

SDHp2m

Solar District Heating

Implementation of Renewable Energy Sources in District Heating Systems in Poland



Dronninglund District Heating, PlanEnergi

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Dr Kazimierz Kujda, President of the Board of the NFOŚiGW

The National Fund for Environmental Protection and Water Management (NFOŚiGW) has been promoting the initiatives leading to modernization and optimization of district heating systems in Poland, consequently fulfilling the national and European commitments in the scope of implementation of renewable energy sources in district heating.

I would like to mention two flag projects of the NFOŚiGW: Effective District Heating and Cooling Systems realized from national funds. On the other hand, the projects under the framework of 1st Priority Infrastructure and Environment 2014-2014 Program, sub-action 1.1.1 Support of the Investments Concerning Production of Energy from RES with Connection to the Grid, are funded by the European Union.

Currently, the NFOŚiGW is working on a new pilot program District Heating Systems Based on RES and Thermal Storages. The key element conditioning implementation RES into district heating systems is thermal storage, that could balance the supply and demand on heat in both summer and winter periods. Owing to thermal storages, one can highly profit from so-called weather-dependent sources of energy that are solar collectors and electrical energy from wind farms (Power to Heat) and simplify the exploitation of geothermal sources and biomass.

As a result of such solution, the highly-exploited sources working on coal, that constitute the base of district heating systems in Poland, could be gradually powered off, without a need to be replaced by boilers powered by the same fuel, and without high environmental cost at the same time.

Results and conclusions from the project SDHp2m will be very useful during formation of a new program, as they are consistent with the strategy of the National Fund for Environmental Protection and Water Management.

The meaning of renewable energy sources in district heating in the European Union

The increase of use of renewable energy sources (RES) in district heating systems, often neglected in the past, becomes one of the European Union's priorities in promotion of the growth of RES share in the overall power consumption and in the actions aiming to decrease the emissions of greenhouse gases. In 2007, the Council of the European Union adopted first, comprehensive Climate and Energy Package „3x20%”, that indicated three main goals of development of the energy policy in the EU until '20: the increase of RES shares in the overall energy share (that is electrical energy, energy carriers in transportation and heat from RES) up to 20% and decrease – also by 20% - of the use of final energy and greenhouse gases emission, in particular from sources having power above 20 MW, for which there have been set reduction goals covered by ETS regulations. The overall goal of 20% share of energy from renewable sources has been divided into member states, and the goal for Poland was set to 15%. The national plan set in 2010, assumes fulfillment of this objective only if the energy share from RES in district heating reaches 17,1% by 2020.

2007 r. first, comprehensive Climate and Energy Package „3x20%”

2010 r. - National action plan in the field of RES

2012 – Energy Efficiency Directive

2015 - Directive on the limitation of emissions of certain pollutants into the air from medium combustion plants

New directive (RED II) on the promotion of the use of energy from renewable sources

Those are not the only commitments concerning district heating. The energy efficiency directives requires reaching, mainly using RES or waste heat (in both cases energy storages are needed), the position of effective district heating system. In this report, the authors focus on the role of solar energy in reaching the minimum 50% share of energy from renewable energy in producing heat used in district heating sector. Currently, according to Polish District Heating Chamber of Commerce (IGCP), only 15% of the district heating enterprises meets the criteria of effective district heating system. What is more, the “MCP” directive (directive on the limitation of emissions of certain pollutants into the air from medium combustion plants) requires fulfilling – mainly using RES and thermal energy storages (in place of highly emitting coal-fired boilers) – higher and higher emission standards concerning sulphur oxide (SO₂), nitrogen oxides (NO_x) and particles(dust). Gradual replacement of the oldest boilers fired with solid fuels, could allow the enterprises to avoid high costs of investment on modernization and adjustment to new environmental standards.

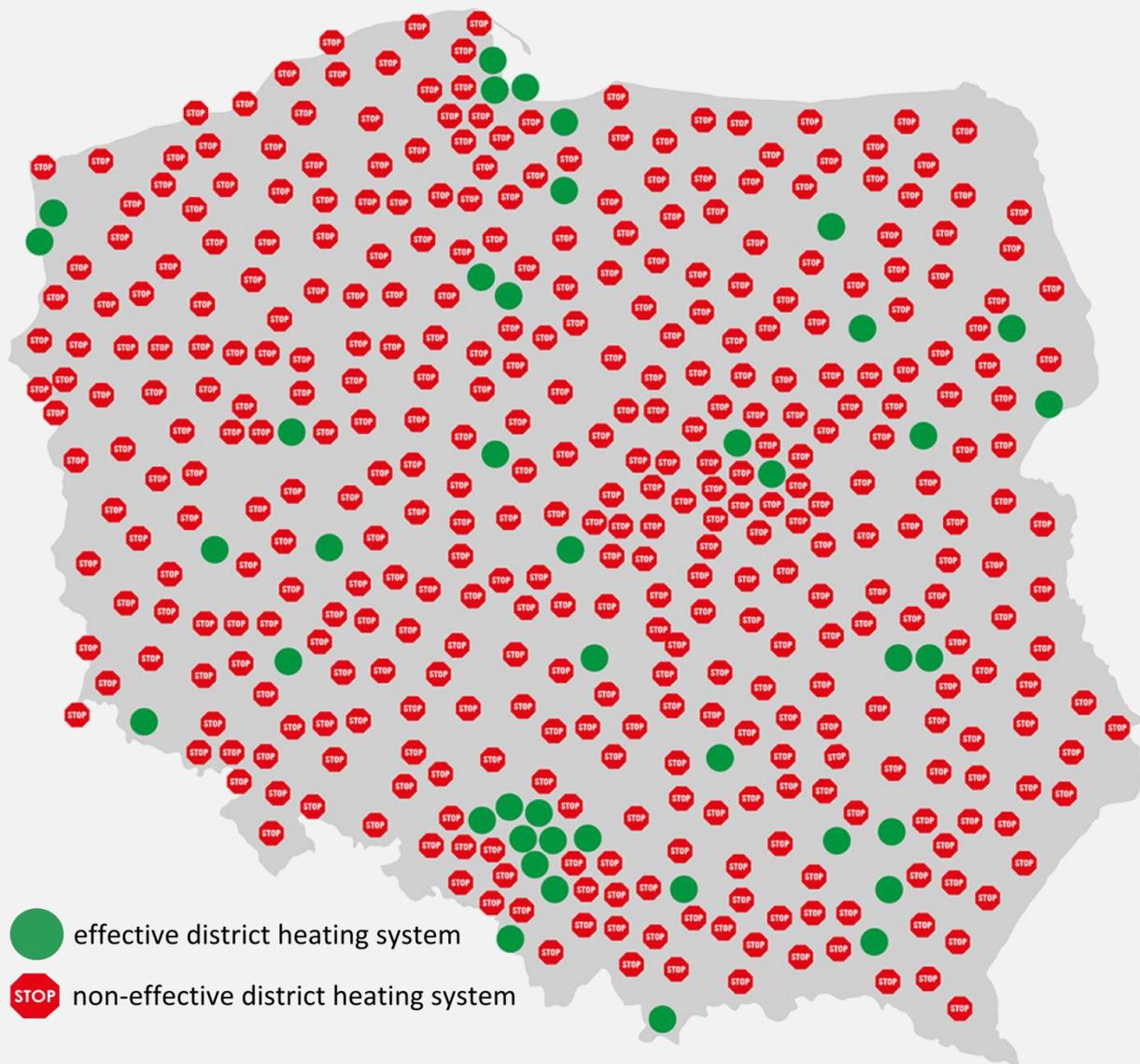


Fig. 1 The map of effective and non-effective district heating systems in Poland. Source: Polish District Heating Chamber of Commerce (IGCP),

The European Committee, under the framework of “The EU Strategy in the Scope of District Heating and Cooling”, requests for full rejection of solid fuels in district heating until 2040 and full rejection of fossil fuels in district heating until 2050, with concurrent increase of RES share in the EU from 16,5% in 2013 to around 50% in 2050, including waste heat. The EU policy has an impact on further commitments – for 2030. The new

directive (RED II), regarding promotion of use of RES [(2016/0382)COD], established the obligation of achieving an annual increase of, at least 1-2%, in the use of RES share in district heating systems.

Upcoming few years in Polish district heating will be the years of accelerated technological transitions in direction of energy effective and low-emission systems, with higher and higher RES share.

Realization of goals and European commitments in district heating sector in Poland

The directive about promotion of RES from 2009 obliges – until 2020 – the increase of share of energy from renewables in all sectors indicating demand on energy, also in the district heating (previous directive referred only to promotion of electrical energy). District heating enterprises in Poland, gradually from the beginning of

the 90s, started the implementation of renewable energy sources into their systems. Firstly, they started to use biomass. However, later on, some of them attempted to implement the geothermal energy into the business. The development of systems based on solar radiation was visible only in 2010 – fig. 2.

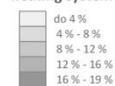
MAP OF LICENSED DISTRICT HEATING COMPANIES IN POLAND

LICENSED DISTRICT HEATING COMPANIES WITH SOLAR COLECTORS SYSTEMS

LEGEND

- conventional energy
- conventional energy supported by solar energy
- conventional energy supported by geothermal energy
- conventional energy supported by biomass energy

The share of the voivodeship in the total installed capacity in the Polish heating system



Energetyka Ciepna Opolszczyzny S. A., OPOLE



0,20 MW
270 m²

Zakład Energetyki Ciepłej Prudnik Sp. z o.o. PRUDNIK/LUBRZA



0,05 MW
70 m²

0,02 MW
33 m²

Miejskie Przedsiębiorstwo Energetyki Ciepłej Sp. z o.o., NOWY SĄCZ



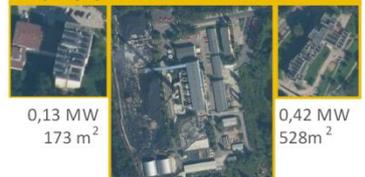
0,07 MW
100 m²

Przedsiębiorstwo Energetyki Ciepłej w Suwałkach Sp. z o.o., SUWAŁKI



0,07 MW
94 m²

Miejskie Przedsiębiorstwo Energetyki Ciepłej Sp. z o.o., OLSZTYN



0,13 MW
173 m²

0,42 MW
528 m²

Zakład Energetyki Ciepłej, IŁŻA



0,30 MW
429 m²

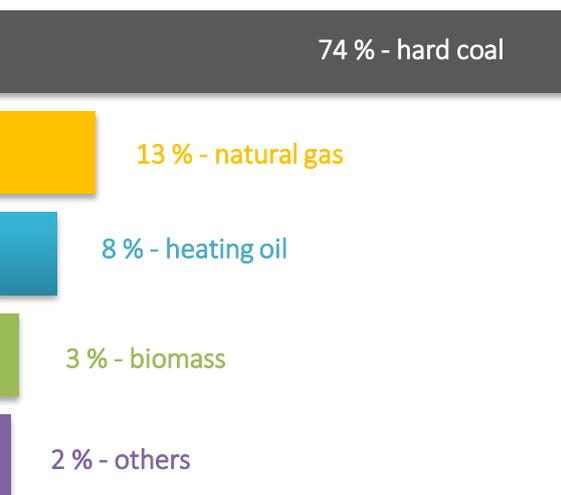
Miejskie Przedsiębiorstwo Energetyki Ciepłej Sp. z o.o., DĘBICA



0,21 MW
293 m²

Fig. 2 The map of licenced district heating companies in Poland with RES installations, including the solar installation in district heating systems. Source: comp. IEO

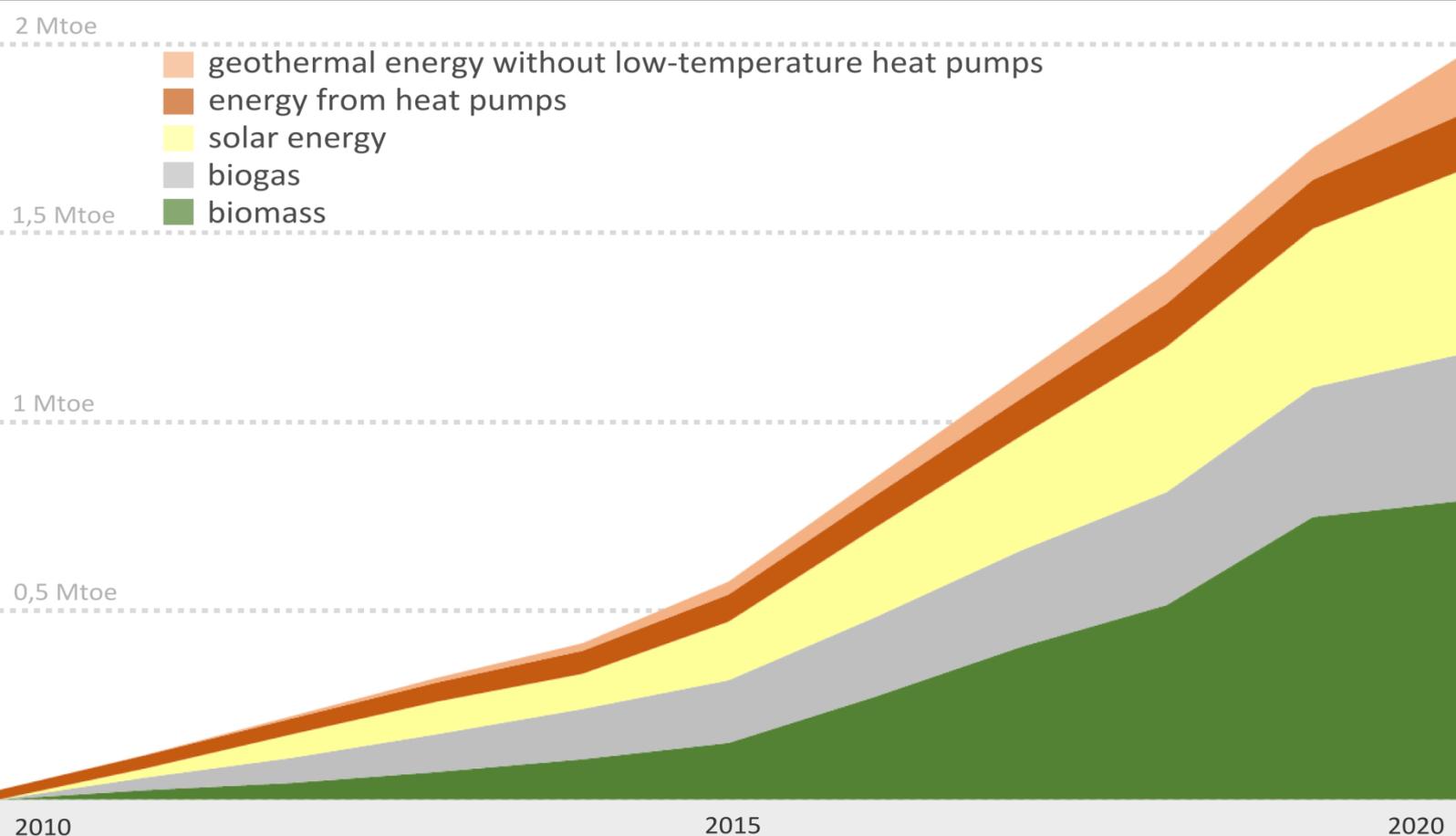
FUEL STRUCTURE USED IN POLISH DISTRICT HEATING SYSTEMS



Currently, the generation unit powering district heating are, in vast majority, based on fossil fuels, and the share of hard coal is equal to 74%. RES in the so-called system district heating still constitutes a small part of fuel mix – around 3% (data from the Energy Regulatory Office, 2016). The district heating systems have a great and untapped potential of implementation of RES and can have a significant impact on fulfillment of 2020 commitments in Poland. It is even more important as, according to the Energy Regulatory Office (data from the end of 2017), Poland should accelerate the development of installations based on renewables, both in district heating sector, as well as the overall share of

RES in energy sector to be able to meet the required terms. There's a need of new installations to increase the share of RES from 11,7% (the end of 2016) to required 15% in 2020. It is worth mentioning, that in accordance with the National Actions Plan (KPD) established by the government in 2010, the share of renewable energy in the form of heat should be equal to 55% of the overall national commitment for 2020. That is why there is a need to invest in various renewable energy sources in this sector. The path of development of investments in RES for district heating sector (the scenario of increase of production of heat from new RES in comparison to the base scenario from 2010) is shown on the fig. 3.

Fig. 3 Assumed increase in energy consumption from RES in heating and cooling, scenario the National Actions Plan (KPD). Source: comp. IEO based on KPD.



In the scope of use of energy from RES in district heating and cooling, the scenario prepared by the National Actions Plan, assumed the increase of use of heat and coolness from RES from around 4 Mtoe in 2010 to 6 Mtoe in 2020 (2 Mtoe increase from 2010 to 2020 – fig. 3), which would constitute 17,1% of overall consumption in Poland. It was assumed, that the increase would occur mainly after 2014, due to increase of use of biomass, biogas and solar energy. The Plan did not consider any use of unbalanced electrical energy from RES, in particular from wind (so-called Power to Heat). In practice, the development of RES deviates significantly from the assumptions, also in the district heating sector. At the end of 2016, the RES share in district heating was equal to 14,7% and the highest deviation is observed in the field of use of solar energy. The solar collectors share for 2020 was established at 14,7 billion m², which is equal to 10 GWth of installed power. According to the government's data, the area of solar collectors in 2017 should be equal to 9,4 billion m². Construction of several large-scale installations with areas of 10-100 thousand m² (the biggest installations in the EU have areas of 200 thousand m²) and connection to district heating systems could allow to direct the development of solar energy to the path established by the National Actions Plan.

Solar District Heating - SDHp2m – the EU's project

Solar district heating systems, that is large-scale systems of solar collectors (greater than 500 m²), together with thermal energy storages (sizes from several thousand to several billion cubic meters) are a modern supplement for current solutions for district heating enterprises. Additionally, these type of systems can cooperate with other types of RES such as heat pumps or Power to Heat technology. First such installations were built in Europe in the 80s. Currently, the biggest amount of installations are present in Denmark, Sweden, Germany and Austria. The European Commission supports actions of implementation of green solutions in district heating sector, amongst others Solar District Heating project SDHp2, in which the Institute for Renewable Energy (IEO) is involved. The project aims to develop and implement in nine participating European regions advanced strategies of expansion and subsidy programs for district heating sector. The actions run under the framework of the project are aimed to launch investments, and thus develop the market in direction of green solutions. On the web page of the project – www.solar-district-heating.eu, the guidelines for construction of RES installations cooperating with district heating systems are available. What is more, on the same webpage, a base of European projects that are already in operation is placed.

Fig. 4 Large-scale system of solar collectors with thermal energy storage cooperating with district heating in Dronninglund, Denmark. Source: PlanEnergi

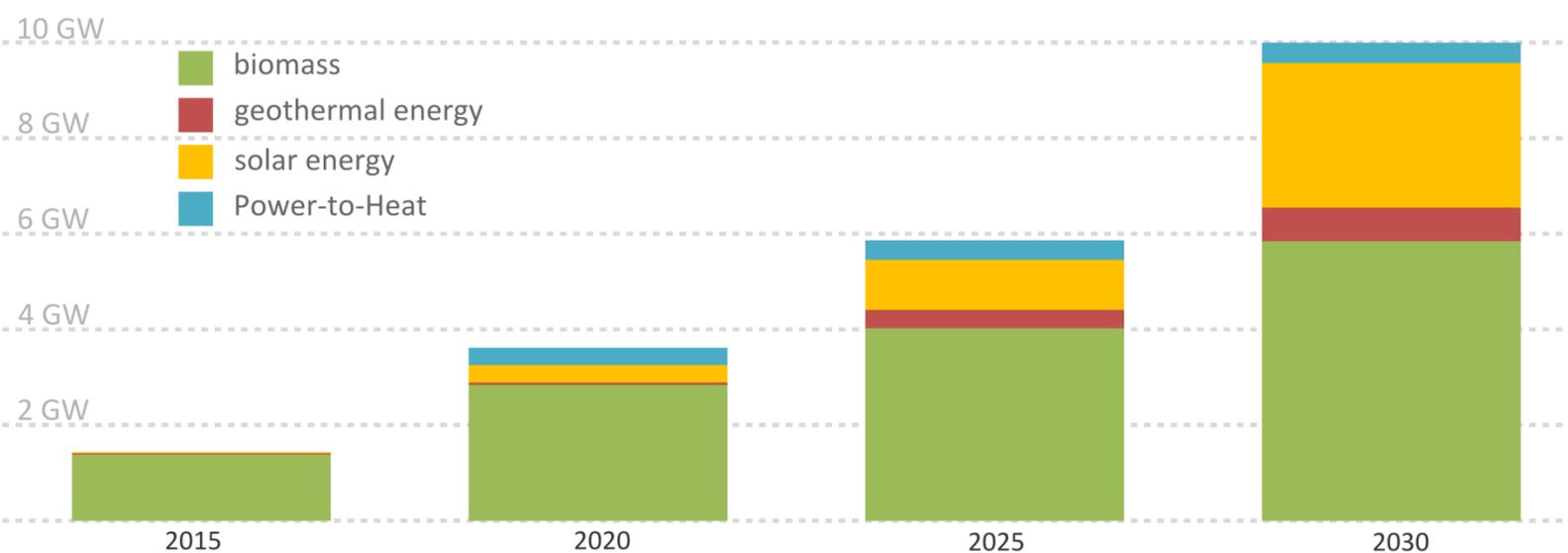


Potential of use of new technologies in RES in district heating systems

Poland is one of the leading European countries considering system heating and this fact points to the huge potential of RES in the sector, both in licensed enterprises, housing associations, communities and developer estates. In order to widely use RES in district heating, there is a need to overcome several technical issues. Currently used technologies in system heating are based on combustion of solid fuels and old business models, that assume keeping the demand on heat on its current level with relatively high temperature of reception, prevent from increasing share of renewables (above few percent), without facing some barriers. One of them is the finite biomass resources and the costs (increasing with the demand), which as the only RES can supply heat with high temperature.

The IEO, assuming that (under European directives) all licensed district heating enterprises will lead to achieve the name of effective district heating system and taking into consideration a trend of implementation of new heating technologies (of III and IV generation, the latter gathers technologies that are not based on combustion processes), conducted an evaluation of real investment potential in RES in district heating. During the research, the scenario Energy Revolution (based on MESAP simulations of national energy mix until 2050, in which in 2030 (investor's perspective) a sub-scenario of system heating was distinguished) was used. The results show that there is a possibility to implement power of 10 GW using RES until 2030 in licensed enterprises. The outcome of simulation is presented on fig. 5.

Fig. 5 Scenario of development of potential of RES in system heating. Source: comp. IEO for Energy Forum.

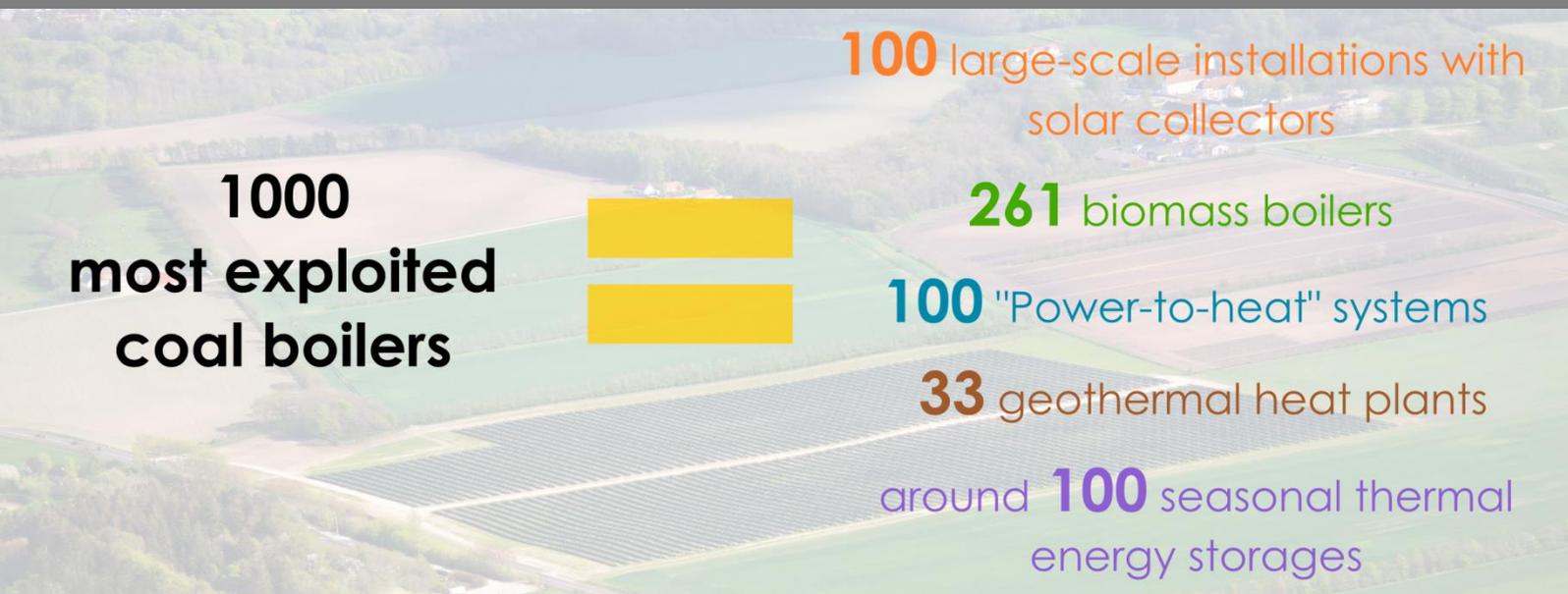


Realization of the scenario would lead to construction of 33 geothermal heat plants, 100 large-scale installations with solar collectors, 261 biomass-fired boilers, 100 Power to Heat systems (with powers equal to 4 MW) and around 100 seasonal thermal energy storages. Such investment program would allow to disconnect up to 1000 most exploited coal-fired boilers while not decreasing the capacity factors of the best coal-fired boilers. The average capacity factors in enterprises will depend on prices on the electric energy market and sizes of thermal energy storages. Realization of such investment package would allow generation of 111 PJ of energy from RES and avoidance of emission of 5 billion ton of coal (that could be used by

other sectors, such as power engineering, metallurgy or chemical industry).

An increase of investment potential in the years of 2015-2030 above 8 GW, is based in 50% on zero emission sources, that can eliminate around 10-20% (depending if sources with the highest emissions would be deactivated) of emissions of highly toxic pollutions. Such modernized heat plants, would contribute to fight against smog in two ways: eliminating individual sources with high emissions (after adding new consumers to district heating system), and subsequently not increasing its own emissions.

Fig. 6 District Heat development scenario. Source: comp. IEO



Competitiveness of prices of heat from RES with heat from conventional sources

Under the framework of the project, basing in the experience of SDHp2m partners, the IEO prepared economic and financial analyses. The analyses based on an assumption, that as a result of investments in RES installations, the price of heat would not increase. On the pilot stage, an additional subsidy of 40% was assumed. The results of calculations of levelised cost of energy (LCOE) for such investments, divided onto 20 years were in average equal to (for different cases) 52 PLN/GJ and were slightly higher than the average price of heat from district

heating systems in 2016. However, when considers trends of the increase of prices of heat in licensed enterprises (data from Energy Regulatory Office), and necessary investments for adaptation to MCP directive and increasing costs of entitlement to emissions of CO₂, in 2019-2022 the prices of heat from present sources of generation would equalize to prices of heat generated in modernized district heating systems based on RES. On the figure below, we present the average unit price of conventional heat with the results of LCOE analysis for RES.

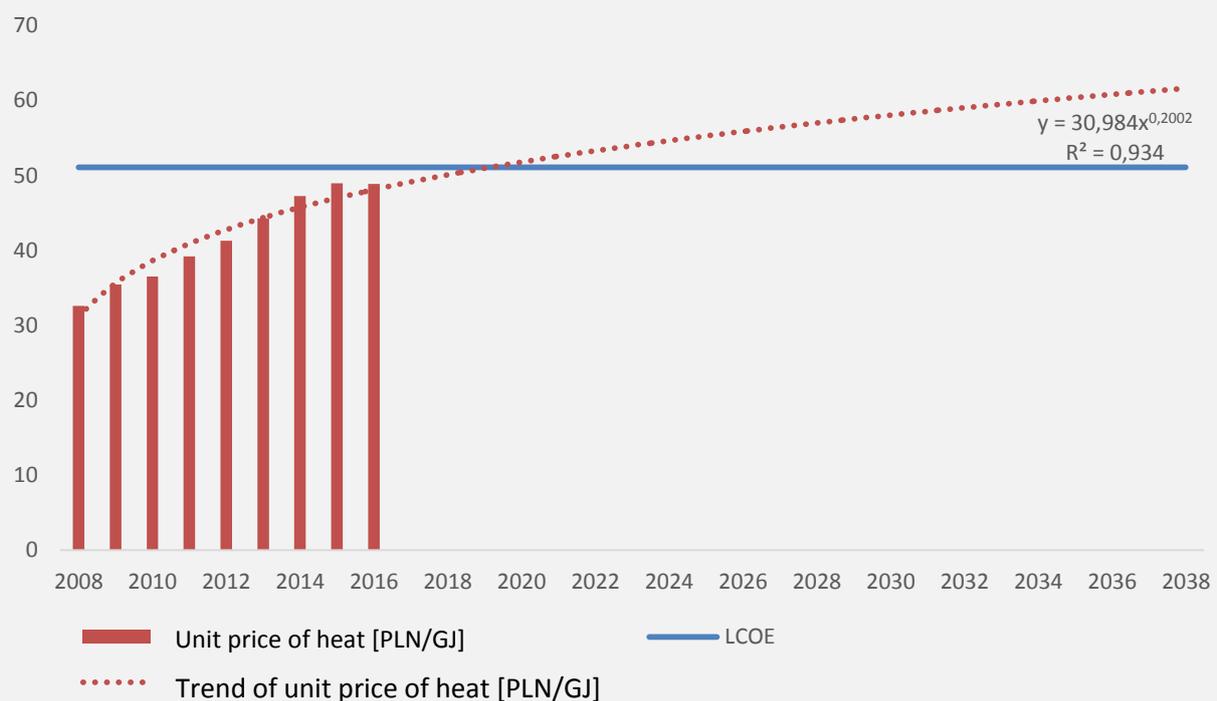


Fig. 7 Average unit price of conventional heat with the results of LCOE analysis for RES. Source: IEO

Actions leading to use of RES potential in district heating systems

The potential and possibilities of wide use of RES in district heating is also seen by the industry. This diagnosis was based on the results of the research conducted in February 2018 by the IEO, in cooperation with the Polish District Heating Chamber of Commerce (IGCP) amongst district heating entities. 44 entities operating with 49 district heating systems participated in the research. The production capacity of the sample was equal to 7 440 MW, which constitutes 13,7% of the overall power installed in Polish district heating systems. The results of the research confirmed high interest of the entities in construction of thermal energy storages and use of several renewable energy sources, also regarding sources so far used to a small extent such as solar thermal energy or wind energy (Power to Heat). The district heating entities plan to use RES. The most popular source amongst the respondents was biomass-fueled boilers. This is due to the fact, that those boilers can be used as a source stabilizing the heating powers and are direct substitution for coal-fired boilers. A high interest in thermal energy storages and solar collectors is a visible, ongoing change in approach to RES and their place in district heating systems.

To launch an innovative modernization potential in district heating and achieve technological transition owing to RES, a wide and open to diverse local conditions program is necessary. The program should be realized in stages, enabling to decrease the investment risk and allowing to accustom the enterprises, housing associations, communities and developer estates to new solutions. At the beginning of 2017, the National Fund for Environmental Protection and Water Management (NFOŚiGW) organized a conference District Heating System Cooperating with Renewable Energy Sources and Thermal Energy Storages. The event, which co-organizer was the Institute for Renewable Energy helped to conduct a broader discussion in the environment of district heating enterprises, housing associations, communities and industry of equipment manufacturing and technological solutions for district heating about practical possibilities of expansion of huge and so far narrowly developed RES in power generation in district heating sector. As an result of the conference, NFOŚiGW started working on a pilot program, that would support implementation of innovative and intelligent techniques of RES and thermal energy storages in district heating sector.

Fig. 8 Conference “District Heating System Cooperating with Renewable Energy Sources and Thermal Energy Storages” in NFOŚiGW. Source: NFOŚiGW



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INSTITUTE FOR RENEWABLE ENERGY (IEO) – THE COORDINATOR OF THE SDHP2M PROJECT IN POLAND

Think-tank IEO was founded in 2001, disposes of necessary knowledge and 17-year experience to realize the task in SDHp2m project, which is support of transformation of Polish district heating systems in direction of RES. The Institute disposes of a team having broad knowledge of the overall of topics from renewable energy, in particular its integration with electric grid and the electric and district heating systems, in the energy policy and law, economic and financial analyses, as well as, technical and design solutions. The IEO has a wide experience in development of technical assumptions and concepts, feasibility studies, business-plans and national and regional development programs. The Institute participates in practical realization of investments in the field of RES (all sources, from weather-conditioned and thermal energy storages, electrical energy, design of micro-grids and management of their energy). The IEO contributed to development of several international research programs connected to forecasting development of RES and energy systems with RES.

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