition of an effective district heating system.

The analysis also included a projection of the generation mix in the centralized district heating sector over the 2050 horizon based on the model results. Chart 26 and Chart 27 show possible scenarios for changing the mix in different technological configurations that meet the requirements of the "Fit for 55" package.

Chart 25. Gas demand forecast for the district heating sector in Poland depending on the development scenario [bcm] source: PTEC's own study



33. National Ten-Year Transmission System Development Plan for 2022 – 2031 developed by OGP-Gaz-System and agreed with the ERO President, 2021.

Chart 26. Projection of the share of heat production from gas-fired cogeneration depending on the development scenario, source: PTEC's own study

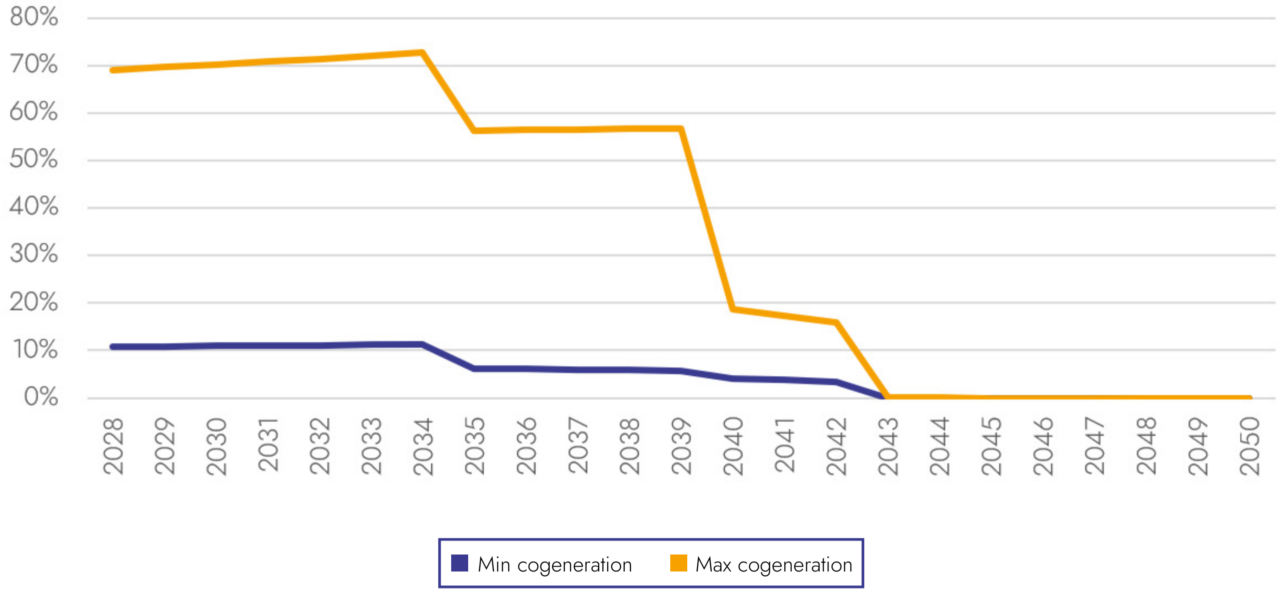
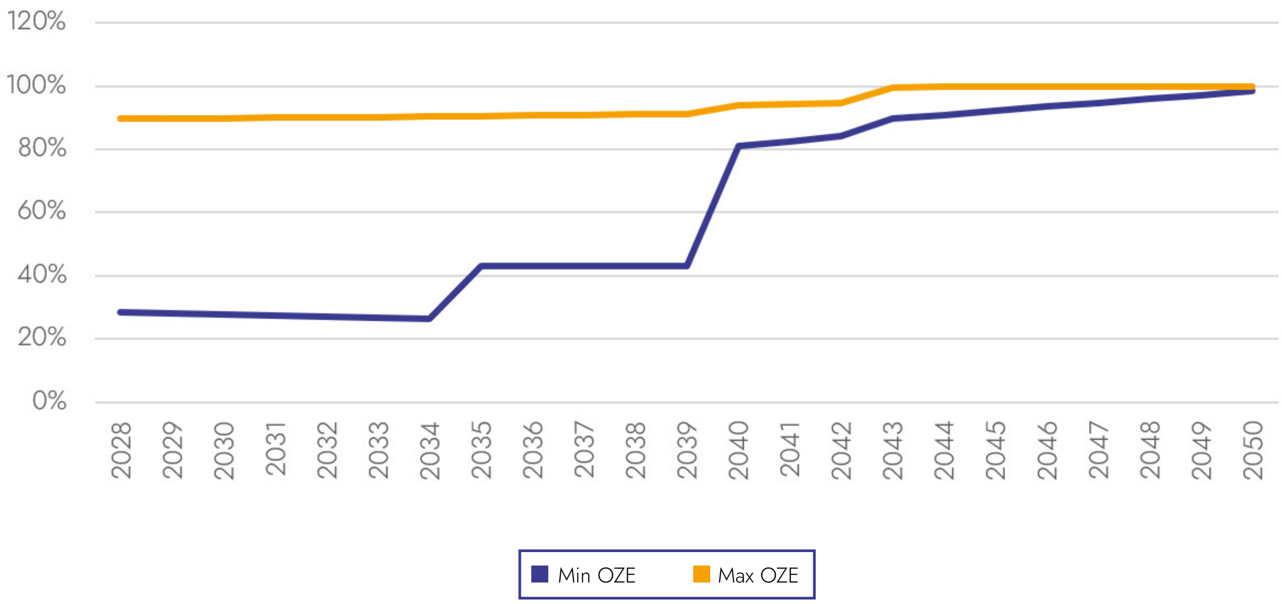


Chart 27. Projection of the share of heat production from RES and waste heat depending on the development scenario, source: PTEC's own study



Technological solutions for individual heat markets will vary depending on site conditions and other specific factors. Nevertheless, from the point of view of achieving the goals of the regulatory requirements (meeting the criterion of an efficient centralized district heating system in subsequent time frames), Chart 28 shows a hypothetical reference fuel mix for the district heating sector allowing the potential of various RES technologies to be used in a sustainable manner, taking into account the prolonged role of gas assets.

Chart 28. Reference fuel mix for the centralized district heating sector in Poland – heat production forecast by fuel source

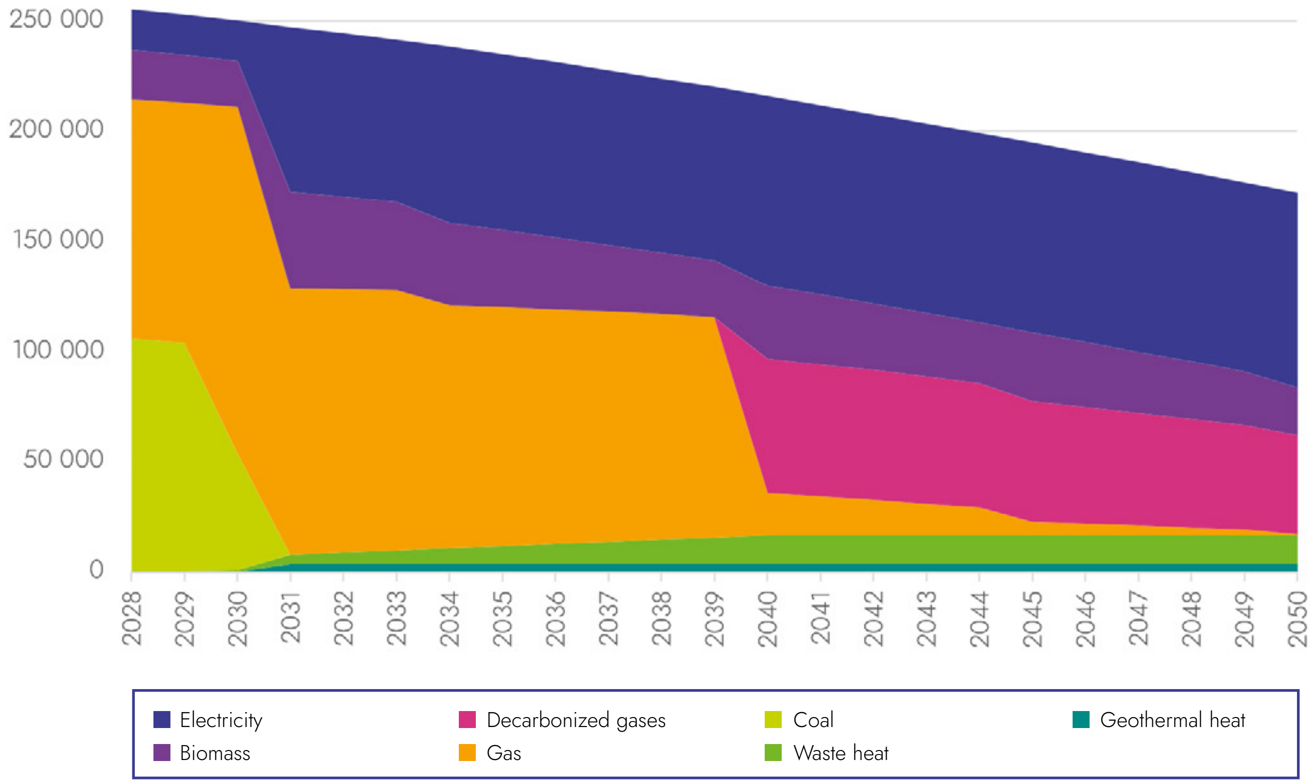
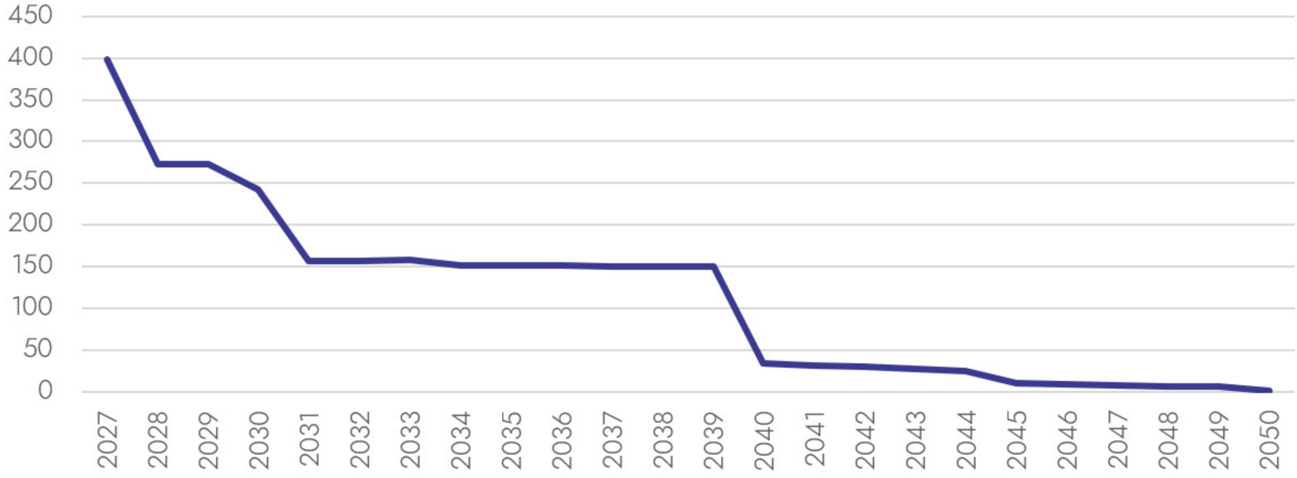


Chart 29. The reference fuel mix for the district heating sector in Poland – projection of the emission factor



Assumptions for the reference fuel mix for the centralized district heating sector in Poland:

- Gradual decommissioning of coal assets – planned by the end of 2030. However, according to Annex III to the EED, the new unit emission factor of 270 g CO_2/kWh for high-efficiency cogeneration (based on fossil fuels) will apply to new units and significantly modernized units after the transposition date of the Annex. Existing cogeneration units may waive this requirement until January 1, 2034, provided they have an emission reduction plan to achieve the 270 g CO_2/kWh threshold by January 1, 2034, meaning that the period may still be extended until the end of 2033.
- The intermediate fuel for achieving the various milestones under the definition of an efficient district heating system will continue to be natural gas, particularly through high-efficiency gas cogeneration, the use of which fits, in terms of the regulations, into the definition of an efficient district heating system by the end of 2039. After this period, as long as a sufficient volume of decarbonized gases is available, it is possible to use some of these assets as RES plants.
- The share of Power to Heat sources will gradually increase in the fuel mix, and the use of heat pumps and electrode boilers with heat storage will be of particular importance to ensure a proper optimization of their operation[34].
- The share of biomass will increase due to the gradual increase in the share of RES in the "Fit for 55" package requirements. An alternative solution to reducing the volume of biomass burned for district heating is the use of decarbonized gases in the existing gas-fired units in the future, which will allow the regulatory requirements to be met using the assets that are already in place. The important thing, therefore, is the available volume of this fuel – if it is not provided, the key role in meeting the requirements of the "Fit for 55" package will continue to be played by biomass-fired sources of heat.

34. Details on the use of Power to Heat units can be found in PTEC's report "Potential for the use of Power to Heat technology in the transformation of the centralized district heating sector in Poland," June 2024.

5.3. Conditioning related to infrastructure and demand facilities

5.3.1. Conditions of the district heating networks

In Poland, the centralized district heating sector, as shown in subsection 1.2, is advanced compared to other countries in Europe. In Poland, heat generation in cities is centralized and heat is supplied by district heating systems over large areas. It supplies an average of 40 to 60% of the population in a given region. Accordingly, the number of district heating networks and district heating customers is significantly higher than in other European countries.

In Poland, district heating networks have a total length of more than 22,000 kilometers. Adapting the heat generation sector to future regulatory requirements will involve great expenditures to modernize such extensive heat transmission and distribution infrastructure. As part of this analysis, due to the impossibility of obtaining accurate data on the diameters of individual district heating networks, it was decided to estimate the scale of capital expenditures necessary for this segment in order to adapt high-temperature networks (which are predominantly in operation in Poland) to the requirements under the Fit for 55 package for heat quantity and quality, i.e. modernization into low-temperature pre-insulated networks. In order to estimate the scale of capital expenditures, the estimated unit expenditures from 2024 for replacement of district heating networks were used, as shown in Table 9, and assumptions were made regarding the diameter of individual district heating networks.

The analysis adopted the average diameters of the district heating networks in each system based on Table 10 and the data for valuing capital expenditures contained in Table 11.

Table 9. Adopted unit prices for replacement of district heating networks depending on diameter, source: PTEC's own study taking into account market price lists

District heating networks made of pre-insulated pipes	Unit of measure	Unit price in PLN
32/110 mm (two-pipe system in a trench)	M	1 950
40/110 mm	M	2 071
50/125 mm	M	2 252
65/140 mm	M	2 347
80/160 mm	M	2 708
100/200 mm	M	2 904
125/225 mm	M	3 295
150/250 mm	M	4 013
200/315 mm	M	5 591
250/400 mm	M	6 009
300/450 mm	M	8 170
350/500 mm	M	8 550
400/560 mm	M	12 299
500/630 mm	M	15 765

Table 10. Average diameters of heating networks, source: PTEC's own study

Diameter of district heating pipes in Polish systems [mm]	Average distribution of pipe diameters using several district heating systems as an example [%]	Length of district heating networks in Poland with a given cross-section [km]
do 100	54%	11946
100-200	23%	5088
200-300	7%	1549
300-400	3%	664
400-500	7%	1549
> 500	6%	1327

Table 11. Adopted unit prices and diameters for valuation of capital expenditures, source: PTEC's own study

Adopted diameter	Unit price [PLN/m]
50/125	2 252
100/200	2 904
150/250	4 013
200/315	5 591
250/400	6 009
500/630	15 765

Based on the above data and the assumptions made, it should be concluded that the modernization of the heat transmission and distribution infrastructure to adapt it to low-temperature networks on the capital expenditure side will amount to approx. PLN 82 billion. In addition, there will also be a need to incur expenditures on replacing or modernizing heat substations. Assuming that some of the assumptions made are subject to the risk of data inaccuracy, and taking into account the current phenomenon of high inflation and the lack of available materials, which also affects price increases, it is estimated that capital expenditures could increase up to PLN 106 billion.

It should also be pointed out that the calculations do not take into account the very difficult to estimate increase in capital expenditures due to claims of landowners in the process of modernization of district heating networks – in Polish conditions there is a large share of land to which distributors do not have legal title.

Modernized or new district heating networks are metered in a completely different way than existing ones. Smart metering of the network also has a significant impact on the spread and delivery of heat to consumers. Thanks to "smart metering", district heating networks can be treated as heat accumulators of several hours and reduce the operation of peak sources, which has a significant impact on heat prices for end users. The analysis assumed that the reduction in peak source operation at times of lowest temperatures, due to smart network metering, would be about 5%. Digitization of the district heating sector, mainly on the network side, is an integral part of its transformation.

5.3.2. Conditions for demand facilities

The most difficult to estimate the necessary investment is the area of modernization of demand facilities in buildings, which includes the modernization, installation or replacement of heat distribution substations and the modernization of the building service systems, without which, it will not be possible to carry out an effective transformation of the centralized district heating sector. The extent of capital expenditures to be determined in this area is all the more difficult because the technical condition of buildings in Poland and building service systems varies, in addition, in some buildings heat is supplied from group heat distribution substations. It should be noted that modernizations of systems inside buildings would require the consents of 100% of the owners, which would pose a major organizational challenge. It has been assumed that the capital expenditures necessary to be incurred for the modernization of network heat demand facilities will amount to 1.4 times the expenditures necessary for the modernization of transmission and distribution infrastructure. Therefore, the amount of these expenditures is estimated to be between PLN 115 billion and PLN 149 billion.

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6. Summary of the analysis

- This report attempts to identify the costs of decarbonization of the centralized district heating sector in Poland resulting from the need to bring the sector in line with the requirements of the "Fit for 55" package (in terms of the definition of an efficient district heating system) and to identify key technologies that will enable the transformation process.

- The analysis was carried out for characteristic heat markets in Poland, classified by contracted capacity. The model is based on detailed macroeconomic, market and technology assumptions for reference heat markets for the period 2024–2050. Four technology options were proposed for each market to meet the definition of an efficient district heating and cooling system. The developed model in each year recalculates the most cost-effective heat sources, taking into account not only the fulfillment of the requirements of an efficient district heating system, but also the variable costs of production, and – for each year – arranges the stack of generating units writing them into the demand resulting from the heat profile for a given variant of the district heating system. This means that the heat production of each unit is based on the demand of a given market and the margin situation in a given year. The generating units with the lowest variable cost operate at the base of the district heating system.

- The analysis also takes into account scenarios for reducing heat demand in district heating systems, resulting mainly from thermal rehabilitation of buildings.

- Meeting the requirements of the EU's "Fit for 55" package will require, in Poland's case, depending on the scenario, expenditures of:
  - from PLN 102 billion to PLN 211 billion – expenditures for generation infrastructure,
  - from PLN 82 billion to PLN 106 billion – expenditures for transmission and distribution infrastructure,
  - from PLN 115 billion to PLN 149 billion – expenditures for modernization of demand facilities.

  that is, in total – from PLN 299 billion to PLN 466 billion for the decarbonization of the centralized district heating sector.

  It is important to point out the likelihood of a non-inflationary increase in capital expenditures due to the following: the need to modernize the entire segment at the same time (the opening of a large work site), the saturation of the Contractors' market or, for example, the interruption of the supply chain due to the geopolitical situation. These aspects are important given the assumed schedule and the need to meet further milestones for the definition of an efficient district heating and cooling system.

- A key aspect of financing the transition of the heating industry (which is beyond the scope of this report), is ensuring the availability of public funds for investment in the area of decarbonization of the sector. It should be noted that the maximum levels of intensity of state aid, set at the level of the EU legislation – which, after the changes introduced in June 2023, severely limit the amount of investment project funding from aid

35. Rozporządzenie Komisji (UE) nr 651/2014 z dnia 17 czerwca 2014 r. uznające niektóre rodzaje pomocy za zgodne z rynkiem wewnętrznym w zastosowaniu art. 107 i 108 Traktatu

funds – amount to, depending on the type of project, only 30 to 45% of the eligible costs. This means that a significant portion of the cost of decarbonization will have to be borne by end users.

- The report analyzes the most important technologies and fuels that can be used to decarbonize the centralized district heating sector. These include:
  - gas sources,
  - biomass sources,
  - geothermal sources,
  - large-scale heat pumps,
  - electrode boilers powered by electricity from RES.

  In the future, cogeneration units could also be fueled by green hydrogen or biomethane, but this still requires the development of a market for these fuels to ensure their actual supply, as well as adequate transmission and distribution infrastructure. The use of waste heat similarly can be one means for transforming the sector, but its availability varies strongly from location to location. An important technology in the transformation process, which will be worth developing further, is heat storage technology, which brings tangible benefits, including improved flexibility in the operation of generating units.

- The report presents a projection of heat production by fuel source. The analysis showed that the intermediate fuel for achieving the various milestones in Article 26 of the EED will continue to be natural gas, particularly high-efficiency gas cogeneration, the use of which fits into the definition of an efficient district heating system by the end of 2044 (until then, high-efficiency cogeneration will be included in the criteria defining an efficient district heating system). Depending on the availability of decarbonized ("green") gases and the resolution to the issue of their transport, there is the possibility of switching fuel at cogeneration units to achieve 75% heat from renewable energy sources as of 2040. The share of Power to Heat sources will gradually increase in the fuel mix, and the use of heat pumps and electrode boilers with heat storage will be of particular importance to ensure a proper optimization of their operation.

- It should be noted that, given the need to increase the volume of heat from RES and waste heat, which will be gradually replacing CHP heat in the district heating system baseload operation, there may be a balancing problem for the national power system (in which CHPs account for approximately 15% of the overall generating capacity), especially given the planned increase in capacity at Power to Heat facilities. The above trend may increase the risk of power shortages in the national power system. In order to ensure the stability of the electricity system and improve the security of energy supply in the local market to reduce transmission losses, it is necessary to recognize the leading role of gas cogeneration in ensuring flexibility, availability and support of the national power system in national energy security. The more renewables there are in the system, the greater the need for stable flexible units, and this is the role of gas-fired cogeneration. It is reasonable, taking into account the above-mentioned economic aspects and the change in the role of district heating systems in relation to the national power system (from supplier to consumer of electricity), to introduce an appropriate mechanism that would reward the flexibility/availability of cogeneration units.

7. Mechanisms and tools needed to be implemented to support the transition of centralized district heating

PLANNING AT THE NATIONAL AND LOCAL LEVELS

The "Transformation determinants related to the cooperation between heat market participants" section points to the special role of cooperation between undertakings, local government and final customers in the decarbonization of the sector. The signposts for the aforementioned heat market participants are the strategic planning documents at the national and local government levels. In this regard, it is crucial to:

Direction of the change	Assumptions of the change	Document
synchronize the activities of municipalities and the strategies of the energy undertaking for heat supplies	The obligation to adapt local municipal development strategies and the heat supply plan to the actual activities taking place in the centralized heat market and technological possibilities, which will increase the efficiency of district heating systems. Introducing mechanisms to oblige a municipality to prepare and update a heat supply plan in accordance with Article 19 section 2 of the Energy Law, including implementation of requirements introduced by the recast EED to oblige municipalities with a population of more than 45,000 to update or prepare such plan. Specifying the deadline for an assessment of the potential of high-efficiency cogeneration in accordance with Article 18 section 1 point 5 and its substantive framework, which will increase the precision and consistency in implementing the obligation to assess that potential. Coordination of planning activities between companies and local authorities, including the inclusion in urban development plans of space for the construction of distributed thermal energy infrastructure, e.g. heat accumulators with the associated infrastructure.	Energy Law Act
Developing a strategy for the district heating sector consistent with other government policies (the Polish Energy Policy until 2040, the National Energy and Climate Plan).	Adopting the document in cooperation with the heating industry, ensuring a broad public consultation.	Developing a strategic document

HEAT MARKET MODEL

The decarbonization process should be reflected in heat tariffs, hence the proposals to introduce:

Direction of the change	Assumptions of the change	Document
flexibility in shaping the tariff for cogeneration units	Freedom for the heat generation undertaking to choose its tariff setting method.	Energy Law Act
tariffs for heat accumulators	Enabling the tariff setting for heat storage facilities using the cost method.	
preference for the construction of renewable sources	Exemption of heat pumps up to 20 MW from the requirement of tariff approval by the ERO President.	
additional component of the capital cost formula	Adding a bonus for generation of heat from renewable energy sources in the formula used by the ERO President.	Information of the President of the Energy Regulatory Office No. 65/2022 on the principles and manner of determining and including return on capital (cost of capital) in heat tariffs for 2023–2025
additional component of the formula for the cost of equity capital	Allowing, in the calculation of the reinvestment bonus for heat generation, to include capital expenditure within x (5) years from the cost being actually incurred.	
increased WACC to cover justified costs for renewable energy technologies, waste heat, and to allow for efficient district heating system status	Coverage of the justified costs of business activity of energy undertakings in the scope of construction, modernize and connection of generating units being RES plants should be remodeled so as to provide them with an opportunity to achieve higher values than the statutory minimum, thus giving a development impulse for renewable sources. Adopting a minimum WACC of no less than 7% plus a bonus for heat generation from RES sources (as described in the subsection on the additional component of the cost of equity formula).	
dedicated distribution tariff for heat pumps and electrode boilers	Reduction of fixed fees and exemption from the capacity fee	Energy Law Act
separating the cost of CO_2 from average heat prices and planning them separately	Introducing, in the simplified method of tariff setting, the possibility of individually adding the cost of purchasing CO_2 emission allowances.	Energy Law Act Heat tariff regulation
minimum revenue	Restoring the regulation's provisions relating to the minimum revenue, the application of which was postponed until 2028.	Heat tariff regulation

Technical aspects of the operation of the heat market will translate into faster achievement of the goal of increasing the share of RES heat and waste heat, so it is necessary to introduce the following:

Direction of the change	Assumptions of the change	Document
an exemption from the obligation to connect RES plants in accordance with the full catalog of the type of energy included in the definition of an efficient system	Extending the possibility of exemption from the connection of RES sources in accordance with Article 116 sections 1 and 2 of the RES Act to an efficient district heating system, as defined in Article 7b section 4 of the Energy Law Act.	Energy Law Act
updating the design parameters used in the design of heating loads in buildings	Changing the climate zones and updating the standards for design temperatures, as they are outdated and incompatible with the currently observed winter temperatures, which is why the heat demand of buildings is oversized significantly.	Energy Law Act, Heat tariff regulation Update of standard: PN-EN 128311-1:2017-08
a change in the definition of waste heat	The definition of waste heat raises a number of interpretive doubts about the validity and possibility of including various heat management technologies within its framework, e.g. to the extent that it applies to municipal waste thermal treatment facilities. It would be advisable to amend/revise the definition which determines the classification of heat produced in WTE plants as waste heat.	Energy Law Act
green heat stream release mechanism	The main premise of the "green heat stream" will be the possibility of dedicating the capacity of new facilities in a given district heating system to specific consumers, whose connection to the district heating network would be possible after meeting the condition of an appropriate value of the non-renewable primary energy input factor. Only those sources that come on line after the legislation comes into effect would be considered as new generating capacity. The role of the new units will be to expand the generation capacity in a given district heating system or to replace the existing generation units. The system would be designed in such a way that the connection of, for example, 10 MW of RES would enable the connection of customers with the contracted capacity of up to 10MW.	The Renewable Energy Sources Act
adequate implementation of the RED III provisions on the use of biomass for energy, consisting in abandoning the implementation of the cascading principle in the Polish system due to the technological structure of the national power system and the heat market, as well as the need to ensure the country's energy security, especially during the periods of prevailing low temperatures	According to RED III, the goal of the principle of cascading use of biomass is to ensure the efficient management of biomass resources. Allowing the use of biomass for energy purposes is advisable if the technological structure of the system in which the source operates requires it, and if the raw material is a guarantor of the energy security of the country or of the local district heating system. At the same time, biomass plants are the primary sources of heat in several of the country's district heating systems, many of them new, and play a key role in supplying entire urban areas. The solutions introduced must therefore take into account the security of energy supply – energy being one of the basic goods – and provide for appropriate preventive measures. In addition, a consequence of introducing the cascading principle into the Polish legal system will be a growing competition for waste material from industry (sawdust, edgings, chips, offcuts), forest biomass (branch wood) or agricultural biomass (hay, straw, residues from agricultural production – especially large-scale farming), while the availability of biomass volumes will be limited. The potential increase in the price of biomass will push up heat prices to socially unacceptable levels and cause serious problems for the operation of heat plants and CHPs. This situation will prevent the planned decarbonization of the heating sector (due to the lack, in the short to medium term, of alternative technologies of appropriate scale), and thus the national RES targets for district heating will not be achieved.	Explanatory statement to the Renewable Energy Sources Act

MECHANISMS TO SUPPORT THE TRANSITION

The changing regulatory environment at the EU level is forcing centralized district heating utilities to continually transform themselves to meet the requirements of the "Fit for 55" package, which will involve significant capital expenditures (they have been indicated in this report). With this in mind, and taking into account the need to carry out the decarbonization process in a way that protects end users from a drastic increase in heat prices, mechanisms should be introduced to mitigate the costs of the "greening of district heating systems". To this end, PTEC members are proposing to introduce new mechanisms or changes to the current solutions:

Direction of the change	Assumptions of the change	Document
a mechanism to reward availability with respect to key units from the perspective of balancing the national power system	The mechanism would operate on the basis of Regulation (EU) 2024/1747 of the European Parliament and of the Council of 13 June 2024 amending Regulations (EU) 2019/942 and (EU) 2019/943 as regards improving the Union's electricity market design. The need to comply with state aid regulations, in particular with the 2022 Guidelines on State Aid for Climate and Environmental Protection and Energy Objectives.	Adoption of a law establishing a new support scheme
operational support mechanism for Power to Heat	The scheme is addressed to energy undertakings operating in the centralized district heating sector. Support provided through a competitive procedure (through a call/auction organized by the ERO President). The length of the support period depends on what technology is supported (it should be 10–15 years, as appropriate).	Enactment of a law establishing an operational support system for Power to Heat or amendment of the RES Act in this regard
trading guarantees of origin for heat from renewable energy sources in a market broader than that covering a given district heating system	Enabling the trading of guarantees of origin for heat from RES not only within the district heating system (as is under the current legal regime), but also outside it. Such a solution will increase the liquidity of the market for guarantees of origin for heat.	The Renewable Energy Sources Act and executive acts
extending guarantees of origin for heat to include waste heat	Introducing a new category of heat that would receive a guarantee of origin. For entities pursuing ESG goals, green heat should include both RES heat and waste heat.	
increasing and facilitating the possibility of obtaining white certificates	Amendments expanding the catalog of efficiency projects, introduction of an ERO ex-post inspection, clarifying the prerequisites for the application of the substitute fee, fully transferring the costs of efficiency improvement projects to district heating tariffs.	Energy Law Act Act on energy efficiency
the possibility of co-firing RDF and biomass that meets the sustainability criteria	Amending the definition of a dedicated multi-fuel combustion plant and of a multi-fuel combustion plant to allow co-firing of RDF and biomass in RES plants and treating the entire energy stream from the biodegradable part of RDF and biomass as emission-free (EU ETS). As a result, the volume of RES heat supplied to the district heating network will increase.	The Renewable Energy Sources Act

improving the operation of the support mechanism for high-efficiency cogeneration units	Introducing an obligation for the ERO President to issue a decision on admission to the system of a guaranteed individual bonus no later than December 31 preceding the year of payment of the bonus. Introducing the possibility of a single update of a bid submitted in a CHP auction or call. Relaxation of reporting obligations for generators with respect to cogeneration units for which support has not been paid. Relaxation of the rule (applicable in the event of a generator's failure to meet its obligation to generate electricity for the first time within a certain period of time) providing for the possibility of participating in the auction/call again after 3 years – by "shifting" the application of this rule from the level of the generator to the level of a given unit, which will allow the generator to "seamlessly" participate in CHP auctions/calls with its other cogeneration units. Extension of the deadline for obtaining a final building permit for a cogeneration unit that has won the auction/call (from 12 to 24 months after winning the auction/call). Changes to the approach in the way the ERO President calculates the individual unit cogeneration bonus, with the aim of making the system more attractive and, consequently, attracting generators to participate in the calls.	Act on promotion of electricity from high-efficiency cogeneration

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INVESTMENT AID

Given the EU's ambitions to reduce CO_2 emissions in the coming decades and the significant investment needs associated with the decarbonization, energy companies operating in the heating sector should have the access to assistance funds to support investment. The most important demands in this regard are as follows:

Direction of the change	Assumptions of the change	Document
Proposal to cover the following projects with the support:		Changes in programs available or creation of a separate program for this type of investment
investments in energy recovery from all types of RES plants and heat recovery installations	Creation of a new program under the Modernization Fund.	
construction of heat storage facilities (as stand-alone projects)	According to GBER, a heat storage facility can be financed by state aid as a separate project.	
construction of plants using biomass for heat production or cogeneration	RED III allows the use of biomass for energy and provides for the possibility of financial support for biomass, excluding industrial roundwood. It seems crucial to mitigate the risk of limited availability of biomass for energy, as such biomass is what guarantees local heat supply in many district heating systems.	
Establishment of a "Transition Fund" (Energy Sector Transition Fund), which is a source of investment support for a wide spectrum of investment projects in the energy field, including district heating transition projects (projects relating to generation, including cogeneration, as well as district heating networks)	"Transition Fund" financed by revenues from the sale of CO_2 emission allowances under the ETS. Funding provided under specific priority programs, the implementation of which would be the responsibility of the National Fund for Environmental Protection and Water Management (NFOŚiGW), with the participation of individual Provincial Funds for Environmental Protection and Water Management (WFOŚiGW). Support in the form of subsidies, preference loans with an option of redemption, and mixed instruments.	Adopting a law establishing a "Transition Fund" or amending the law on the greenhouse gas emission allowance trading scheme
providing investment support for the construction of electrode boilers that generate heat for district heating systems	Funding (in the form of a subsidy and/or a preferential loan) for investment in the construction of electrode boilers for district heating systems.	Changing the "RES – source of heat for the district heating industry" Program by expanding the scope to include the possibility of subsidizing electrode boilers or creating a separate program for this type of investment
applying, in a flexible manner, the criteria of the EU taxonomy for projects involving natural gas-fired units	Consideration by NFOŚiGW/other financing institutions of the recommendations, prepared in 2023 by the energy industry and published by the Ministry of Development and Technology, regarding the application of technical eligibility criteria (indicated in the so-called supplementary delegated act on EU taxonomy), relating to, among other things, high-efficiency cogeneration based on natural gas and heat production in gas-fired sources for efficient district heating.	Introducing appropriate provisions in the documents for a given cogeneration support program (in particular, programs funded from the Modernization Fund).

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COOPERATION WITH THE NATIONAL POWER SYSTEM

The centralized district heating sector is an essential element in stabilizing the operation of the national power system through combined heat and power production. At the same time, the district heating industry has immense potential to take advantage of surplus renewable electricity generation, as well as its storage and conversion to renewable heat. For an even greater cooperation between the sectors, it is necessary to:

Direction of the change	Assumptions of the change	Document
enable a widespread use of Power to Heat in the heating industry	Maximizing the use of electricity generation by RES plants without compromising the security of the national power system. Converting excess electricity during its overproduction by RES plants into heat, storing it and then consuming it at the peak of heat demand. Digitization of district heating networks. Hybrid district heating systems based on heat pumps and electrode boilers coupled with a thermal storage tank which perform a stabilizing function of the National Power System, managing surplus energy from the production of wind and photovoltaic power plants.	
introduce the possibility to qualify the entire heat stream generated by heat pumps (classified as a renewable energy source) as heat from renewables for the purpose of meeting the definition of an efficient district heating system	This is how the matter of calculating the amount of heat from heat pumps is presented in: Commission Recommendation (EU) 2024/2395 of 2 September 2024 setting out guidelines for the interpretation of Article 26 of Directive (EU) 2023/1791 of the European Parliament and of the Council as regards the heating and cooling supply – Chapter 3.1.2.	The Renewable Energy Sources Act
introduce a possibility to classify heat generated in electrode boilers as heat from RES for compliance with the definition of an efficient district heating system	Electricity from renewable energy sources used for heat generation in electrode boilers should be certified with guarantees of energy origin (or a mechanism based on guarantees of origin) or power purchase agreements (PPAs).	The Renewable Energy Sources Act

ENVIRONMENTAL PROTECTION

Environmental regulations are one of the key areas supporting the transition of the centralized district heating sector in Poland. What is referred to here are those regulations that affect the cost of carrying out licensed activities related which involve the use of the environment, and therefore also affect prices for end users of heat, as well as the mechanisms for financing investment projects. The key environmental demands include:

Direction of the change	Assumptions of the change	Document
Support of the Polish government in discussions with the EC on:		Commission's GD 11 guidelines on CNPs
recognition of 2030 as a settlement year for demonstrating significant CO_2 reductions declared under the Climate-Neutrality Plans (CNPs)	Completion of investment projects leading to the achievement of a significant reduction is possible by 2029, so there will be full generation from the new sources in 2030. It is therefore reasonable to operate new generation sources in 2030 to confirm the achievement of a significant reduction, i.e. 30.4% (relative to the average of the 2019-2023 period). Such an approach would be consistent with the CNP sheet which aggregates data in the 2026–2030 perspective. In addition, in the context of the short period of project implementation compared with the targets set, it is reasonable to allow operators to demonstrate significant reductions by investment projects commissioned in 2030, while maintaining the principle that the cost of these investment projects will be included in the amount of the necessary expenditures equivalent to the value of free CO_2 emissions allowances for a given plant.	
the possibility of including a plant outside the boundaries of an ETS facility in the demonstration of significant CO_2 emission reductions – CNP	Literally indicating the possibility of including installations operating outside a facility covered by the EU ETS in a significant reduction – without the need to extend the GHG emission permit to include these plants; this applies to plants that operate for the benefit of the heat network fed by the facility and do not cause emissions, provided that the operator of the installation operating outside the site of the Facility covered by the EU ETS and the EU ETS Facility is the same entity.	
transfer of additional free CO_2 emissions allowances from 2026 onwards before significant emission reductions are achieved	The European Commission's guidelines should clearly indicate that district heating undertakings implementing a CNP will receive additional free emission allowances each year – starting from 2026. Such a solution will have a beneficial effect on the liquidity of district heating undertakings and will be correlated with the timing of capital expenditures.	
change in fees for water services for heat pumps	Discharge (into surface water) of water used in heat pumps should not be subject to a variable fee that depends on their temperature – exceeding the temperature of 26°C of the discharged wastewater; in cases where the temperature of the water taken is so high that, despite running it through the heat pump, it cannot be cooled down below 26°C	Water Law Act
making the variable fee for heat pumps dependent on the amount of energy drawn (not consumed) by water-based systems	Making the variable fee dependent on the amount of energy drawn (not: consumed, as under the currently applicable regulations) by systems using water drawn, used and then discharged to water or the same aquifer in the same amount and not deteriorated quality, except for the change of its temperature, and for non-returned process water drawn and not directly intended for heating or cooling.	

reducing the duration of, or introducing a mechanism to derogate from, the prohibition on siting civil structures for RES plants, such as PV, on closed landfill sites	Reducing the duration of, or introducing a mechanism to derogate from, the prohibition on siting civil structures for RES plants, such as PV. Currently, the use of closed landfill sites for PV is severely limited, while the required momentum for PV development could take advantage of the available post-landfill land that is unsuitable for other land use.	Regulations on landfill sites
allowing a plant to operate in the event of a crisis caused by extraordinary circumstances beyond the operator's control	Implementing the provisions of the revised IED in a manner that ensures maximum flexibility, particularly with regard to the possibility of applying derogations from emission limits in the event of emergencies resulting in the emergence of disturbances in the energy sector.	Environmental Protection Law

INVESTMENT PROCESS

In order to accelerate the transformation of the heating sector, selected administrative procedures should be streamlined and simplified, which includes:

Direction of the change	Assumptions of the change	Document
adopting a fast track in administrative proceedings for investment projects related to the decarbonization of the heating industry, including significantly speeding up and simplifying the issuance of decisions on environmental conditions for project implementation	Speeding up the issuance of environmental decisions, including reducing the number of requests to the applicant to provide missing elements in documentation which are made by the authorities competent to issue a decision on environmental conditions / the authorities which are reviewing the application. Setting the maximum time for the decision-making procedure. Fast-track process for administrative permits for the construction, expansion and operation of facilities for renewable energy production, including heat pumps, energy storage facilities located on the same site, as well as the assets necessary for their connection to the grid, including a grid connection permit.	Construction Law Energy Law Act Law on environmental impact assessment
significantly speed up and simplify the issuance of permits for projects relating to RES sources in the district heating sector	Implementation of the provisions of RED III with regard to the areas of accelerated RES development that realistically accelerates the implementation of decarbonization projects.	The Law on Spatial Planning and Development, the Construction Law, the Law on Renewable Energy Sources.
facilitating the investment process for the construction/ reconstruction of the district heating network	Facilitating the preparation and implementation of investments in the construction, alteration or modernization of district heating networks, including with regard to the procedure for obtaining approvals for entering the area (determining the content of rights in rem on the real property through which the district heating network runs or will run).	Dedicated special Act of Parliament

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