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IMPLEMENTATION OF THE EUROPEAN GREEN DEAL IN THE POLISH HEATING

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Abstract: Heat supply is an important sector of the country's energy economy. Modern heating systems should guarantee the reliability of heat supply while limiting the impact on the environment. It results from the objectives of the climate policy implemented in the European Union, which is based on decarbonisation, reducing greenhouse gas emissions, developing renewable energy and improving energy efficiency. As a consequence of such a policy under the European Green Deal is the need for a rapid transformation of the Polish heating sector with the use of innovative low-emission technologies. The article discusses the framework of the European Union's climate and energy policy and the directions of Poland's energy policy in the area of heating. The characteristics of the heat market in Poland and key indicators related to the objectives of the Green Deal in relation to other European Union countries are presented. Then, the directions of system heat transformation with the use of renewable energy sources and heat storage technologies are discussed. The achievements of Polish heating companies in the field of introducing renewable energy sources and innovative technologies were presented. The possibilities and limitations of the transformation of the Polish heating sector were also indicated.
Keywords: heating systems; energy transformation, renewable energy sources; decarbonisation

1. INTRODUCTION

Thermal power energy satisfies the living needs of society as well as industrial recipients, constituting an important element of every national economy. It is estimated that heating and cooling consume half of the EU's energy and much of it is wasted. Therefore, the priority of the European Union is to implement a strategy that will make heating and cooling more efficient and sustainable (European Commission, 2016). It should help to reduce energy imports and dependency on external sources, to cut costs for households and businesses, and to deliver the EU's greenhouse gas emission reduction goal. Continuing its activities in the area of environmental protection and counteracting climate change, the European Commission presented the European Green Deal in 2019. It is a new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy.

The main goal is to achieve zero net greenhouse gas emissions in 2050, with economic growth decoupled from the use of natural resources (European Commission, 2019). This requires conversion the energy sector, including heating, to low-emission technologies and reducing the consumption of fossil fuels in favor of renewable energy sources. This poses special challenges to the Polish heating sector, which currently uses more than 70% of coal fuels (ERO, 2020).

2. FRAMEWORK FOR THE CLIMATE AND ENERGY POLICY OF THE EUROPEAN UNION AND POLAND

In order to meet the threats of global climate change on Earth and environmental degradation, the European Union has been pursuing a rigorous climate and energy policy for over a dozen years as part of its sustainable development strategy. Its practical implementation is a series of packages, policies and proposals to reduce greenhouse gas emissions and promote renewable energy sources (RES):

- 2008 - the first comprehensive climate and energy package "3x20%";
- 2011 - Energy Roadmap 2050 action plan;
- 2012 - Directive on energy efficiency;
- 2014 - A policy framework for climate and energy in the period from 2020 to 2030 (updated in 2018);
- 2015 - "MCP" Directive on the limitation of emissions of certain pollutants into the air from medium combustion plants;
- 2016 - An EU Strategy on Heating and Cooling;
- 2018 - a new directive (RED II) on the promotion of the use of energy from renewable sources;
- 2019 - European Green Deal action strategy;
- 2021 - European Climate Law and the "Fit for 55" Package.

The quantitative targets included in the first energy and climate package of 2008 assumed by 2020:

- reduction of greenhouse gas emissions by 20% (compared to 1990 levels);
- improvement of energy efficiency by 20%;
- increasing the share of renewable energy sources by 20%.

As a continuation of activities related to climate protection and reduction of greenhouse gas emissions, the European Commission published in 2011 the "Energy Roadmap 2050". A reduction in greenhouse gas emissions by 80-95% by 2050 (compared to 1990) and decarbonisation in order to create a European low-emission energy system were adopted. Four tools are expected to help implement this plan: energy efficiency, renewable energy sources, nuclear energy and carbon dioxide sequestration technology. In the following years (2014 and 2018), the framework for the climate and energy policy until 2030 was defined. The key goals for 2030 are:

- cuts of greenhouse gas emissions by at least 40% (from 1990 levels),
- increasing the share of renewable energy by at least 32%,
- improvement of energy efficiency by at least 32.5%.

The latest European Green Deal strategy assumes that by 2050 Europe is to become the world's first climate neutral continent. In turn, the "Fit for 55" Package assumes a further reduction of emissions by at least 55% and 40% of energy from renewable sources by 2030.

For the development of district heating systems, the MCP and RED II directives and the directive on energy efficiency (Directive 2012/27/EU) are of particular importance. The latter Directive defines an "efficient district heating and cooling system" as one that uses at least 50 % renewable energy, 50 % waste heat, 75 % cogenerated heat or 50 % of a combination of such energy and heat. This means supporting the development of heating infrastructure (heat sources and networks) in the use of high-efficiency cogeneration, waste heat and energy from renewable sources.
The EU regulations in the field of climate and energy policy are then implemented into the laws of individual member states. The Energy Policy of Poland until 2040 (PEP2040) adopted in 2021 (Ministerstwo Klimatu i Środowiska, 2021) is based on three pillars:

- I Pillar. Just transition
- II Pillar. Zero-emission energy system
- III Pillar. Good air quality

The plan assumes a national energy and climate transformation, to which approximately PLN 260 billion will be allocated by 2030, from EU and national funds under various mechanisms. The key indicators of PEPP2040 are:

- by 2030, GHG emissions will be reduced by approx. 30% compared to 1990;
- in 2030, the share of renewable energy in energy consumption will be at least 23%;
- energy efficiency will increase – for 2030, a target of 23% reduction of primary energy consumption.

The development of heating and cogeneration has been set as a specific objective in the third pillar. It was assumed that in 2030 the share of RES in heating will be 28.4%.

3. THE STATE OF POLISH HEATING IN THE CONTEXT OF THE GREEN DEAL

District heating systems in Poland cover an average of 65% of household heat demand. The technical potential of heating companies is determined by two key figures, i.e. the installed thermal power and the length of the operating heating networks. The basic values for system heating in Poland, according to the ERO report (2020), are presented in Table 1.

Table 1.
The potential of system heating in Poland in 2002, 2008 and 2019

Specification	Unit of measure	Data in years		
		2002	2008	2019
Number of licensed heating companies	-	894	530	396
Thermal power installed	MW	70 952.8	61 456.0	53 560.9
Power ordered by recipients	MW	38 937.0	35 461.1	34 408.0
Length of heating networks	km	17 312.5	19 104.1	21 701.2
Annual heat production	TJ	467 527.8	396 622.4	365 628.7
Including cogeneration	TJ	no data	250 675.7	237 466.9
Annual total heat sales	TJ	469 355.5	395 861.4	344 712.6
Heat delivered to recipients (from network)	TJ	298 938.1	254 156.1	226 671.8
Average efficiency of heat transfer	%	88.2	87.6	86.7
Decapitalisation ratio of fixed assets	%	54.75	59.40	48.87

Source: own elaboration according to the Energy Regulatory Office (URE, 2017 and 2020)

Diversification of fuels used for heat production in domestic heating companies is still very slow. Coal fuels used in heat sources still account for over 70% (Figure 1).

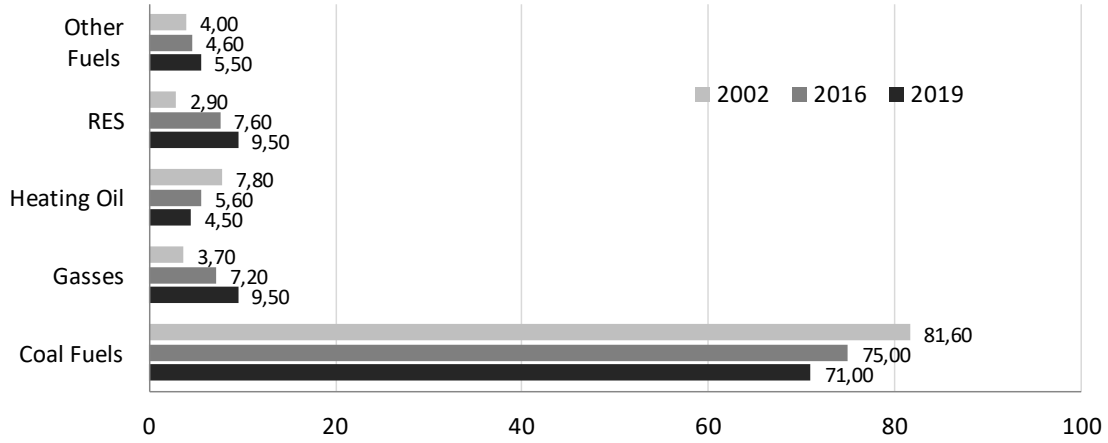

Fig. 1. The structure of fuel consumption for heat production in Polish heating companies [%]
Source: own study according to the Energy Regulatory Office (URE, 2017 and 2020)

Compared to the Polish thermal power sectors other EU Member States are characterized by a great diversity of fuels used, and often a significant share of renewable energy sources (Figure 2).

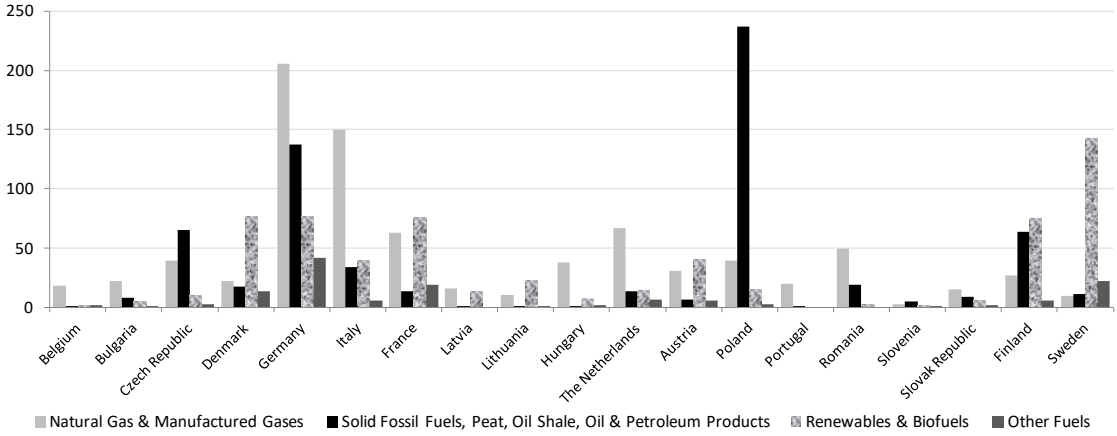

Fig. 2. Production of heat from various fuels in selected EU countries in 2018 [PJ]
Source: own elaboration according to the European Commission, *EU energy in figures*, 2020

The share of hard coal and other fossil fuels in combustion processes results in a significant emission of pollutants into the atmosphere. Table 2 shows the amount of gas and dust emissions in the Polish heating sector in the years 2002-2019. Despite a significant decrease in the intensity of pollutant emissions, Poland is the country with the highest unit emission of carbon dioxide (kg CO2 / toe) in the EU (Figure 3).

Table 2.
Emission of pollutants in the Polish heating sector in selected years of the period 2002-2019

Year	Number of companies that reported pollutant emissions	Emission of pollutants [tons]			
		CO_2	SO_2	NO_x	Dusts
2002	752	56 479 225	339 243	122 013	No data
2010	418	43 696 776	160 036	73 487	22 728
2015	376	35 955 661	96 964	74 422	11 963
2019	361	35 295 760	58 774	45 914	6 763

Source: own study based on data from the Energy Regulatory Office, 2011, 2015 and 2020

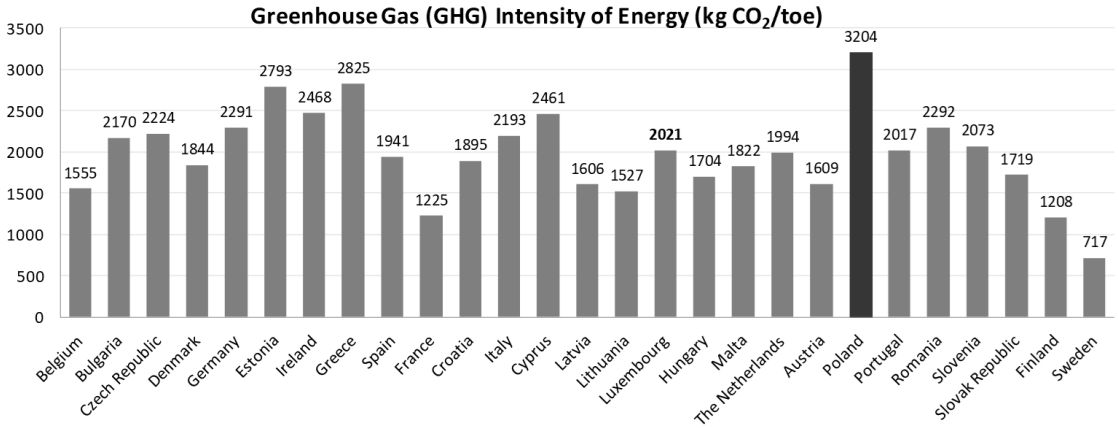

Fig. 3. Carbon dioxide emission intensity for all types of fuel in EU countries in 2018
Source: own elaboration according to the European Commission, *EU energy in figures*, 2020

An important factor characterizing the domestic heating sectors is the efficiency of heat supply, defined as the ratio of the supplied useful heat energy to the final energy consumption (Kavvadias et al., 2019). In a large part of the EU Member States, this indicator is relatively low - below 70%, as shown in Figure 4.

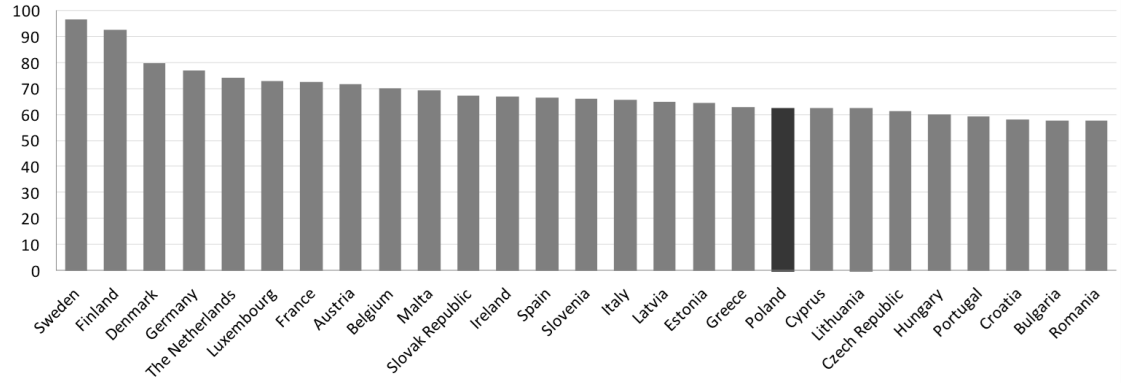

Fig. 4. Overall national heating supply efficiencies in EU countries [%]
Source: according to Kavvadias et al., 2019

At the national level, countries with the lowest share of fossil fuels show higher overall efficiency in the district heating sector. This is the case in Sweden, Finland and Denmark, where a large part of the heat demand is met by renewable energy sources (see Figure 2). This proves that the transformation of the heating sector towards renewable sources is an important segment in the process of decarbonisation of the Polish energy sector.

4. DIRECTIONS OF SYSTEM HEATING TRANSFORMATION

The future of heat supply systems are 4GDH and 5GDH - low-temperature district heating systems using renewable energy sources and heat storages (Lund et al., 2021). The Fourth Generation District Heating (4GDH) has been defined as a coherent technological and institutional concept, which by means of smart thermal grids assists the appropriate development of sustainable energy systems (Lund et al., 2014). 4GDH systems provide heat supply to low-energy buildings from heating systems with low

network losses. Their important feature is the use of low-temperature renewable heat sources integrated with the operation of intelligent energy systems. The fourth generation district heating presented conceptually in Figure 5 defines the possible paths for the decarbonisation of the heating sector.

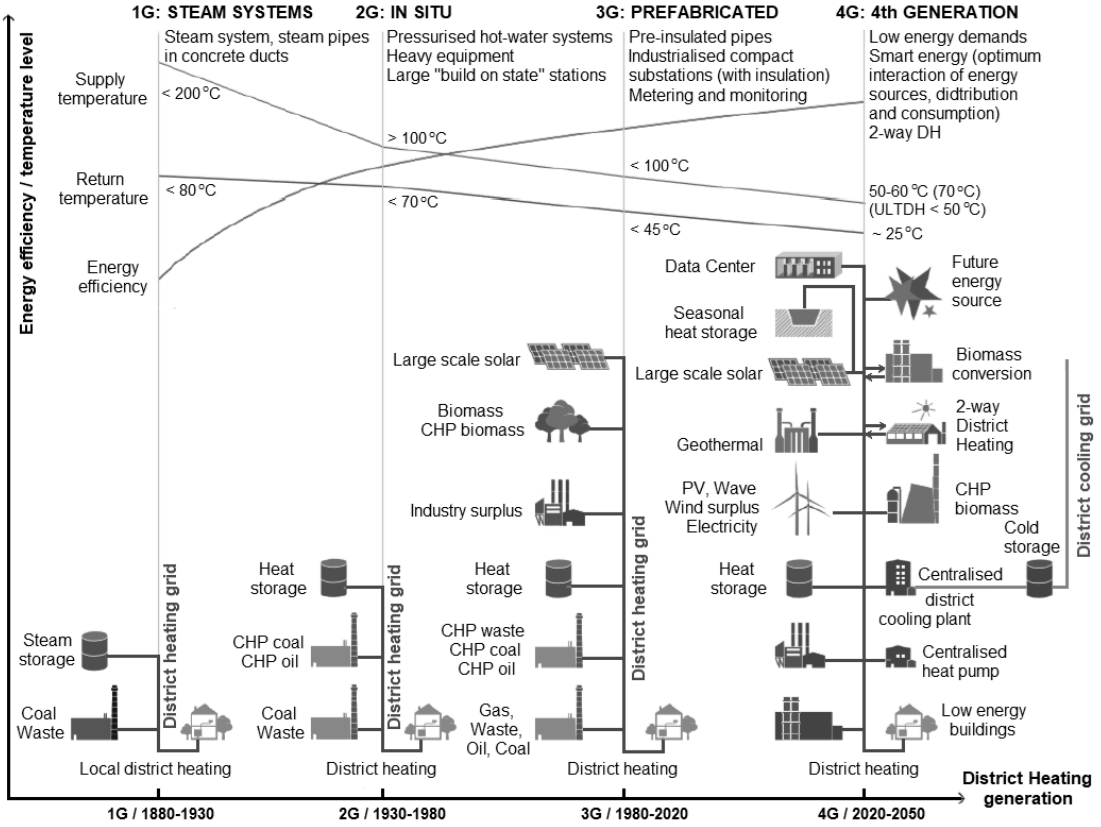

Fig. 5. The idea of 4th Generation District Heating in comparison to the previous generations
Source: according to Lund et al., 2021

The advantages of low-temperature district heating include: reduction of heat losses in the network, the ability to connect multiple renewable heat sources (recipients), greater utilization of thermal storage units and improvement of the power-to-heat ratio in cogeneration systems (Imran et al., 2017). The practical applications of low-temperature district heating networks are presented in Table 3.

Table 3.
Practical application of LTDH

Location	Year	Supply Temp.	Return Temp.	Outdoor Temp.	Heat Supplied	Heat Loss	
		ºC	ºC	ºC	GJ	GJ	%
Kirsehir, Turkey	1995	57	38	11	39 312	5 739	14,6
Munich, Germany	2006	59	33	10	6 534	155	2,4
Okotoks, Canada	2007	39	31	4	2 705	141	5,3
Lystrup, Denmark	2009	52	34	8	986	186	18,9
Falkenberg, Sweden	2010	78	44	7	1 374	122	8,9
Høje Taastrup, Denmark	2013	70	40	9	1 978	263	13,3

Source: according to Imran et al., 2017

In recent years, the district heating and cooling market has attracted attention to low temperature district heating (LTDH) networks due to their benefits in terms of efficiency, greenhouse gas reduction, flexibility in the use of renewable energy sources and economic benefits (Bach et al., 2016; Olsthoorn et al., 2016; Wiśniewski et al. 2019; Bamisile at al., 2020). A flexible coupling of power and heat sectors can contribute to both renewable energy integration and decarbonisation. There are different means to convert electricity into heat. The most important options for the residential heating sector are shown in Figure 6.

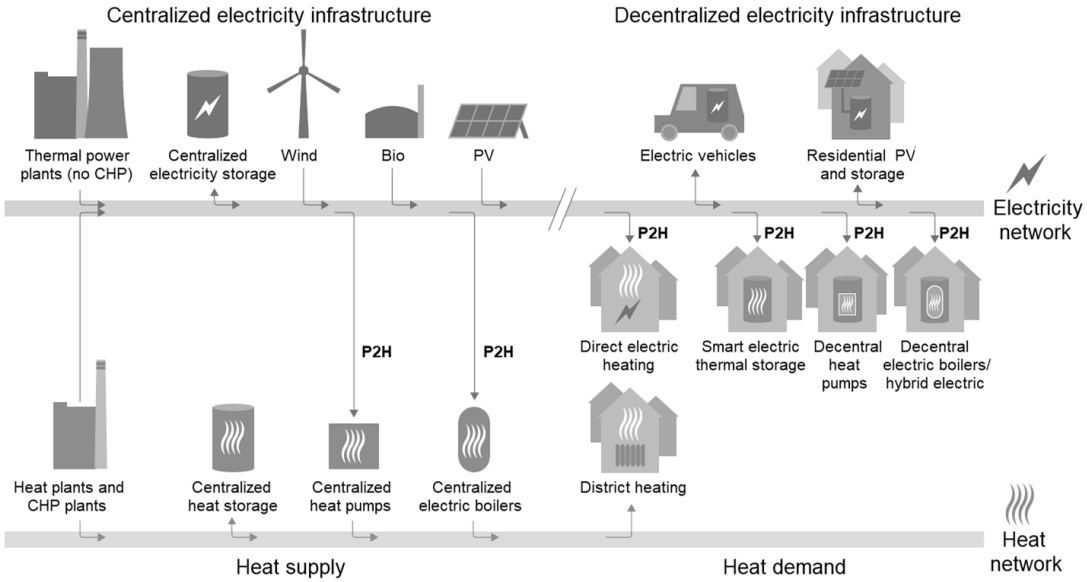

Fig. 6. Interconnections of power-to-heat options with electricity and district heating networks
Source: Bloess et al., 2018

The potential of RES in heat engineering and their efficiency are growing rapidly along with the development of heat storage technology, both in several-day and seasonal cycles. Seasonal storage facilities are primarily used to accumulate surplus energy from renewable sources and from cogeneration units produced in the summer season. They are a technology already commercialized in some European countries, e.g. in Denmark, Germany, Sweden and the Netherlands (Tokarczyk et al., 2020).

5. RENEWABLE ENERGY SOURCES IN POLISH HEATING COMPANIES

Poland's energy policy until 2040 in the area of heating is to ensure universal access to heat by supporting the development of ecological and efficient heating systems. The transformation of heating should meet three basic goals (Forum Energii, 2019):

- improve air quality and limit climate change;
- provide thermal comfort;
- guarantee energy security.

The main energy carrier that allows to increase the share of renewable energy sources in heating is biomass, although it has limitations related to its sustainable acquisition. There are also significant potentials of geothermal energy, biogas and solar energy in the country, the popularity of which will increase as the cost of obtaining it decreases. Possibilities of developing the use of RES in Polish district heating based on the resources available are shown in Figure 7.

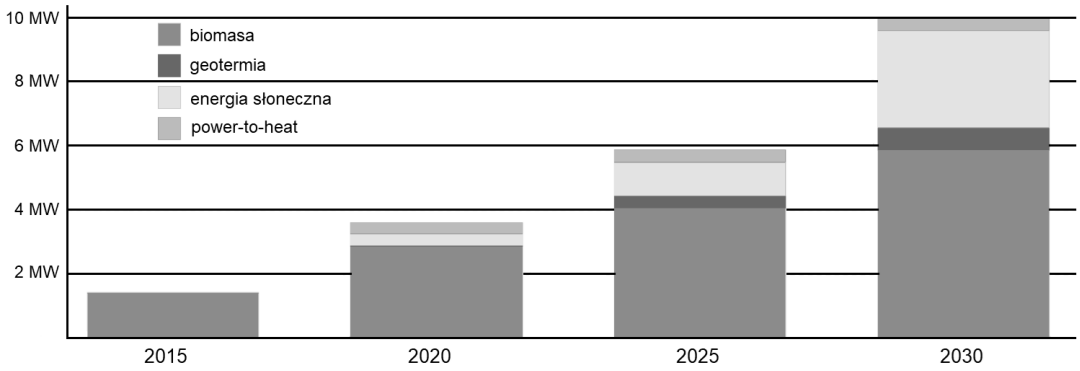

Fig. 7. Scenario for the development of the RES potential in district heating in Poland
Source: according to Instytut Energii Odnawialnej, 2018

The list of recently completed and currently implemented investments in Table 4 proves the increase in the use of biomass in district heating.

Table 4
Biomass-fired heat generation units co-financed from OPI & E 2014-2020

Investor - location (city)	Electrical power	Thermal power	Costs	Year of commissioning
	MW_e	MW_{th}	million PLN	
PUGK Sp. z o.o. - Nidzica	-	2.5 + 5	17.9	2018
MPEC Sp. z o.o. - Olsztyn	-	25	54.6	2020
MPEC Sp. z o.o. - Łomża	-	12.5	26.8	2020
	3.2	12.5	57.2	2023
PEC Sp. z o.o. - Suwałki	-	2×12.5	40.7	2020
ZEC Sp. z o.o. - Dzierżoniów	1.0	5.0 ORC	35.8	2021
PEC Sp. z o.o. - Biała Podlaska	-	5 + 12	30.6	2021
MPGK Sp. z o.o. - Krosno	-	7.0	12.8	2021
MPEC Sp. z o.o. - Nowy Sącz	-	7.0	14.5	2021
Energa Kogeneracja Sp. z o.o. - Elbląg	25	30	<200	2021
Zambrowskie Ciepłownictwo i Wodociągi	-	8.0	17.5	2021
PC Sp. z o.o. - Działdowo	-	5.1	13.1	2022
PEC Sp. z o.o. - Wyszków	2.07	10.56	65.7	2022
PEC Sp. z o.o. - Ciechanów	0.8 + 1.0	11.1 + 1.2	49.4	2022
Energa Kogeneracja Sp. z o.o. - Kalisz	11.3	21.3	151.7	2022
ZEC Sp. z o.o. - Orzysz	-	2×5.0	21.9	2022
ZUT Sp. z o.o. - Tomaszów Mazowiecki	-	5.1	12.3	2022
MEGATEM EC-Lublin Sp. z o.o.	12	35	219.3	2023
Ciepłownia Rydułtowy Sp. z o.o.	1.3	5.3 ORC	41.4	2023
MPEC Sp. z o.o. - Lębork	-	5.1	13.1	2023
MPEC "GIGA" Sp. z o.o. - Augustów	-	8.0	20.5	2023
Energetyka Cieplna Sp. z o.o. - Wieluń	-	2×5.0	23.1	2023
VEOLIA Południe - Tarnowskie Góry	-	12.0	27.4	2023
MPGK Sp. z o.o. - Włodawa	-	15.0	36.8	2023
Spółdzielnia Mieszkaniowa "Świt"- Ełk	-	10.0	24.2	2023
MEC Sp. z o.o. - Mrągowo	-	8.0	20.7	2023

Attention: ORC - Organic Rankine Cycle
Source: own study based on the list of projects co-financed by OPI & E 2014-2020 (https://mapadotacji.gov.pl/projekty/ [access: 18.08.2021]) and other internet sources

Poland has very large geothermal water resources, several times greater than, for example, Germany. In the years 1995-2017, the National Fund for Environmental Protection and Water Management granted 31 subsidies - for a total amount of PLN 154 million - for geothermal exploration and geological works. Thanks to this, the first geothermal heating plants in the country (with a heating network) were established in Podhale, Pyrzyce, Poddębice, Mszczonów and Stargard Szczeciński (Table 5). On the other hand, the use of thermal energy from solar collectors remains marginal in the Polish heating sector (Table 6) - together with geothermal energy it is approx. 0.015% of the total heat produced.

Table 5
Geothermal heat plants in operation and under construction until 2023

Investor - location (city)	Geothermal power	Temperature of water	Costs	Year of commissioning
	MW_{th}	ºC	million PLN	
Geotermia Podhalańska - Bańska Niżna -Zakopane	40.7	82-86	~260	1993-2017
	13.7	82-86	20.7	2020
	18.1	82-86	42.8	2021
Geotermia Pyrzyce	14.8	61	60.6	1997
	4.1	61	6,2	2023
Geotermia Mazowiecka - Mszczonów	3.7	42	10.7	1999
Geotermia Uniejów	3.2	68	17.0	2001
G-Term Energy Sp. z o.o. - Stargard Szczeciński (Geotermia Stargard)	12.6	83	40.0	2005/2012
	12	83	95.9	2020
	20	90	75	2023
Geotermia Poddębice	10	68	25.0	2013
Geotermia Toruń Sp. z o.o.		62	66.2	2008/2021
MPEC Sp. z o.o. - Konin			56.1	2023
PEC Sp. z o.o. - Sieradz	22	52	76.9	2023
MZEC Sp. z o.o. - Koło	11.5		37.3	2023

Source: own study based on the list of projects co-financed by OPI & E 2014-2020 (https://mapadotacji.gov.pl/projekty/ [access: 18.08.2021]) and other internet sources

Table 6
Licensed heating companies with solar collector systems

Investor - location (city)	Solar power	Surface	Year of commissioning
	MW	m^2	
ZEC Sp. z o.o. - Wołomin	0.30	380	2007
MPEC Sp. z o.o. - Olsztyn	0.127	173	2010
	0.423	528	2010
MPEC Sp. z o.o. - Dębica	0.205	293	2010
ZEC - Iłża	0.30	429	2011
ZEC Sp. z o.o. - Lubrza/Prudnik	0.0487	69.6	2012
	0.023	33	2011
Energetyka Cieplna Opolszczyzny - Opole	0.20	269.64	2016
MPEC Sp. z o.o. - Nowy Sącz	0.07	100	2016
PEC Sp. z o.o. - Suwałki	0.0659	94.12	2016

Source: own study based on Instytut Energii Odnawialnej, 2018 and internet sources

The implementation of the goal adopted in PEP2040 in the form of increasing the share of renewable energy sources in heating in 2030 to 28.4% requires very large investment outlays in heating companies, which at the same time have to pay for more expensive carbon dioxide emission allowances. Therefore, the National Fund for Environmental Protection and Water Management co-finances projects in clean technologies under the following programs (https://www.gov.pl/web/nfosigw/):

- "Energia Plus" (budget PLN 4 billion) - subsidies up to 50% of costs for ORC technology as part of heating plants, CHP plants or geothermal power plants, as well as loans for up to 20 years when the project aims to maintain or obtain by the heating system the conditions of an "effective system district heating", and at least 30% will be allocated for communal and living purposes;
- "District heating" (PLN 150 million in subsidies and PLN 350 million in loans) - support for companies producing thermal energy for communal and living purposes, the majority shareholder of which is a local government unit (at least 50% of shares), and the ordered heat capacity is not exceeds 50 MW;
- "Providing access to thermal waters in Poland" (budget PLN 300 million) - subsidies for local government units for exploration and recognition of thermal water deposits in order to use the obtained heat for heating;
- "Polska Geotermia Plus" (budget PLN 600 million) - construction of a new, expansion or modernization of the existing heating plant/combined heat and power plant / geothermal power plant, or modernization or expansion of the existing energy generation sources by a heating plant/combined heat and power plant/geothermal power plant, based on a geothermal source.

Very important for the development of district heating in Poland is the project "Heat Plant of the Future, or a heat system from RES", financed by the National Center for Research and Development (NCBiR) from European Funds. It is an undertaking carried out in the form of pre-commercial procurement (a new form of promotion and implementation of innovations). The aim of the project is to develop and implement technologies that will enable the transformation of heating systems based on fossil fuels into energy and cost-effective enterprises. The leader of the ranking list of this competition was the Consortium of Rafako Innovation and the Institute for Renewable Energy (IEO). The technology demonstrator (budget PLN 38 million) will be located on the premises of PEC in Końskie. The concept assumes the production of thermal energy from solar radiation using large-scale solar collectors and a power-to-heat solution using green energy. However, the most important element of the system will be a seasonal heat storage made in a technology that has not been used in Poland so far. Thanks to the support of the National Center for Research and Development, PEC Końskie may have 80% of heat from RES as early as 2025, and in 2030 the entire district heating system may be completely independent of the prices of fossil fuels and the prices of CO_2 emission allowances. The solutions of the Rafako-IEO consortium will be applicable to heating plants of various sizes throughout Poland.

6. CONCLUSION

The next several years in the Polish heating sector will undoubtedly be a period of accelerated technological changes and transformation of heating systems towards energy-efficient and low-emission ones, with an increasing share of energy from renewable sources. This is due to the need to implement the European Union's climate

policy implemented, inter alia, by the directive on renewable energy sources, the so-called "RED II Directive". According to the policy adopted by the Union, only economies based on knowledge and investing in the latest technologies limiting the impact on the environment have a future. The requirement to significantly improve technical and economic indicators (energy efficiency, emission levels, reduction of heat losses) forces heating companies to introduce innovative technologies in the area of heat generation and management of heating systems (Wrzalik, 2019).

The inevitable decarbonisation and transformation of the Polish energy sector under the European Green Deal is a major challenge for Polish heating companies. The problem of the Polish heating sector is the dominance of coal fuel (low share of RE$S), low and often negative profitability and lack of funds for investments. In order to achieve the goal set out in PEP2040 (in 2030 at least 85% of heating systems with an ordered capacity of more than 5 MW are to be energy-efficient), it is necessary to strongly support from public aid as well as deregulate the heating sector and increase its profitability. The program "Heat Plant of the Future, or a heat system from RES" implemented by NCBiR has the potential to pave the way for a new generation of heating systems in Poland (4th and 5th generation technologies). This gives the prospect of bringing the Polish heating sector to the European Green Deal standards included in the new EU climate package "Fit-for-55" (it will come into force in 2024).

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