Clean heat 2030

Strategy for heating

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PREPARATION OF THE REPORT AND SUBSTANTIVE SUPERVISION

Andrzej Rubczyński, Forum Energii

AUTHORS

National Energy Conservation Agency (KAPE)

Paweł Gilewski
Piotr Gutowski
Magda Jóźwiak
Joanna Ogrodniczuk
Wojciech Stańczyk
Tadeusz Skoczkowski
Agata Skrzypek
Arkadiusz Węglarz
Anna Wierzchołowska-Dziedzic

Institute for Structural Research

Aneta Kiełczewska
Piotr Lewandowski
Jakub Sokołowski

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· Jacek Piekacz

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PARTNERS

Izba Gospodarcza Ciepłownictwo Polskie

European Climate Initiative EUKI

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Foreword

It is no longer necessary to convince anyone in Poland that improving air quality is a priority and at the same time a huge challenge. Smog destroys health, lowers the quality of life, generates costs and devastates the image of Poland in the world. How to improve air quality? What incentives should be created? How are the costs change kept at a reasonable level and how to gain social acceptance for them?

The sources of air pollution in Poland are mainly heating, transport, industry and energy. The most dangerous is the so-called low emission from sources producing fumes at an altitude of less than 40 m. These are mostly buildings that use their own heating sources. Our ambition, however, was to present an idea for the entire heating sector. In this report we analyse heat production in district heating systems, as well as in individual buildings. We refer to costs, technology and energy efficiency. We are looking at possibilities for improving air quality, as well as reducing CO_2 emissions, which is important in the context of climate change.

We have analysed different scenarios for introducing changes in the heating sector - more and less ambitious. The results of the surveys are clear - if there are no incentives to modernise, air quality will continue to deteriorate and costs will increase. Modernisation is therefore necessary. In order to succeed, we need the determination of the decision-makers, the appropriate target setting, the plan and the money. The last points are, fortunately, are available in various sources, they only need to be directed properly. There is a need to set ambitious targets and develop actions.

Our analysis shows that the first and most important step is to improve the energy efficiency of buildings. Without it, the exchange of heat sources for less polluting ones will result in increased costs. Secondly, it is important to eliminate solid fuels from individual heating by 2030. Domestic coal-fired furnaces are the largest source of pollution in Poland. Coal should be replaced by district heat, gas or pellets, depending on local conditions. In the long run, Poland will face electrification of heating, i.e. first of all a wide application of heat pumps. Even if it seems to be an abstraction today, such a strategy will ensure Poland's energy independence, emission reduction and moderate heat prices. The transformation of the energy system towards renewable sources, the reform of the energy market and the tariff system must start today. With the current high and flat energy prices, electrification of district heating remains an unattractive option for the time being.

The development of district heating systems is also crucial. The vast majority of them are ineffective according to European law and, if they do not change, they are in danger of being closed down in the long term. This would further worsen the air quality in cities.

The last, extremely important element of heat transformation is to taking care of those on a low-income and those who may not be able to cope with the exchange of heat sources. The energy transformation should be fair. For the majority of Poles, an increase in the price of energy by e.g. 10% is not a problem, but for the poorest group such a bill may not be affordable. A fair and transparent mechanism for distributing the costs of energy transition is essential to reach a compromise and gain public support.

We hope that the proposal of our strategy for district heating will contribute to the construction of a system that will provide Poles with heat at a good price. At the same time, it will guarantee life in a clean environment for our children.

Yours faithfully,

Joanna Maćkowiak-Pandera

President of the Forum Energii

1. Key conclusions

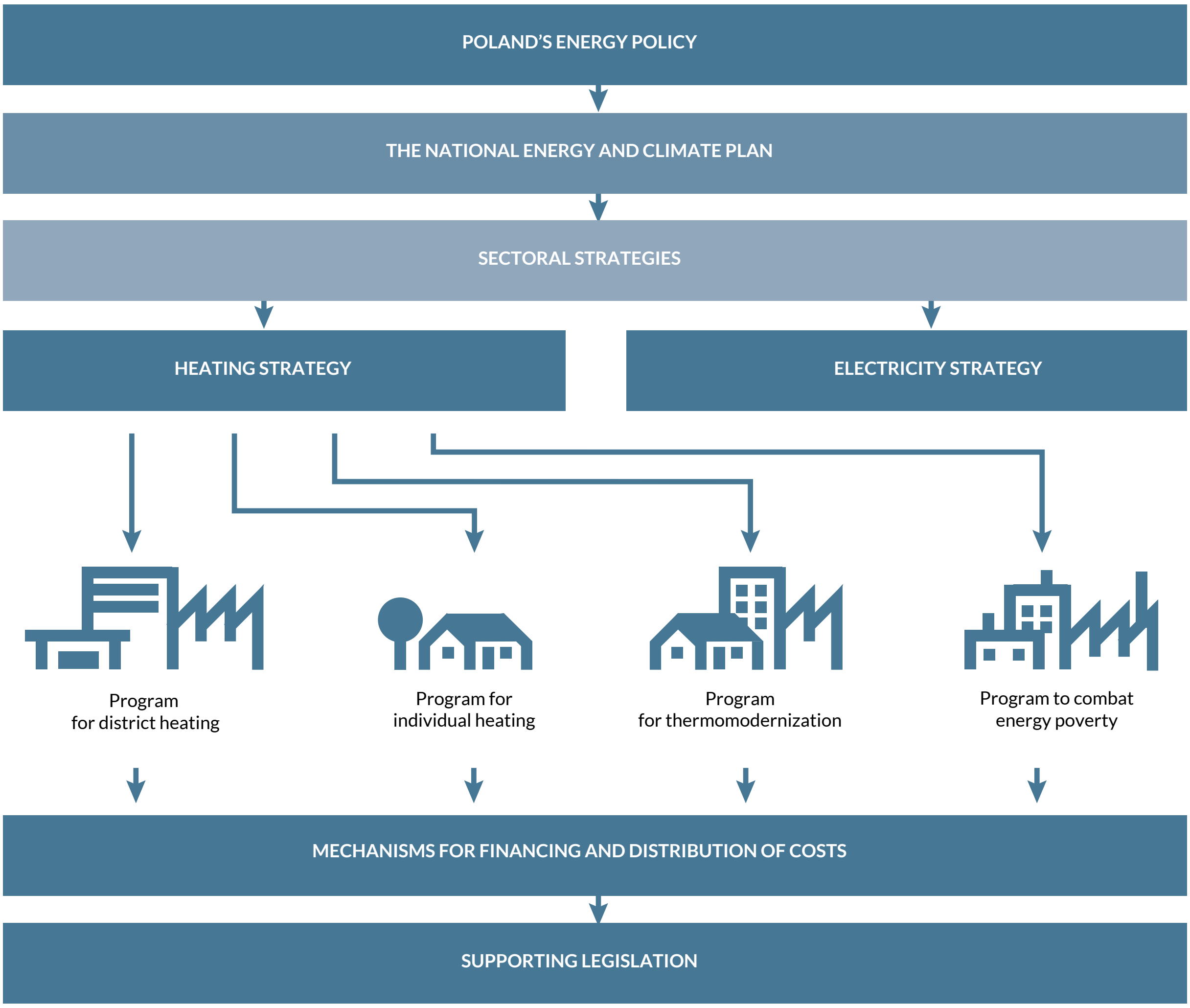
By 2030, Poland can significantly improve air quality and reduce CO_2 emissions from heating - both district heating and individual heating.

The strategy for district heating should be based on the assumptions of key government documents such as Poland's Energy Policy 2040 and the National Energy and Climate Plan 2021-2030. Firstly, it should set targets to be achieved in 2030 and 2050. Secondly, it should present a comprehensive programme for the modernisation of district heating, which will cover the following areas:

- district heating systems,
- generation of heat in households,
- energy efficiency in buildings.

Implementation of the strategy requires legal changes and preparation of financing mechanisms to achieve the adopted objectives. It is also important to prepare a programme that includes the poorest technical and financial assistance for those with a low-income. Figure 1.1 shows the vision of the Forum Energii concerning the strategy for district heating and its place among the strategic national documents relating to the energy sector. This report has been prepared in accordance with the presented diagram.

Fig. 1.1. Hierarchy of strategic documents defining objectives and directions of operation of the energy sector



In order to develop final recommendations, we analysed, the consequences of four scenarios of district heating modernization, from a national perspective:

- **BAU reference scenario** (business as usual), hereinafter referred to as Scenario I, assuming maintenance of the current fuel structure and a constant share of RES at the level of 16%.
- **Minimum scenario** (scenario II), i.e. 27% share of RES in 2030 and further increasing trend. The level of CO_2 emission reduction is a result of RES share and not an objective.
- **Efficiency scenario** (scenario III), i.e. 32% share of renewable energy sources and 30% CO_2 emission reduction by 2030 and a minimum 60% RES share and an 80% reduction in CO_2 emissions by 2050.
- **Decarbonisation scenario** (scenario IV), i.e. total CO_2 reduction in the whole heating sector by 2050.

Below we present the results of how the efficiency scenario will affect the environment and fuel balance, which allows us to achieve the objectives adopted by the European Union.

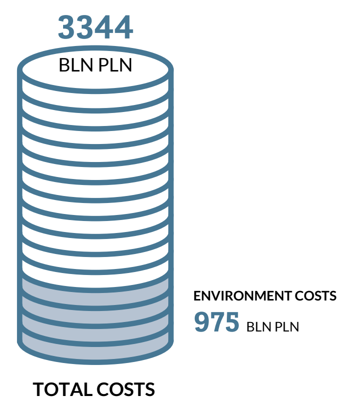
What exactly can we achieve by 2030 and 2050?

Emission reductions compared to 2016

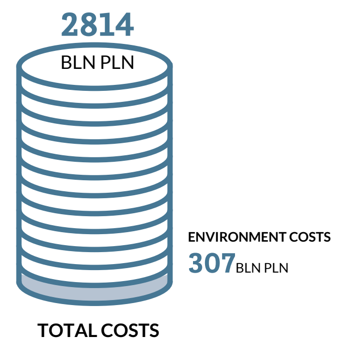
	INDIVIDUAL HEATING			DISTRICT HEATING	
	CO_2 EMISSIONS	DUST EMISSIONS		CO_2 EMISSIONS	DUST EMISSIONS
	36 MLN TONNES/YEAR	131 THOUSAND TONNES/YEAR	2016 BASE YEAR	32 MLN TONNES/YEAR	16 THOUSAND TONNES/YEAR
	42% LESS 21 MLN TONNES /YEAR	91% LESS 12 THOUSAND TONNES/YEAR	2030	16% LESS 27 MLN TONNES /YEAR	53% LESS 7,5 THOUSAND TONNES/YEAR
	76% LESS 8,6 MLN TONNES /YEAR	99% LESS 1 THOUSAND TONNES/YEAR	2050	81% LESS 6 MLN TONNES /YEAR	82% LESS 3 THOUSAND TONNES/YEAR

Total costs of heat supply in Poland in 2016-2050

REFERENCE SCENARIO



EFFICIENCY SCENARIO



Energy security - less risk of being dependent on imported fuels

COAL IMPORTS FOR HEATING		GAS IMPORTS FOR HEATING
5 MLN TONNES LESS	2030	1 MLD 1 BLN M³ MORE
20 MLN TONNES LESS	2050	1 MLD 1 BLN M³ LESS

RECOMMENDATIONS

1. The use of non-renewable primary energy (EP) in buildings will be reduced by 80% compared to the reference scenario by 2050. This measure should be the result of improving the energy efficiency of buildings and increasing the share of energy from renewable sources in the heat stream.
2. The share of heat from RES will reach 32% in 2030. Continued decarbonisation of heating and cooling in the following years will result in at least an 80% reduction in CO_2 emissions in 2050 compared to 2016.
3. In individually heated buildings coal will be replaced by district heat, gas and biomass (e.g. pellets) by 2030. In the long term, other RES sources will also be used and electrification of district heating will continue.
4. District heating will be modernised to enable intelligent energy management and maximise the use of diversified primary energy sources, in line with the strategy for a circular economy.
5. Effective mechanisms will be put in place to finance the transformation of district heating using revenues from the Emissions Trading Scheme (EU ETS), funds from the new EU financial perspective and national tax mechanisms.
6. An action programme for heat consumers will be developed with the aim of improving energy efficiency in order to reduce heating costs. In addition to financial support, the programme will also provide substantive assistance in the preparation of thermomodernization and replacement of heat sources.
7. Protective programmes will be prepared, combined with measures to improve air quality. They will be dedicated to vulnerable groups, e.g. those affected by energy poverty, the elderly or low-income groups.
8. Educational programmes will be launched to build public environmental awareness and raise awareness of ways to reduce household heating costs.

Proposals for actions are described in more detail in the chapter „Activities"

2. Purpose of the study

The main objective of this analysis is to propose a strategy for heating that will improve air quality in Poland and at the same time contribute to the reduction of CO_2 emissions while keeping the cost of heating at a socially acceptable level.

The strategic vision for heating must include not only district heating, but also individual heating sources. Both are significant consumers of fuels - coal, gas and biomass - in volumes comparable to the industrial energy sector. Therefore, their future should be considered not only in terms of the environment, but also in terms of power generation.

Technological changes in the entire heat supply sector, in addition to a significant improvement in air quality, will improve the national fuel balance and reduce the national dependency on imports of resources. It is also worth noting that a well-planned strategy will support the functioning of the National Power System (NPS). In the future, the modern heating sector will increasingly be coupled with the NPS as an electricity consumer and system service provider.

With this project we want to support the national discussion on the low-emission transformation of the entire heat supply area.

3. Scope and methodology of analysis

We started our analysis in mid-2018 with a diagnosis of heating. We have identified challenges related to the comfort of heating in households and public buildings. We took into account environmental effects, costs and the impact on household budgets.

Definition of heating

We broadly define heating - as both district heating, i.e. heating systems together with generation sources, and individual heating installations in households.

In the expert group, we have set targets for heating for 2030 and 2050, referring to national challenges and European commitments. We analyzed ways to modernize heating in Poland and indicated the preferred scenario, which will allow the improvement of air quality in Poland and comply with the commitment to reduce CO_2. An important part of the study is the estimation of the total cost of modernization of the heating system and ensure thermal comfort, as well as the impact on the household budgets of Poles.

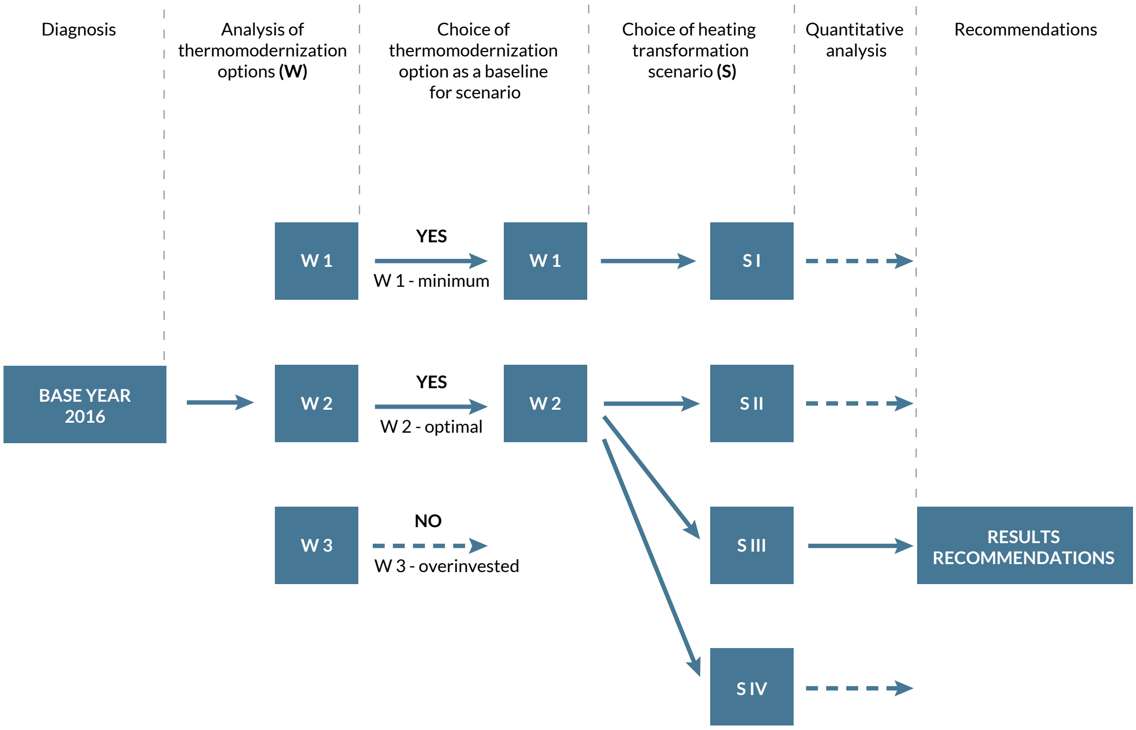
A significant contribution to the shape of the analysis was made by the Chamber of Commerce Polish District Heating.

Phases of works:

1. Analysis of best European practices for the effective modernisation of district heating. Its results were described in the report of the Forum Energii „Good District Heating Practices" from Denmark and Germany. Conclusions for Poland".
2. Comprehensive diagnosis of heating in Poland, identification of key challenges.
3. Assessment of the possibilities of improving the energy efficiency of buildings and the choice of an optimal scenario from three alternatives.
4. Development of assumptions for the analysis of modernisation scenarios for the whole area of heat supply.
5. Preliminary definition of CO_2 reduction targets and RES share for 2030 and 2050 to be verified.
6. Workshop with experts - evaluation of the adopted objectives and assumptions. Outline of four scenarios of heating transformation (presented on page 6).
7. Modelling and analysis of calculation results.
8. Workshop with experts, discussion on results.
9. Developing an action plan and recommendations.

The following block diagram shows the stages of works and the way of defining the scenarios for modernization of heating system.

Fig. 3.1. Stages of works and construction of heating modernisation scenarios



4. Context of the project

Domestic heating found itself at a crossroads. For years, decisions have been delayed, and the implementation of European regulations has been delayed. The result is a terrible condition of the air and high heating costs in relation to household income. The modern Polish heating system started to develop in the post-war period, when three new heating segments were developed:

1) individual heating in areas with dispersed housing development,

2) simple district heating systems using coal-fired boilers in small towns,

3) combined heat and power plants in all major cities where local power plants were in operation before the war.

The fuel was, of course, coal - a domestic, cheap and widely available resource. In the 1990's, privatisation of heating companies brought a wave of modernisation of heat and power plants and heating networks. Today, thanks to the economies of scale and the sale of two products (electricity and heat), large companies show considerable profitability, which allows them to face future challenges. Meanwhile, small district heating systems, responsible for the supply of about 40% of domestic heating are inefficient (according to the legal definition). Their profitability is low, and there is a growing risk of lack of access to state aid against further decapitalisation and even collapse[1]. Households using individual furnaces - a group twice as large as the others in terms of heat consumption - were left to their fate. Due to many years of negligence and delay in implementing system solutions, this group is the most important source of poor air quality in Poland. The development of the gas network has only enabled some households to switch to gas heating.

1 According to the Forum Energii report „Transformacja ciepłownictwa 2030. Małe systemy ciepłownicze", November 2017, Warsaw.

4.1. Pressure of change - why do we need a transformation in heating?

The Polish heating industry is under enormous pressure, which results from the accumulation of many factors, of which the most important are:

- **The worst air quality in the European Union - huge health costs.**

  Thirty-six out of the fifty most polluted cities in the European Union are located in Poland. Every year, poor air quality causes more than 40,000 people to die prematurely. Awareness of the problem has risen rapidly in recent years. The challenge is not only to reduce CO_2, but above all to reduce emissions of sulphates, nitrogen, dust and the cancerous benzopyrene. There is a growing need to exchange the more than 3.5 million energy inefficient and air polluting boilers and coal-fired furnaces. Estimates of the Ministry of Enterprise and Technology (2018) show that in 2016 in Poland the annual health costs resulting from smog and poor air quality reached EUR 30 billion.

- **Exhaustion of national coal reserves.**

  The entire heat supply area consumes approximately 24 million tonnes of hard coal annually. This is only 7 million tonnes less than the professional power industry consumes in the production of electricity. Such a significant volume of coal for heating purposes, apart from environmental damage, contributes to an increase in Poland's import dependancy due to the decreasing domestic supply. We forecast that hard coal mining in Poland will amount to about 20 million tonnes in 2050. Without changing the paradigm of heating, use of waste energy (being a side-product of other processes, e.g. industrial and cooling) and renewable energy, without implementing high energy efficiency standards, Poland's energy dependency will grow. The high share (60%) of coal also carries the risk of an increase in the price of heat. This is the result of the rising cost of purchasing CO_2 emission allowances and the constantly tightening of gas and dust emission standards.

- **Old equipment and inefficient systems.**

  About 80% of district heating systems, especially small ones (from 1MWt to about 100MWt), are inefficient according to the Energy Efficiency Directive. This means that in the long term they will not be able to benefit from public aid. As a result, the price of heat will increase significantly. This problem is greater than it seems. Inefficient systems are mainly located in small towns where the price of heat in relation to income of the population is the highest. In addition, the demand for heat is decreasing as a result of the thermal modernization of buildings, climate change, as well as increasingly restrictive environmental standards resulting in an increase in the costs of heat production. Without strategic actions the problems of heating systems in small towns will continue to grow and unit heat prices will rise. This, in turn, will lead to a decrease in the competitiveness of district heat in relation to individual heat sources and disconnection of consumers from the network. As a result of operational and economic problems there will be a risk of bankruptcy for many small district heating systems.

- **Low energy efficiency of buildings.**

  Households consume approximately 33% of the national primary energy stream, mainly for heating purposes. Many buildings, especially those built before the end of the 1990s, have still not been thermomodernized. The implementation of heating modernisation programmes will not be effective if the energy efficiency of buildings does not increase earlier. Lack of strategies for the renovation of buildings may lead to inefficient allocation of resources.

- **Increasing demand for clean district heating.**

  From 2021, the normative value of the annual non-renewable primary energy demand indicator will be significantly reduced. It will be necessary to diversify the production mix and increase the share of energy from renewable sources, which will make it possible to supply new buildings with district heating. District heat from coal-fired cogeneration, even in efficient systems, will not meet the energy efficiency standards of new buildings[2].

2 According to the Efficiency Directive, Article 4: „Member States shall establish a long-term strategy for mobilising investment in the renovation of the national stock of residential and commercial buildings, both public and private.

- **Development of new technologies.**

  As the climate changes, the demand for heat decreases and the demand for cooling increases. The production profile and functioning model of heating companies will change. They will increasingly offer comprehensive services related to the year-round provision of thermal comfort, and not just seasonal sales of heat. In addition, changing technologies create new opportunities. The large-scale, centralized power supply will gradually be displaced by sources using RES and waste energy, cooperating with 4G and 5G low-temperature smart grids.

4.2. Barriers

The transformation of heating, although necessary, encounters a number of barriers. The most important of these are:

- **Fear of increasing costs.**

  Heat is a basic and essential right. Meanwhile, the cost of heating represents the largest share of expenditure of less wealthy Poles. Energy poverty affects about 1.3 million (10%) households in Poland. However, according to the Supreme Audit Office (NIK), energy allowances are very rarely used. There is a lack of effective support for the poorest. At the same time, the fear of a severe cost increase for this group justifies the lack of modernisation activities. Meanwhile, lack of such actions can be considered as denying the right to live in a clean environment. Health costs, including the risk of loss of life, are paid by society as a whole.

- **No strategy.**

  Successive governments have failed to adopt strategies and long-term goals, which is a serious barrier to changes in heating. None of the governments has set out an action plan, despite the parallel adoption of EU commitments and growing awareness of air pollution. Air quality cannot be improved in a sustainable way without the elimination of solid fuels, especially from individually heated households. This involves proposing other ways to supply heat. Despite growing imports of coal, decision-makers are worried about confronting the domestic coal sector. An alternative to this fuel can sometimes be gas (where a network is available), pellets, in some cases district heating networks and, in the long term, electricity. Communicating the upcoming changes to society is a challenge that requires the development of a range of protective measures, financial mechanisms, changes in industrial policy and educational campaigns.

- **Lack of stimulating financial mechanisms.**

  It is difficult to invest in clean energy sources and energy efficiency when it is worth burning rubbish and coal in inefficient furnaces and boilers. Until now, CO_2 emissions in district heating systems have not been a problem, because the prices of CO_2 emission allowances have been low. The existing tariff system is not properly constructed because it does not transfer the investment costs to the heat price at the level expected by the investor.The priority of the Energy Regulatory Office is to keep the price of heat as low as possible. This relationship between heating costs and investment costs results in a long payback period for energy efficiency investments. The disadvantages of a white certificate system also discourage district heating companies from investing in energy efficiency. All this reduces the use of district heating to improve air quality in Poland, and also slows down the process of improving the energy efficiency of buildings.

- **Lack of planning tools at local level.**

  The Energy Law does not give local authorities a sufficiently strong role in planning and implementing changes in the heating sector. Only a small number of Polish municipalities have adopted comprehensive heat, electricity and gas supply plans. An even smaller number implements these properly. The lack of national heating policy and financing tools does not motivate more activity. At the same time, local anti-smog resolutions prove that modernization can gain social acceptance.

5. European Union regulations

The functioning and development of heating depends not only on the factors described above, but also on the EU regulations implemented into Polish law. In this chapter we have decided to mention those legal acts which are important for the further functioning of the sector. The European Union implements the energy and climate policy by formulating targets on RES, energy efficiency and CO_2 emissions , dust and other pollutants. For the planning of activities in the heating sector in Poland it is important to set targets for 2030 and 2050.

Until 2030 the European Union as a whole plans to achieve the following objectives:

- a minimum 40% reduction in greenhouse gas emissions compared to 1990 (in the sectors covered by the EU ETS Directive, including energy and heating, a 43% reduction is expected compared to 2005).
- 32.5% improvement in energy efficiency compared to the 2007 forecast,
- an increase in the share of renewable energy in gross final consumption of energy in the European Union to 32%.

5.1. EU key legislation for the modernisation of heating[3]

Improving air quality

1. **CAFE (Clean Air for Europe) Directive on air quality in Europe**

   It is the basic legal act concerning the methodology of measurement and acceptable levels of air pollution in EU countries - particulate matter (PM10 and PM2.5), sulphur dioxide (SO_2), carbon monoxide (CO_2), nitrogen dioxide (NO2) and benzene.

2. **NEC (National Emission Ceilings) Directive for the period 2020-2030**

   It concerns the reduction of emissions of certain atmospheric pollutants - NO_x, SO_2, PM2.5, ammonia, methane and non-methane volatile organic compounds. It sets reduction targets for 2020, 2025 and 2030. In addition, it imposes an obligation on Member States to submit air pollution control programmes to the European Commission together with information from monitoring, balances and emission projections.

3. **IED (Industrial Emissions Directive)**

   It applies to industrial emissions from large combustion plants (>50 MW total fuel capacity supplied). It introduces the principles of integrated prevention and control of pollution arising from industrial activities. The resulting BAT conclusions (from 18 August 2021) set stricter emission limit values. In addition, Best Available Techniques (BAT) conclusions also covered substances remaining outside the EU requirements to date, such as mercury, hydrogen chloride, hydrogen fluoride and ammonia.

4. **MCP (Medium Combustion Plants) Directive on the limitation of emissions from medium-sized energy plants**

   It introduces provisions setting emission standards for sulphur dioxide (SO_2), nitrogen oxides (NO_x) and particulate matter (dust) for combustion plants with a rated thermal input of 1-50 MWt. The standards apply to new plants from 20 December 2018, existing sources > 5 MWt from 2025 and existing sources 1-5 MWt from 2030. It also lays down rules for monitoring carbon monoxide emissions.

Reduction of greenhouse gas emissions: ETS and non-ETS areas

5. **ETS Directive on the CO_2 Emissions Trading System**

   It refers to the emissions trading area (ETS). Combined heat and power plants with a capacity of more than 20 MWt are entitled to 30% of free allowances per year in the period 2021-2025, and after 2025 to a gradually

3 Summary of legal acts on district heating by Małgorzata Mika Bryska, Veolia Energia Polska.

reduced pool. It defines the rules of allocation of resources from the Modernization Fund and defines the manner of using revenues from the sale of CO_2 emission allowances. It introduces the obligation of a competitive tender for investments benefiting from free allowances.

6. **Regulation on the inclusion of emissions from land use and forestry in the climate and energy policy framework until 2030**

   It concerns the non-ETS area (e.g. buildings, waste, agriculture and transport). It introduces legally binding targets for the reduction of greenhouse gas emissions. In the case of Poland, the mandatory reduction of ammonia and greenhouse gas (GHG) emissions in 2030 is to be 7% compared to 2005.

Legislative package "Clean energy for all Europeans"

7. **Energy Performance of Buildings Directive**

   It aims to support Member States and investors in achieving the long-term objective of greenhouse gas emissions and decarbonisation of the construction sector by 2050. The Directive sets out the principle of striking a balance between decarbonising energy supply and reducing final energy consumption. According to its provisions, all new buildings must have been nearly zero-energy buildings as of 2021. The directive also introduces the obligation to develop national long-term strategies for the renovation of buildings and to define key milestones and measures to achieve the 2050 target. Member States are required to implement the Directive by 10 March 2020.

8. **Energy Efficiency Directive**

   The EU indicative target is a minimum of 32.5% improvement in energy efficiency by 2030 compared to the energy consumption projections developed in 2007. Member States are required to determine their indicative contribution (primary or final energy savings or reduction of energy intensity) to the EU target. Member States may set a target on the basis of primary or final energy consumption. It also adopts a mandatory national target for actual energy savings for the period 2021-2030 of not less than 0.8% of annual final energy consumption averaged over the last three years before 1 January 2019.

9. **RES Directive on the promotion of energy from renewable sources**

   It introduces a binding EU target of a 32% share of RES energy in gross final energy consumption by 2030. It sets the annual growth rate of the share of heat and cooling from RES and waste heat in the heat stream supplied to consumers, which is at least 1.3 p.p. (y/y) (or 1.1 p.p. if RES only) by 2030.

Waste and water management

10. **Waste package**

    It sets eight new targets for waste management. Member States will progressively increase the re-use and recycling of municipal waste from 55% in 2025 to 65% in 2035. (in 2035, a maximum of 10% of municipal waste may be stored).

11. **Water Directive**

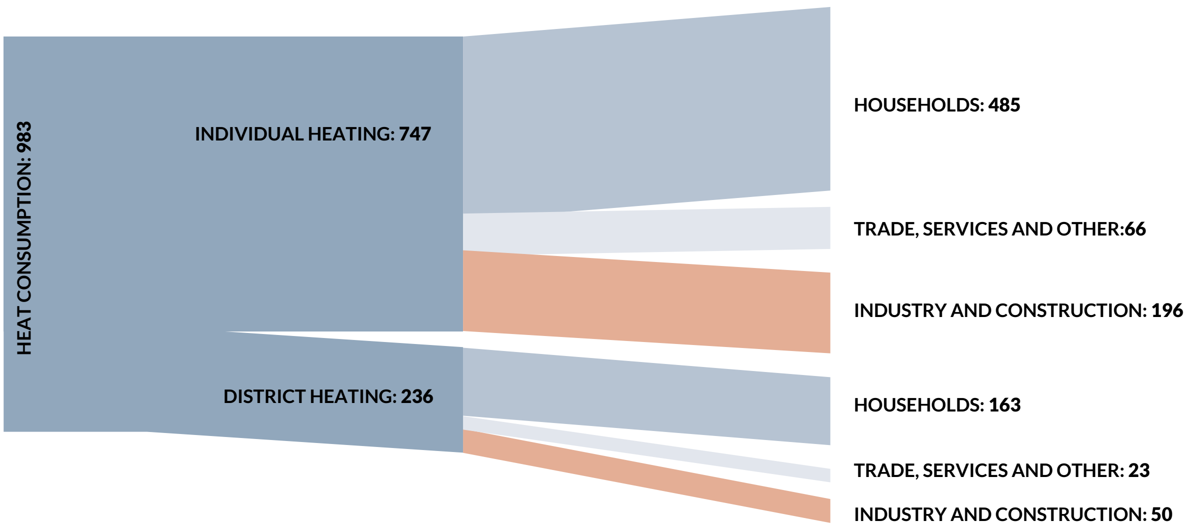
    The water and wastewater sector is responsible for 3.5% of electricity consumption in the EU and will continue to grow. At the same time, leakages account for 24% of total water consumption in the Union and the energy sector is the largest consumer of water (44% of water consumption). The Directive introduces a requirement to evaluate the potential for energy savings that is being lost in technological processes.

6. Diagnosis of heating

How much heat do we use?

In 2016, primary energy consumption in Poland was 3948 PJ (petajoule = 1 million gigajoules) and final energy consumption was 2957 PJ. The largest group of energy consumers are households (30%), followed by transport (28%), industry (22%) and services (13%), and finally other entities (7%). In the national final energy stream, a significant share is represented by heat for heating purposes. Total heat consumption was 983 PJ, of which 1/4 is produced in the district systems and the remaining part - in individually heated households, trade, services, industry and construction (Fig. 6.1.).

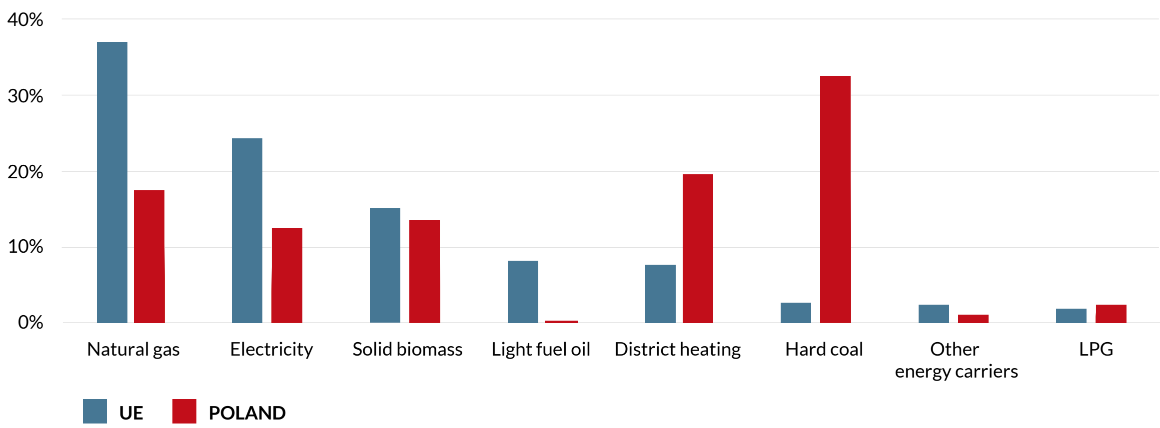
Fig. 6.1. Heat final energy consumption in 2016 (PJ)



Source: own calculations of the National Energy Conservation Agency (KAPE S.A.) based on data from the Central Statistical Office (GUS) and the Energy Regulatory Office (URE).

The structure of consumption of energy carriers in households in Poland and in the EU differs significantly. In Poland, coal has a large share, while in the EU it is gas. Biomass consumption is at a similar level. Poland has a higher share of district heating.

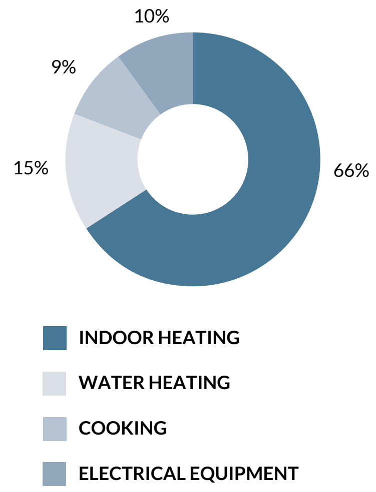
Fig. 6.2. Structure of energy consumption in households in the EU and Poland in 2016



Source: compiled on the basis of EUROSTAT and GUS data.

The largest share of energy in households is consumed by: indoor heating (66%), domestic water heating (15%), cooking meals (9%) and lighting and electrical equipment (10%) (Fig. 6.3). However, the amount of energy used for indoor heating is steadily decreasing as a result of the thermal modernisation of buildings and the construction of new buildings with a lower heat demand. In modern buildings, the challenge remains to reduce energy consumption for domestic hot water heating - due to the low efficiency of the installation.

Fig. 6.3. Energy use in households in Poland

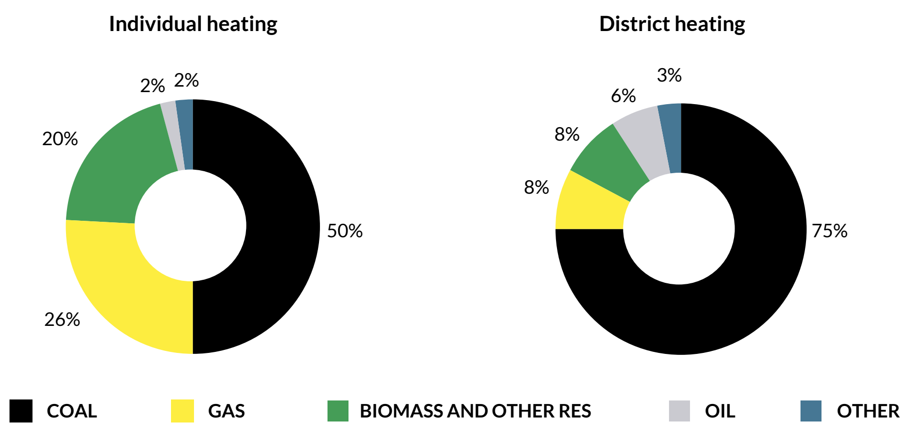


Source: Energy efficiency 2006-2016, GUS, Warsaw 2018.

What fuels do we use in heating?

In total, 24 million tonnes of coal are used annually in heating, 12 million tonnes each in district heating systems and individually heated buildings. This represents approximately 38% of the steam hard coal mined in Poland. The total heat capacity of individually heated buildings is 139 GWt (73 GWt coal, 31 GWt gas, 31 GWt biomass, 4 GWt other) and in district heating plants 54 GWt (44 GWt coal, 6 GWt gas, 4 GWt biomass). Figure 6.4 shows the structure of energy consumption in the segment of buildings heated individually and with district heat.

Fig. 6.4. Structure of energy consumption in individually heated buildings and district heating

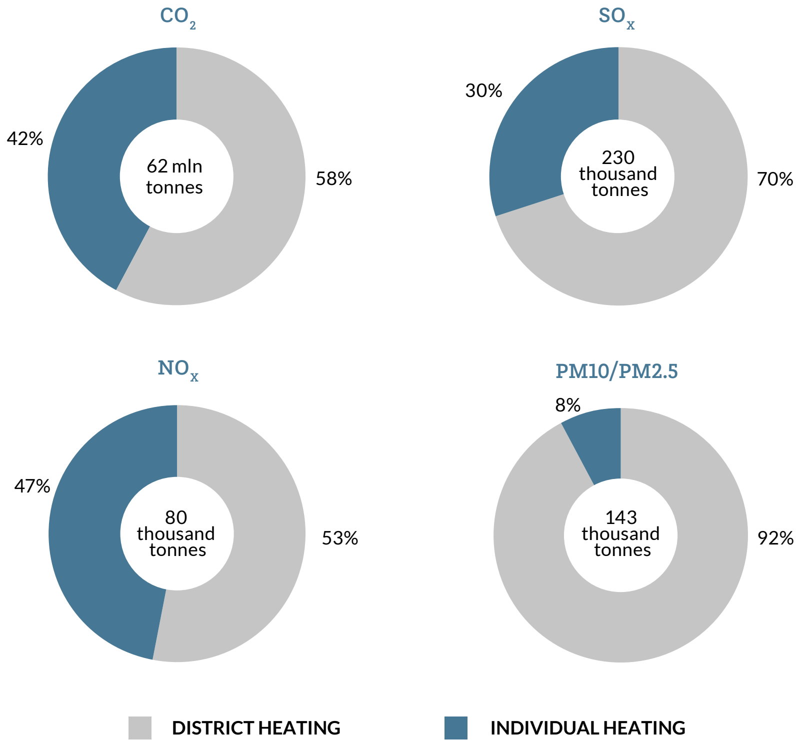


Source: KAPE S.A. own study on the basis of GUS and URE data.

What pollution is generated by the heat supply process in Poland?

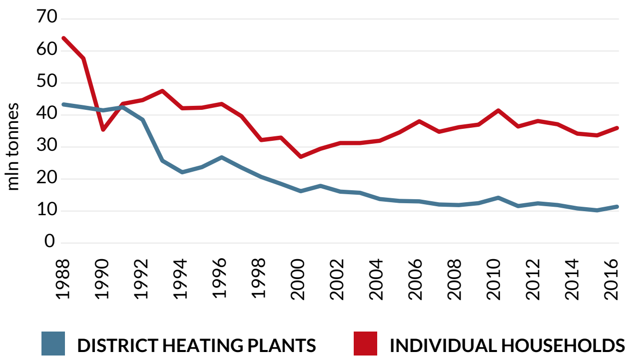
Heating is a source of emissions of sulphur compounds, nitrogen, benzopyrene and dust, as well as carbon dioxide. The main reason for poor air quality in Poland is low emissions from individual sources (apart from transport) of heat generation in over 5 million buildings. Pollutants are introduced into the atmosphere from low chimneys in areas with residential buildings. Approximately 3.5 million of these buildings are supplied with heat from low-efficiency coal-fired sources. Old, energy inefficient boilers and furnaces fired with poor fuel are the main cause of smog production.

Fig. 6.5. Annual emissions from the heat supply area in Poland



Source: KAPE S.A. own study.

Fig. 6.6. Annual CO_2 emissions from district heating plants and individually heated households

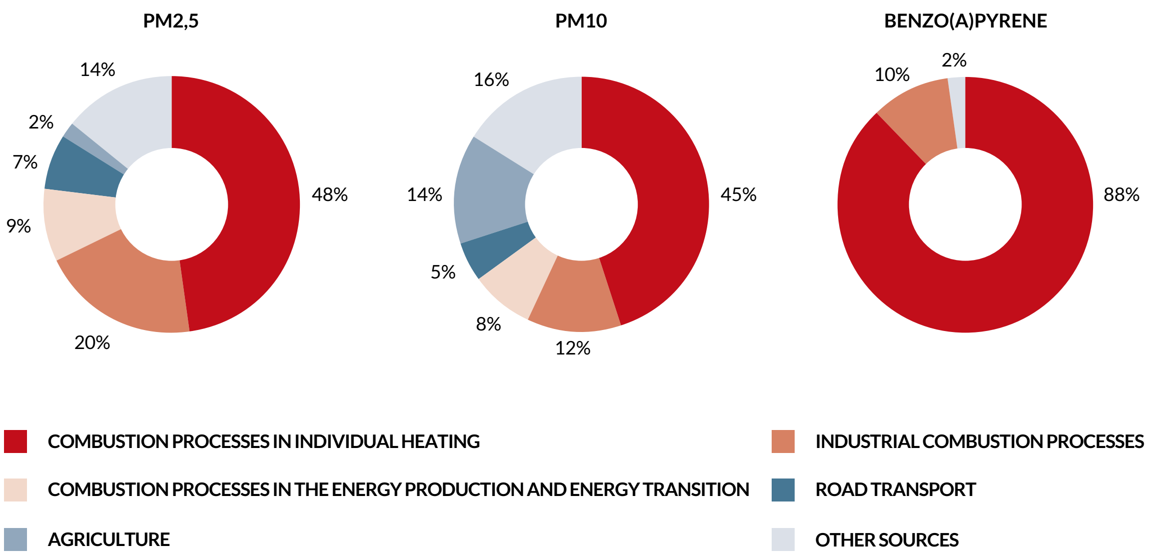


Source: based on Eurostat data.

The energy efficiency of buildings has slowly improved over the last three decades. The market price of resources forced savings, including the thermal modernisation of buildings. As a result, the increase in heating costs has been reduced, as well as dust and gas emissions. Modernisation of heating companies and improvement of energy efficiency in district heating systems resulted in a decrease in CO_2 emissions in the 1990s. On the other hand individually heated buildings did not undergo such a thorough modernization, which resulted in a smaller decrease in CO_2 and other pollutants emissions. Combustion of low quality fuels, with high unit energy consumption of buildings, has strengthened the smog problem in Poland.

The main cause of smog in Poland is low emissions, i.e. emissions of dusts and harmful gases from sources less than 40 m high. First of all, it concerns pollution from furnaces in individually heated houses and car transport.

PM10, PM2.5 and benzo(a)pyrene dusts are particularly dangerous for our health.
In small towns the dominant source of low emissions are household furnaces.
In large agglomerations, road transport is mainly responsible for smog.
Professional power engineering has a relatively small impact on the formation of smog.

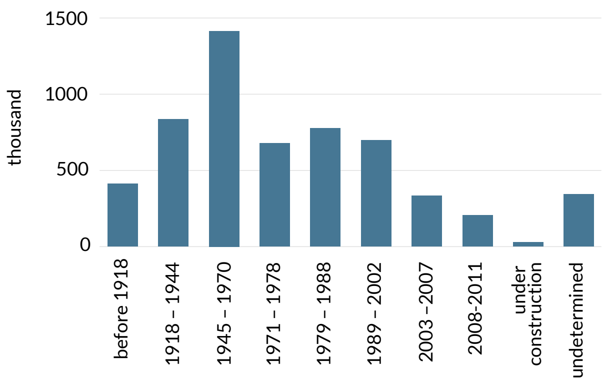


Source: own elaboration based on the data of the National Centre for Emissions Management (KOBiZE).

Energy efficiency of buildings

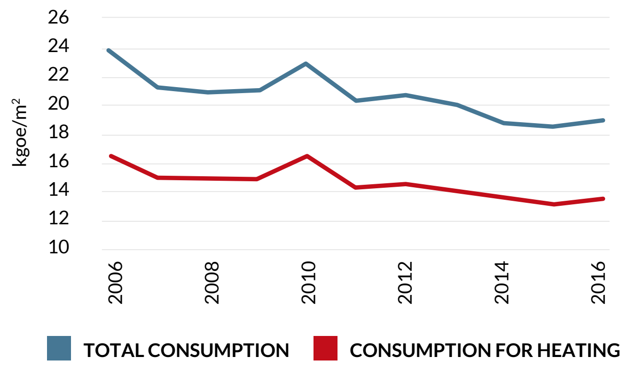
In 2016, in 6.2 million buildings there were 14.27 million flats with a total floor surface of over 1 billion m² (an increase of 105 million m² since 2006). More than half of the flats (7.92 million) were located in multi-family buildings. The largest number of flats (5.25 million) constructed in the years 1961-1980 (Fig. 6.7.) are mainly flats in multi-family large plate buildings built using energy-intensive system technologies. The average growth rate of the floor surface of the residential sector in Poland in the years 2006-2016 was 1.6%, which resulted in an increase in floor space by 15%. Most of the buildings built in 1967-1985 were thermomodernized. The lowest number of thermomodernization works was carried out in buildings established prior to 1945. It is estimated that more than half of the buildings classified are insulated, 10% are buildings partially insulated and as much as 30% are non-insulated buildings.

Fig. 6.7. Age structure of housing stock in Poland



Source: Residential buildings. National Population and Housing Census 2011, Central Statistical Office (GUS), Warsaw 2013

Fig. 6.8. Final energy consumption in households in Poland in relation to the floor surface



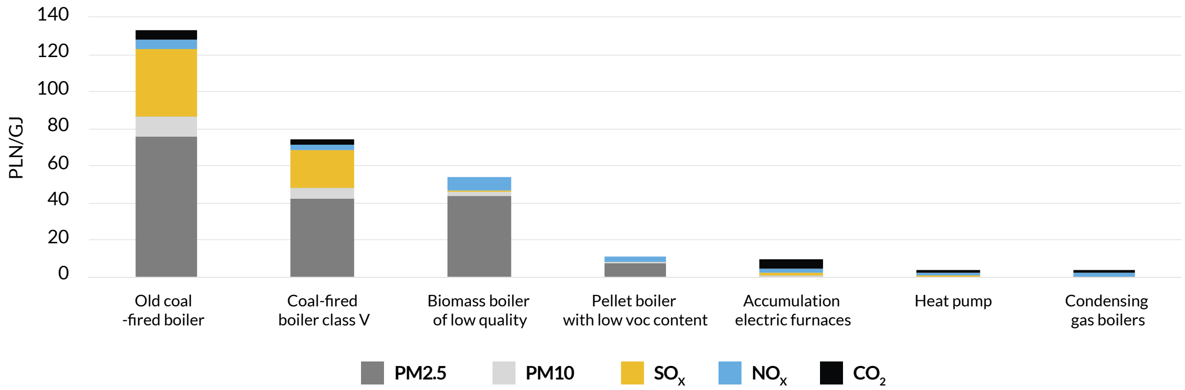
Source: compiled on the basis of GUS data.

Unit final energy consumption in households is reduced (per surface area unit). The exceptions are the years 2010 and 2012, when the general increase in energy consumption was due to climate conditions. There still exists a great potential for reducing energy consumption in buildings, in particular for heating purposes. Current consumption is on average approximately 160 kWh/(m^2*year) per year. This figure significantly deviates from the values specified in the technical conditions for newly constructed buildings, which is 95 kWh/(m^2*year) for single-family buildings and 85 kWh/(m^2*year) for multi-family buildings. From 2021, similar indicators will amount to 70 kWh/(m^2*year) and 65 kWh/(m^2*year), respectively.

Who should cover the external costs of heat production?

The external costs of generating heat are the costs of health and environmental impacts of fuel combustion, as well as the destruction of road infrastructure or buildings, etc. These are borne by society as a whole, including those who use modern and environmentally friendly heating systems themselves. The worse the fuel and the worse the technical condition of the furnace (boiler), the higher the external costs. However, they are not reflected in the price of heat for individual households. They are shared by society in general. The lack of a mechanism for including external costs in the price of heat (or fuel) makes it profitable to use the cheapest and most harmful ways of producing heat and pass these costs on to others. In many European countries environmental charges are applied to fuels combusted in individual heating installations. Such an approach improves the competitiveness of clean technologies. For professional plants, the CO_2 emissions trading scheme partly fulfils this function. The price of the allowance in 2018 has risen to EUR 20 per tonne and is likely to increase further. Over time, it will cause an increase in the price of heat produced from coal, and in the long run may result in the disconnection of customers from the district heating networks. Fig. 6.9 shows the difference in external costs of individual heat sources. Use of solid fuels is the least advantageous from a social perspective as it generates the highest external costs. These are in particular high for low quality fuels used in inefficient furnaces. Even for class V boilers, external costs are several times higher than for the other analysed sources.

Fig. 6.9. Comparison of unit external costs for 2017 by harmful substances for different heat sources



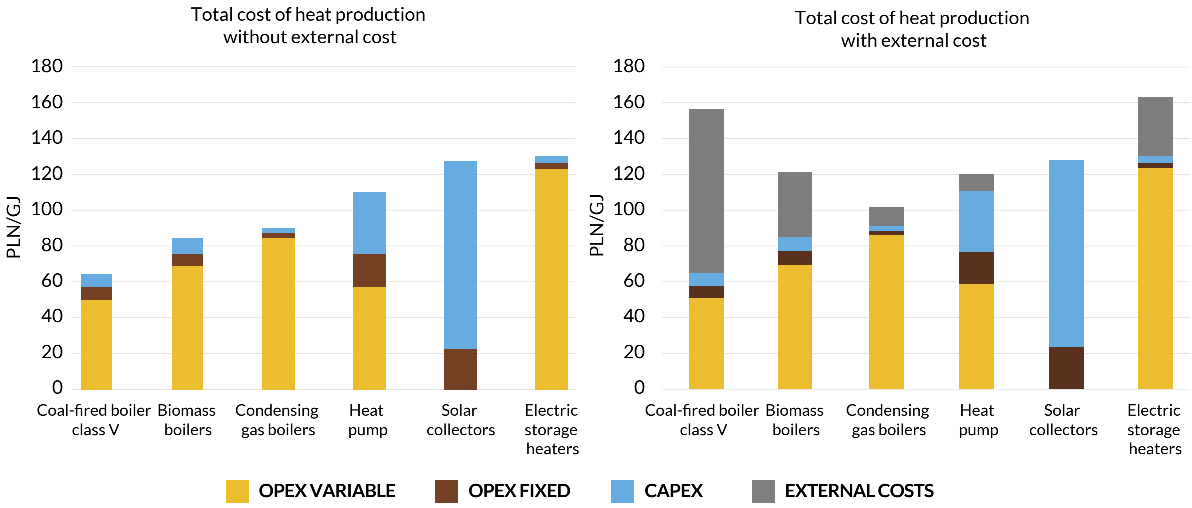
Source: KAPE S.A. own study.

Costs of heat production in individual sources

When selecting a new heat source, the LCOH (Levelised Cost of Heat) indicator is used for a full comparative assessment of production costs. It shows the average cost per unit of heat incurred over the entire cycle. It contains investment outlays and capital costs, forecasted variable costs, including fuel costs. The heat price calculated in this way is higher than we know from current market practice, due to the projected increase in variable costs. The expenditure incurred by the household does not fully reflect the real cost of heating. Depending on the type of fuels used, the efficiency and modernity of heat sources and the energy standard of the building, larger or smaller portions of pollutants are emitted to the environment. The diagrams (Fig. 6.10.) show the costs of heat production without taking into account external costs (household perspective) and taking them into account (social perspective). In the first case, the cheapest heat will come from a coal-fired boiler and in the second case from a gas-fired boiler. It should be noted that in the case of a heat pump it is possible to reduce the price of heat by applying an appropriate electricity tariff or subsidizing investments at the level of 40-50% of CAPEX. According to the analyses, in such a situation the heat pump becomes a competitive solution for a coal-fired boiler, even without taking into account the external cost.

The ”polluter-pays” principle should reasonably be extended to the group of equipment used in individual heating. This will unleash market-based incentives for the modernisation of district heating.

Fig. 6.10. Total cost of producing heat (LCOH) from different sources without external cost and with external cost (LCOH+)



Source: KAPE S.A. own study.

What is the effect of comprehensive measures?

In order for the exchange of heat source to bring the expected economic and environmental results, it should be combined with thermomodernization, the scope of which is strictly dependent on the technical condition of the building. Table 6.1 presents the results of the analysis of thermal modernisation options combined with replacement of the heating source for a typical uninsulated single-family building heated with a coal-fired boiler produced before 1980. In Table 6.2 - the same data for a typical multi-family building heated from a local coal-fired boiler house.

We assumed the adaptation of thermomodernized facilities to the stricter thermal requirements in force since 2021 for new buildings[4], which has an impact on the CAPEX level. It should be stressed that the high level of investment is the result of current, very high prices on the construction services market.

Single-family buildings

Table 6.1. Comparison of thermomodernization options with replacement of a heating source for a single-family building

Modernisation option	Building baseline	Thermo without replacement of the source	Thermo + gas boiler	Thermo + district heating substation	Thermo + heat pump	Thermo + heat pump + PV
Investment expenditures (PLN)	–	121000	123000	129000	139000	149000
Final energy consumption (GJ/a)	184	32	18	16	6	2
Operating cost (PLN/year) [(a)]	5280	930	950	750	1060	320
External cost (PLN/year)	12300	2200	140	550	210	50
SPBT simple payback period (in years)	–	28	28	28,5	33	30
SPBT + external cost (in years) [(b)]		8.3	7.4	7.9	8.5	8.6
Dust emissions (kg)	240	40	0	0	0	0
CO_2 emissions (kg) [(c)]	15000	2650	1270	2000	1400	400
Share of variable costs in household budget (%) [(d)]	11	1.9	2.0	1.6	2.2	0.7
Minimum level of CAPEX funding (%) [(e)]		28	29	30	39	33

The calculations refer to a building with an area of 105 m^2. It is an average building, representative of buildings of two age groups, prior to 1945 and 1946-1966. This means that the building has no insulation layer, the windows are old, wooden and the building is leaking. The modernization is responsible for bringing it up to the WT2021 standard not only in terms of heat transfer coefficient through all partitions, but also in terms of the total primary energy demand factor.

[a)] 2016 energy carrier price.

[b)] External cost depending on the type of heat source and consumption of non-renewable primary energy (SPBT - Simple Pay Back Time).

[c)] CO_2 emissions per 1GJ of district heat were assumed as for 2016.

[d)] Variable cost of heating for disposable household income amounting to PLN 47878 zl.

[e)] The level of the CAPEX grant was calculated in such a way that the investor has returns on their investment over the lifetime of the built-up installations.

Source: KAPE S.A. own study.

Final energy savings result from thermomodernization, replacement of the heating source and RES implementation (in the last option). Thermomodernization with installation of heat pump and photovoltaic panels will allow for the greatest savings in operating costs. However, due to the significant level of expenditure this investment solution has a longer payback period than a thermomodernization with replacement of the heat source with a condensing gas boiler, which pays off quickest. Considering the external costs (looking at the cost of heating from a social perspective), the simple payback time is reduced to less than nine years for each option. Such a result justifies the implementation of the investment and support for thermomodernization from public funds.

4 Defined in the Regulation of the Minister of Infrastructure of 12 April 2002 on technical conditions to be met by buildings and their location.

Multi-family buildings

Table 6.2. Comparison of thermomodernization variants with replacement of a heating source for a selected multi-family building (area of 2500 m², 30 apartments)

Parameter	Building baseline	Thermo without replace-ment of the source	Thermo + gas boiler	Thermo + district heating substation	Thermo + district heating substation + solar collectors	Thermo + heat pump
Investment expenditures (PLN)	–	1662000	1686000	1737000	2009000	1877000
Final energy consumption (GJ/a)	2868	917	447	402	130	158
Operating cost (PLN/year) [a]	82500	26300	24000	18300	6000	26000
External cost (PLN/year)	192300	27000	3500	13400	3300	5100
SPBT simple payback period (in years)	–	30	29	27	26	33
SPBT + external cost (in years) [b]	–	7.5	6.8	7.1	7.6	7.7
Dust emissions (kg)	3800	1200	0	400	0	0
CO_2 emissions (kg) [c]	235000	75000	24000	48500	19000	26000
Share of variable costs in household budget (%) [d]	14.4	1.8	1.7	1.3	0.9	1.8
Minimum level of CAPEX funding (%) [e]	–	32	30	26	24	40

[a] 2016 energy carrier price.

[b] External cost depending on the type of heat source and consumption of non-renewable primary energy (SPBT - Simple Pay Back Time).

[c] CO_2 emissions per 1GJ of district heat were assumed as for 2016.

[d] Variable cost of heating for disposable household income amounting to PLN 47878 zl.

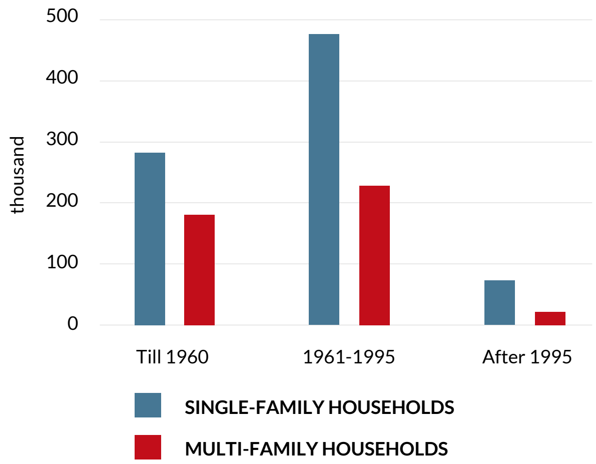
[e] The level of the CAPEX grant was calculated in such a way that the investor has returns on their investment over the lifetime of the built-up installations.

The greatest savings in operating costs in multi-family buildings will be achieved by thermomodernization of the facility with exchange of heat source for a district heating substation and the installation of solar collectors for the purpose of preparing domestic hot water. Such a solution is particularly attractive for inefficient district heating systems, as it allows an increase in the share of energy from RES. In the case of efficient systems with a high share of cogeneration, the optimum should be found (also taking into account the external cost) between the share of energy from RES and cogeneration. The analysis of the simple payback time shows that the most cost-effective option is to carry out a thermomodernization with replacement of the source with a gas-fired boiler plant. From the perspective of the necessary financial support, which should encourage the implementation of the investment, we notice that the least support for thermal upgrading is required in the case of a single-family building combined with the development of gas boilers and district heating substations. Whereas in the case of multi-family buildings, it is combined thermo-modernisation with exchange of heat source for district heating substation and construction of solar collectors.

Energy poverty

An important challenge in the context of low-emission transformation of heating is the phenomenon of energy poverty in households. First of all, energy-poor households are often located in apartments with low energy efficiency and use high-emission heat sources. Secondly, these households may not be able to independently adapt to the changes associated with the transformation. Thirdly, a possible increase in the running costs of obtaining heat may increase the risk of energy poverty.

Fig. 6.11. Number of energy-poor households by type and period of building



Source: Institute for Structural Research on the basis of the annual survey of household budgets of the Central Statistical Office (GUS).

Energy-poor households are those that have difficulties in meeting their energy needs due to low income or housing characteristics. To measure energy poverty, we employed the High Costs Low Income indicator (Sałach & Lewandowski, 2018). The rate of energy poverty is defined as the share of energy-poor households among all the analysed households. The classification of households as energy-poor is based on two criteria: high hypothetical energy expenditure and low income. Hypothetical energy expenses are expenses necessary to achieve the standard in a given type of apartment.

In this chapter we present a diagnosis of energy poverty in Poland, with particular emphasis on the differences resulting from the characteristics of inhabited buildings and the type of heating used. The statistics are presented at the level of households, divided into two types of buildings - single-family and multi-family.

Significant energy consumption occurs in buildings prior to 1946 (34% of the total energy consumption of households in the EU), which house a large proportion (25%) of energy-poor households.

The concentration of energy poverty among the inhabitants of single-family houses and old multi-family buildings is reflected in the spatial structure of this phenomenon. More than half of energy-poor households are located in rural areas, most of them live in single-family houses (Tab. 6.3.). Another important group of energy-poor households, although much smaller, are residents of multi-family houses in large and medium-sized cities. They are mainly residents of old tenement houses.

Table 6.3. Structure of energy-poor households, depending on the type of building and class of housing location (2016)

	Type of building				Total	
	Single-family		Multi-family			
	Number (thousand)	Share [(a)]	Number (thousand)	Share [(a)]	Number (thousand)	Share
Large city	62	5 %	163	12 %	225	17 %
Medium city	51	4 %	114	9 %	164	13 %
Small town	91	7 %	95	7 %	186	14 %
Village	649	50 %	82	6 %	731	56 %
Total	853	65 %	453	35 %	1306	100 %

[a)]Share in the total number

Source: IBS own study based on GUS 2016 data.

Energy poverty is particularly frequent among households living in single-family homes, which use fuel-fired furnaces or central domestic heating as their main source of heating. Among households using their own central heating or fuel-fired furnaces, but living in multi-family buildings, the scope of energy poverty is smaller (Tab. 6.4.).

Table 6.4 . Structure of energy-poor households, by type of building and main source of heating (2013)

	Type of building				Total	
	Single-family		Multi-family			
	Number (thousand)	Share [(a)]	Number (thousand)	Share [(a)]	Number (thousand)	Share
Central domestic heating	939	64 %	72	5 %	1011	68.6 %
Central heating from the network	4	0 %	209	14 %	213	14.5 %
Fuel furnaces	171	12 %	42	3 %	213	14.5 %
Electric (gas) furnaces	15	1 %	21	1 %	36	2.4 %
Total	1129	77 %	344	23 %	1473	100 %

[a)]Share in the total number

Source: IBS own study based on GUS 2013 data[5].

The research carried out allows the following conclusions to be drawn:

- Approximately 1.3 million (almost 10%) households in Poland are energy-poor (2016).
- The energy poverty rate is more than twice as high in single-family homes as in the case of multi-family buildings.
- The older inhabited buildings are, the greater the risk of energy poverty.
- Final energy consumption in buildings with a high risk of energy poverty is high compared to the average energy consumption in average buildings.
- Energy poverty is not the same as income poverty - around 40% of energy-poor households are not income poor.
- For about 50% of energy-poor households, the main source of income is a pension or other nonprofit source.
- Energy poverty affects the inhabitants of rural areas to the greatest extent, followed by small towns.
- The energy poor often live in relatively large spaces, which translates into high costs of heating and possible thermomodernization.
- Energy poverty is particularly frequent in single-family homes where the main source of heat is fuel-fired furnaces or domestic central heating.
- Coal and firewood are the most commonly used fuels in poor households that are individually heated.

5 The data in this Chapter is based on National Household Budget Surveys (2016) and Household Fuel and Energy Consumption (2016) by GUS. Statistics on heating are based on available data for 2013 and the rest of data for 2016. The „Total" values in tables 6.3. and 6.4. are not fully comparable. This is due to the time differences in the performance of the tests and the changes in the level of poverty. In 2016 the energy poverty rate in 2016 was 9.8% and in 2013 it was 11.0%.

7. Thermomodernisation of buildings - why is it so important?

According to the European Commission's estimates, buildings consume about 40% of the total final energy stream in the EU. Reducing this energy stream will not only translate into environmental benefits, but also reduce the EU's dependence on fuel imports. In 2016, this indicator for the EU amounted to 53% (about 30% for Poland and has been growing steadily for years). Before proposing scenarios for the modernization of heat sources, we checked what benefits Poland could gain by implementing the programme for the thermal modernization of buildings. The selection of appropriate heat sources should only begin after the reduction of energy consumption in buildings. We have developed three variants of thermomodernization paths with different number of buildings meeting the energy consumption standards, which will be in force from 2021. This study is also important from the perspective of EU legislation, which focuses on stimulating the rate of growth in the renovation of existing buildings. Member States are obliged to develop long-term strategies for the modernization of buildings emissions leading to their full decarbonisation. This chapter is an attempt to outline such a strategy.

What are the options for the modernisation of buildings?

Table 7.1. Options of thermomodernization paths for buildings in Poland

First option	Second option	Third option
Natural thermomodernization option	Moderate option	Dynamic option
It assumes that the energy efficiency of buildings in Poland is increasing in line with the historical trend. Approximately 20% of buildings will be modernised by 2050. The overall efficiency will be improved by: demolition of old buildings, construction of new ones and thermomodernization. Average national heat consumption in existing buildings will slowly decrease.	It assumes an accelerated rate of thermomodernization, so that by 2050 the number of buildings subject to thermomodernization will increase to 75%. **As a result of the final comparative analysis this option is considered to be optimum.**	By 2050, it assumes comprehensive thermomodernization of all buildings in Poland, with the exception of buildings subject to liquidation for technical reasons and buildings excluded from the process due to their historical and cultural values.

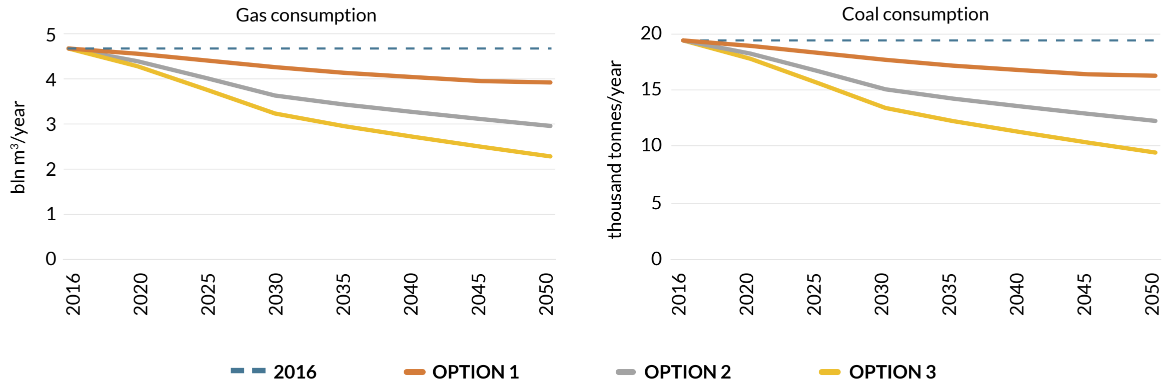
What do we gain from thermomodernization?

The results of the analysis show that by improving energy efficiency on a national scale, significant economic and environmental benefits can be achieved:

1) **Reduced fuel consumption and pollutant emissions**

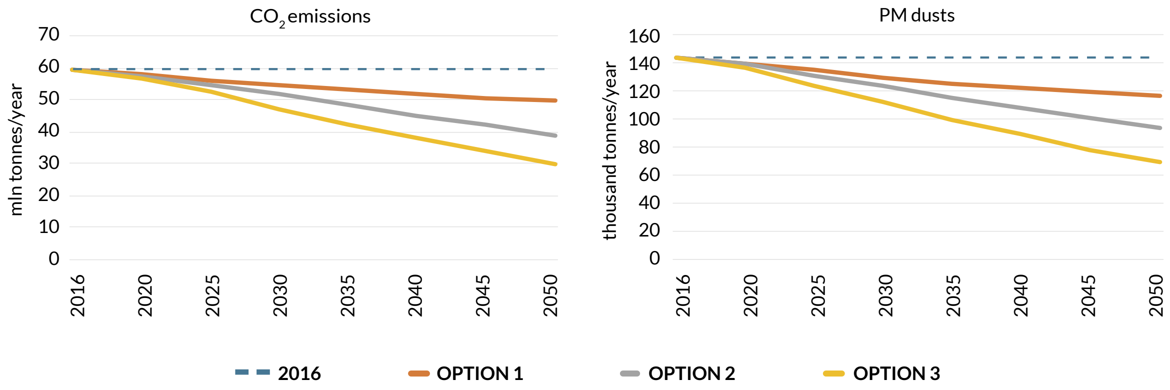
Reduced heat consumption means, above all, lower demand for fuels, especially hard coal and natural gas. As shown in Fig. 7.1., in 2050 the difference in annual coal consumption between the moderate (optimal variant) and actual consumption in 2016 reaches as much as 7.2 million tonnes, and gas 1.7 billion m^3. Lower fuel consumption also means lower pollutant emissions (Fig. 7.2.) and less need to import.

Figure 7.1. Annual consumption of fossil fuels for household heating



Source: KAPE S.A. own study.

Fig. 7.2. Emissions of CO_2 and PM dusts in thermomodernization options and in 2016



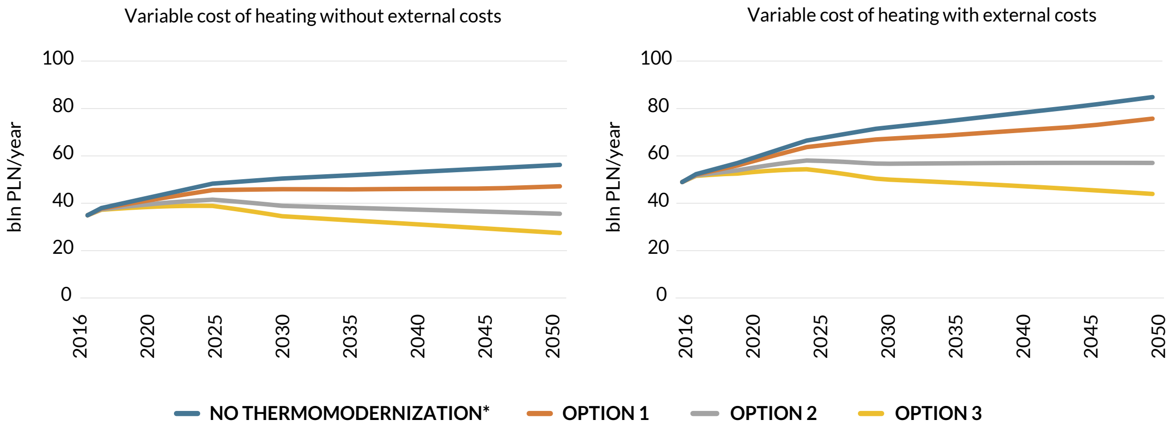
Source: KAPE S.A. own study.

Thermomodernisation in the second option will result in a positive effect of a 35 % reduction in greenhouse gas emissions from the whole area of heat supply and a 35 % reduction in emissions of PM10 and PM2.5 - the main smog polluters - by 2050. In the analysis period, heating companies will reduce the total cost of purchasing CO_2 emission allowances by PLN 37 billion until 2050, paying a total of PLN 124 billion instead of PLN 161 billion.

2) **Lower heating costs**

By 2050, the difference between the annual costs of the option without thermomodernization, i.e. maintaining energy efficiency of buildings at the level of 2016, and the second option amounts to PLN 21 billion, and, taking into account external costs, increases to PLN 28 billion (Fig. 7.3).

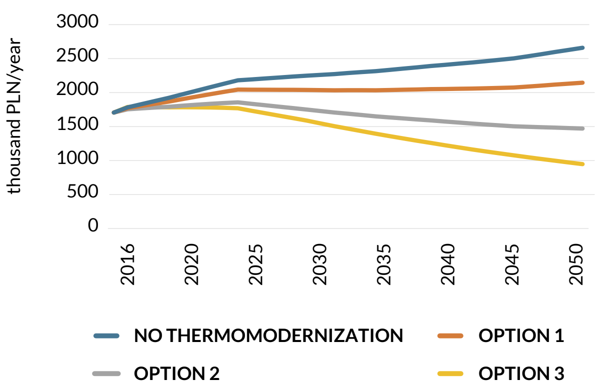
Fig. 7.3. Annual variable cost of heating in Poland without and includ with external costs



* Estimated cost with energy efficiency of buildings from 2016.

Source: KAPE S.A. own study.

Fig. 7.4. Annual variable cost of household heating without and after thermomodernization



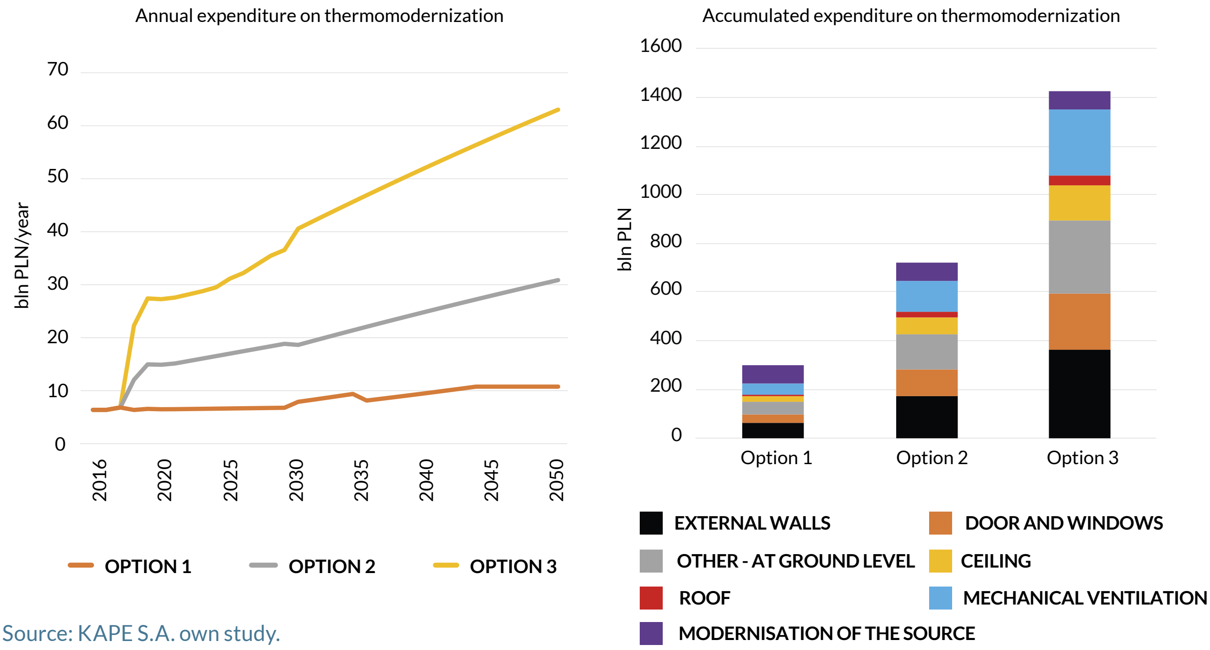
Source: KAPE S.A. own study.

Thermomodernisation of buildings will also contribute to the reduction of the annual variable cost of heating of an average household (Fig. 7.4). In the case of no thermomodernisation and in the first option, irrespective of the fuel used, heating costs will increase due to the projected increase in fuel prices. The remaining options allow for a decrease in the average cost of variable heating. The calculations presented do not take into account external costs, the integration of which would increase the discrepancies.

How much will it cost?

The cumulative costs of thermomodernisation by 2050 seem to be high. It is therefore necessary to find the optimum balance between the inputs and the environmental, financial and economic effects achieved. The stimulation of modernisation activities in the construction sector is, on the one hand, an investment expenditure, on the other hand, an increased domestic turnover, development of small enterprises in the construction sector and new jobs. That is why we should also view the results of the analysis presented as an economic opportunity and not just expenditure. It should be taken into account that we make conservative assumptions about the value of unit capital expenditures. The costs of labour and building materials have recently been high, which is reflected in the assumptions made. In addition, the level of expenditure is influenced by the assumption that the modernised buildings will meet the energy standards specified in the regulations for 2021 (WT21).

Fig. 7.5. Annual and cumulated expenditures on thermomodernization in Poland until 2050, by options of thermomodernization



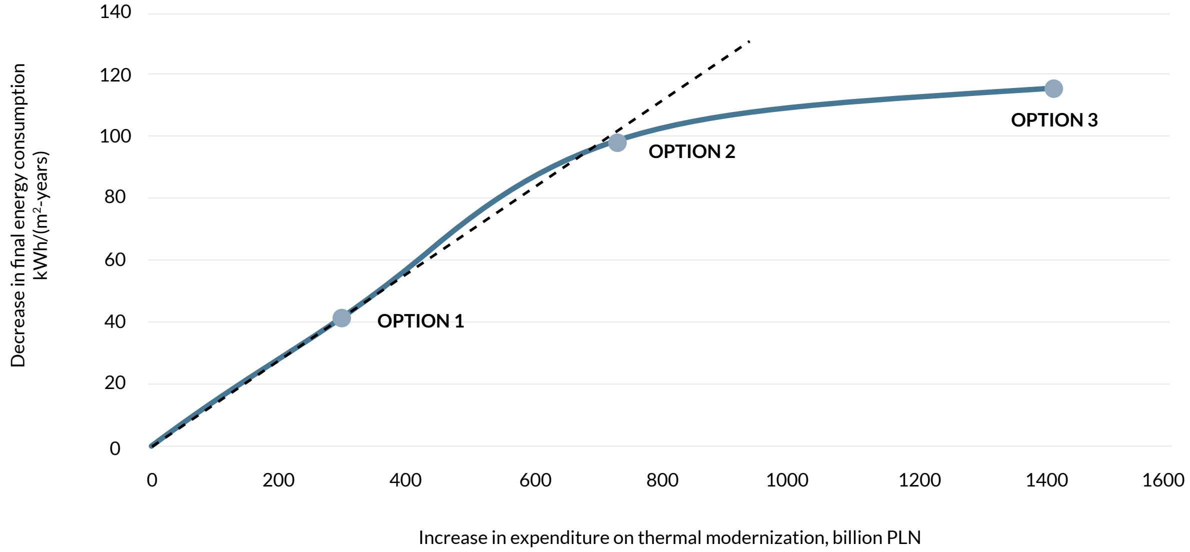
Source: KAPE S.A. own study.

In the second recommended option, cumulated investment expenditures until 2030 amount to PLN 218 billion, and by 2050, another PLN 502 billion. They concern all buildings in Poland, both those that use individual heat sources as well as those connected to heating networks. As a result of the thermomodernization of buildings, the cumulative value of cost savings (in the period 2016-2050), including external costs, will amount to PLN 540 billion compared to a situation where buildings would maintain a unit level of energy consumption as in 2016. Therefore, the savings balance most of the investment expenditures, amounting to PLN 720 billion. It should be noted that the analyses very conservatively estimated the value of external costs. Assuming the values reported for example by the Ministry of Enterprise and Technology would cause the balance of savings to significantly exceed the expenditure incurred. It is also worth remembering the multiplier effect caused by investment expenditures in the country and the increase in employment. Estimates show that for every new job in construction there is one in services and associated industries. Moreover, the above analysis does not value the reduced dependence on imports of fuels (gas and coal) and the purchase of CO_2 emission allowances on external markets in monetary terms, which should also be taken into account in the cost-benefit balance.

Which thermomodernization option do we recommend?

We considered the optimal variant to be the one in which each subsequent zloty spent on thermomodernization gives the effect of a decrease in energy consumption of a value not less than the previous zloty spent. When this rule ceases to work, further investment in thermomodernisation should be considered unjustified and further reductions in the primary energy consumption of buildings should be sought in an increased use of energy from renewable sources. The rule described above is illustrated in Figure 7.6, which shows that the reduction in final energy consumption in relation to the effort required to achieve this reduction is lower in the third scenario than in the second scenario. This means that in the third scenario the „overinvestment" of thermomodernization activities takes place in view of the resulting decrease in final energy consumption. Therefore, the second option should be considered as the optimal variant of thermomodernization, which is the foundation for the three scenarios of heating transformation described in the next chapter.

Fig. 7.6. Optimisation of the choice of the thermomodernization scenario in Poland by 2050



Source: KAPE S.A. own study.

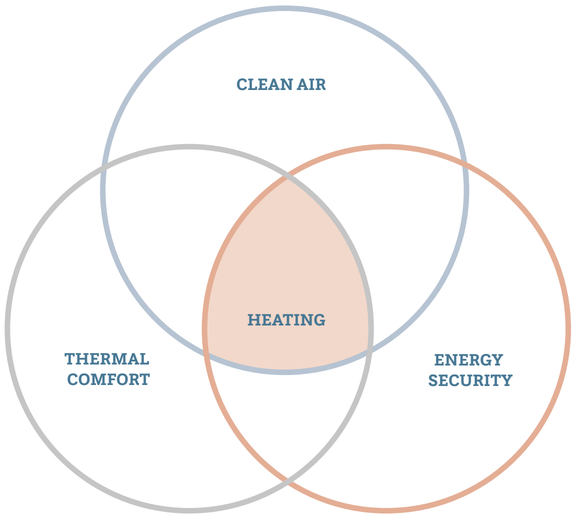
8. Low-emission transformation scenarios

8.1. Strategic objectives

District heating is under enormous pressure, as we wrote in chapter 4. Its transformation should pursue three basic objectives:

- improve air quality and reduce climate change,
- ensure thermal comfort,
- guarantee energy security.

Fig. 8.1. Objectives of heating transformation



Source: Forum Energii

Effective implementation of strategic objectives requires their quantification. After intensive consultations with experts, we have adopted the following objectives to be achieved:

1. **A 30% reduction in CO_2 emissions by 2030 and 80% by 2050 compared to 2016.**

   The formulated objective applies to all heating both within the ETS and non-ETS (generation units of less than 20 MW and individually heated households). We considered the inclusion of the non-ETS sector to be crucial due to the fact that more than 50% of CO_2 emissions come from households. The starting point was the adopted EU regulations up until 2030.

2. **In 2030 32% share of RES in the total heat stream, and in 2050 not less than 60%.**

   We have taken into account the EU's 2018 RES commitments as well as the economic benefits for the country thanks to the use of local RES sources, the potential of which exceeds the heating needs of Poland.

3. **A 56% reduction in the final energy consumption of buildings by 2050 compared to the projected reference scenario.**

   The combination of a reduction in final energy consumption and an increase in the share of RES allow for a significant reduction in non-renewable primary energy (the objective is a reduction of 80% by 2050). This can be achieved either by a significant increase in the share of the RES stream and a less ambitious reduction in final energy, or vice versa, by a large decrease in final energy with a smaller increase in the share of RES. Figure 8.2 shows one of the possible options, where the final energy reduction is 56% and the share of RES in the final energy stream is 60%. As a result, a reduction in non-renewable primary energy consumption of 80% is achieved.

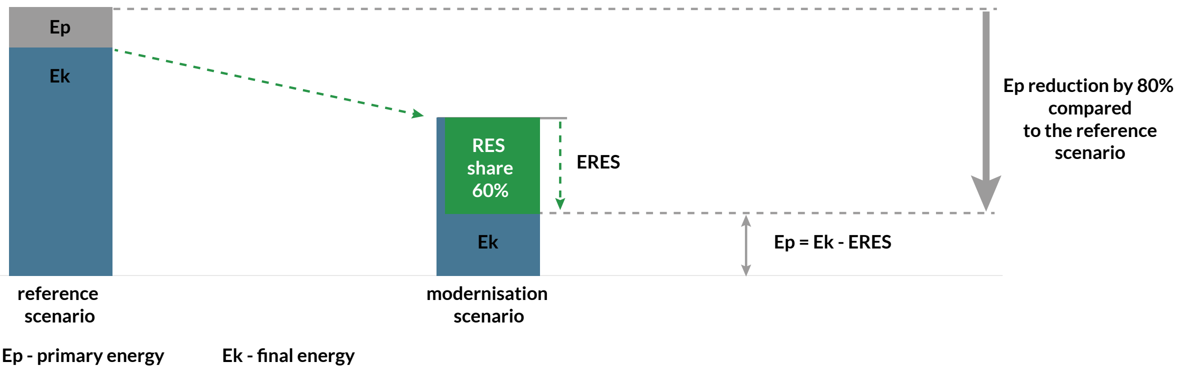
4. **Complete replacement of coal by other sources of primary energy in individual heating by 2030 and in district heating by 2050.**

   Without the elimination of coal from the process of heating individual households, the improvement of air quality in Poland will not be possible or will take place only in the future generations. In addition, this objective is necessary to improve Poland's fuel balance.

5. **Changing inefficient district heating systems to efficient by 2030.**

   This is the most important challenge, especially for small district heating systems, identified by us in earlier studies.

Fig. 8.2: Reducing the use of non-renewable primary energy in buildings as a combination of reduction of final energy consumption and use of renewable energy for heating purposes (ERES)



Source: Forum Energii.

In conclusion, we have assumed that national heating must meet the following objectives:

Objectives	2030	2050
Objective 1: Climate	Reduction of CO_2 emissions (compared to 2016) by **30%**.	Reduction of CO_2 emissions (compared to 2016) by **80%**.
Objective 2: RES	Share of RES energy in the heating stream of **32%**.	Share of RES energy in the heating stream at the level of minimum **60%**.
Objective 3: Energy efficiency	Reduction of the final energy consumption of buildings by **24%** (compared to the reference scenario)	Reduce the final energy consumption of buildings by **56%** (compared to the reference scenario)
Objective 4: Health and energy security	Replacement of coal by other sources of primary energy in individually heated buildings	Decarbonisation of heating
Objective 5: District heating systems	Transforming all district heating systems into efficient systems	-

8.2. Four scenarios for heating

Expert discussions and consultations resulted in the development of four scenarios for heating transformation. We have used this approach to examine the impact of achieving the objectives set. Each scenario is a combination of different energy mixes in heating and the number of buildings connected to the district heating network. The scenarios take into account the sector of individually powered buildings and district heating.

Table 8.1. Comparison of heat supply sector transformation scenarios in Poland

Scenario	CO_2 emissions mln tonnes/year			RES share %			Thermo-modernization option	Technological mix	
	2016	2030	2050	2016	2030	2050	2016-2050	2030	2050
I	68	63	67	17	16	16	1	hard coal - 58% natural gas - 23% biomass - 16% PV - 0% other - 3%	hard coal - 58% natural gas - 23% biomass - 16% PV - 0% other - 3%
II	68	49	18	17	27	47	2	hard coal - 42% natural gas - 27% biomass - 18% PV - 4% heat pumps - 3% other - 6%	hard coal - 0% natural gas - 49% biomass - 16% PV - 11% heat pumps - 13% other - 11%
III	68	47	14	17	32	62	2	hard coal - 25% gnatural gas - 39% biomass - 22% PV - 5% heat pumps - 3% other- 6%	hard coal - 0% natural gas - 35% biomass - 20% PV - 13% heat pumps - 18% other - 14%
IV	68	34	0	17	40	100	2	hard coal - 16% natural gas - 42% biomass - 21% PV - 6% heat pumps - 7% other - 8%	hard coal - 0% natural gas - 0% biomass - 16% PV - 24% heat pumps - 31% other - 29%

Source: KAPE S.A. own study.

Additional assumptions

1. a switch from combustion of hard coal in district heating
2. a discontinuation of hard coal combustion in individual sources in 2030, 2035 and 2040 in scenarios 4, 3 and 2 respectively.

The scenarios are described in detail below:

Scenario I - reference (unchanged; business as usual).

It means maintaining the status quo in the Polish heating industry. With regard to thermal modernisation of buildings, the first option described earlier in Chapter 7 has been adopted. No major reduction in CO_2 emissions or increase in the share of RES is assumed.

Scenario II - minimum.

It assumes a 27% share of renewable energy sources in 2030 in heating with a continuation of the trend until 2050. Reducing CO_2 emissions is not the overriding goal - emissions result from the planned energy mix. The RES technologies used are primarily biomass-fired sources, photovoltaics and heat pumps, including hybrid RES as a combination of heat pumps and photovoltaic panels. The generation mix is supplemented with waste heat from industry, geothermal energy and biogas. In addition, it was assumed that coal fuels will be abandoned by 2040 in individual heating systems. The optimal option of thermomodernization was adopted (second).

Scenario III - efficiency.

It assumes a reduction in CO_2 emissions in 2030 and 2050 of 30% and 80%, respectively, and a share of renewable energy sources of 32% in 2030. The share of RES in 2050 is about 62% and is a derivative of the assumed mix of generation sources, which guarantees the achievement of the CO_2 reduction target. In addition, by 2035, the elimination of coal fuels was adopted in individual heating and optimal thermal modernization of buildings (second option).

Scenario IV - decarbonisation.

It assumes the reduction of CO_2 emissions in 2030 and 2050 by 40% and 100%, respectively, and the share of RES in 2050 at the level of 100%. It is in line with the trends of the EU climate policy and provides for the possibility of a complete withdrawal from fossil fuels in the heating sector. The district heating network plays a smaller role here, and decentralised systems are becoming more important. It is also very important to integrate heating with the power sector, especially in order to make optimal use of the surplus electricity from RES in PtH (Power to Heat) sources. The scenario takes into account optimal thermal modernisation of buildings (option 2) and elimination of coal fuels in individual heating by 2030.

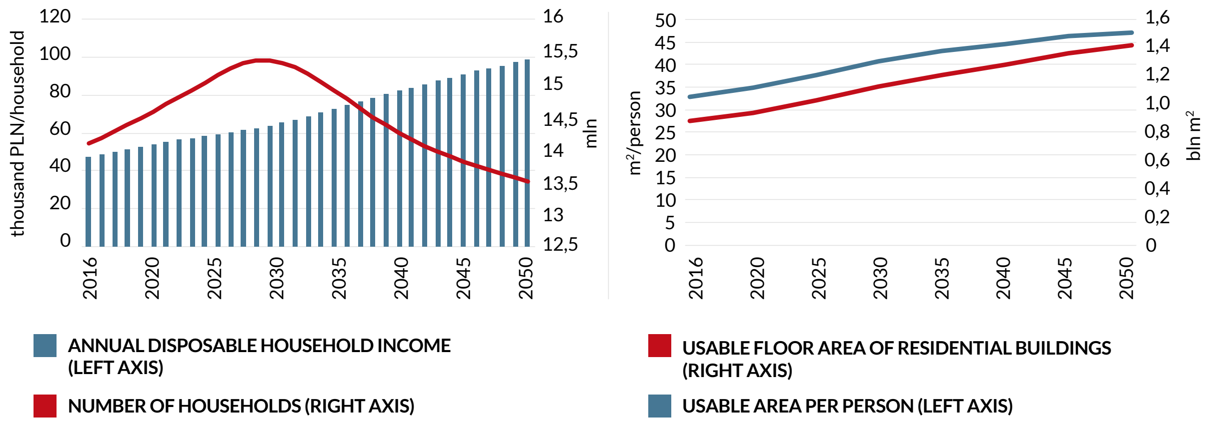
8.3. Basic assumption for scenarios

The development of scenarios for the transformation of the heating sector took into account macroeconomic and demographic assumptions illustrating the change in the wealth of Poles and the number of inhabitants and households, as well as the increase in the total usable floor area.

Households

It is estimated that Polish society will become richer. Forecasts for 2016-2050 indicate that the real average growth of the Polish GDP by 2050 may amount to about 2.7% annually, and 2.9% per capita. The disposable income of households will also increase (Fig. 8.3.). At the same time, according to current forecasts, the population and households are expected to fall slowly, but this does not mean that the number of apartments will fall. The analysis assumes an increase in the usable area per person, which is a reflection of both a higher the standard of living, as well as a greater number of flats per household. Consequently, the total the usable area of buildings will increase and thus also the usable area will increase per capita of the country (Fig. 8.3). One of the effects of this trend will be an increase in user costs. The increase in the number of apartments per household and the increase in investment expenditure.

Fig. 8.3. Annual household income and number of households and total useful floor area of apartments and per capita

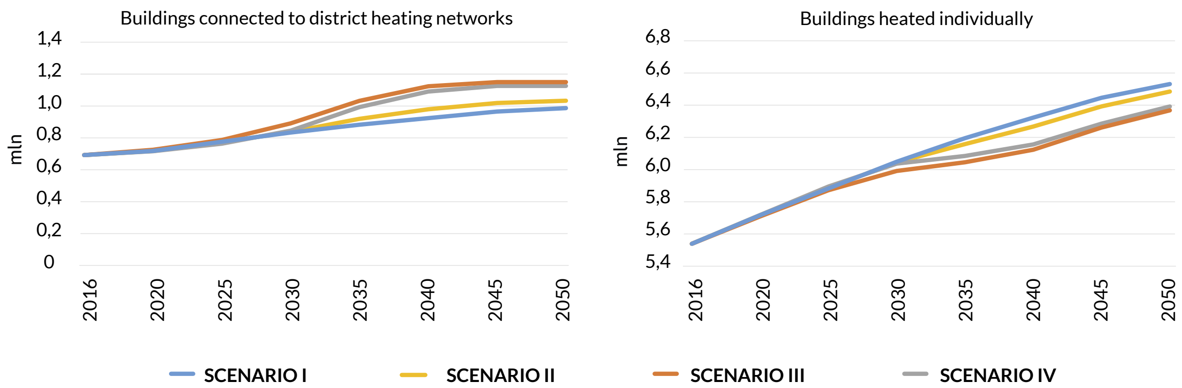


Source: KAPE S.A. own study.

Number of buildings supplied by district heating networks and individually

We assume that the number of buildings connected to the district heating network will grow in all scenarios - the slowest in the reference scenario, in which the development of system sources is the least dynamic. In the third scenario, due to the assumed dynamic development of system sources, the largest number of connections to district heating networks occurs.

Fig. 8.4. Number of buildings connected to district heating networks and supplied individually

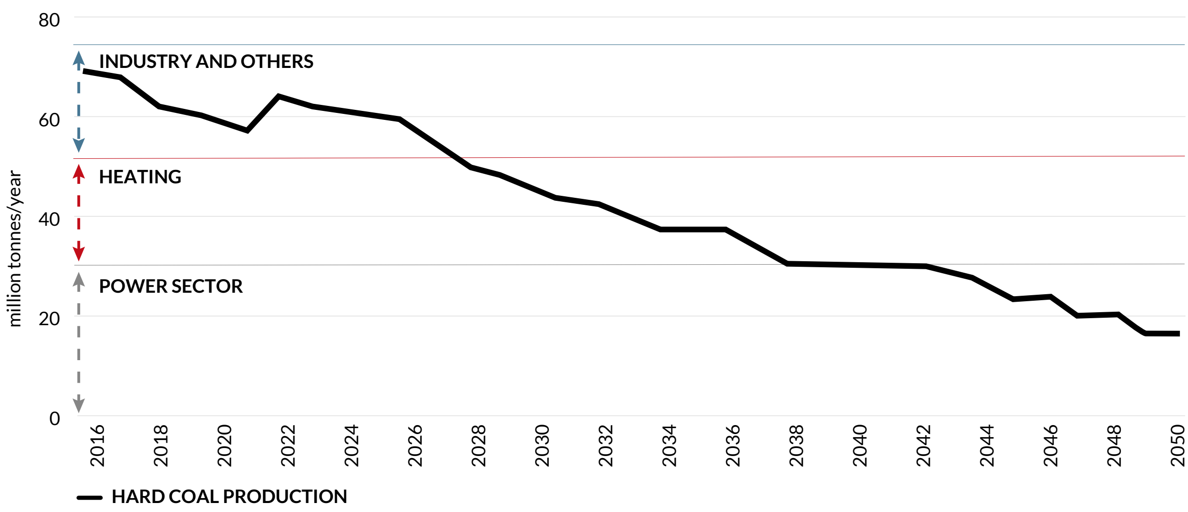


Source: KAPE S.A. own study.

Fossil fuel balance

The availability and price of energy carriers, as well as the cost of purchasing CO_2 emission allowances, are among the main constraints determining the structure of generation sources used in the heat supply sector. In analyses it was assumed that the availability of fossil fuels in Poland will decrease in the following years due to the gradual exhaustion of economically available resources. For hard coal, it has been assumed that its domestic production will decrease from 70.5 million tonnes in 2016 to 20 million tonnes in 2050. Graph 8.5. presents a forecast of hard coal mining in Poland with the current demand for the fuel imposed by the power industry, heating (district and individual) and the industry.

Fig. 8.5. Forecast of domestic hard coal supply compared to the current demand for the production of electricity and heat and for industry in Poland



Source: own elaboration of KAPE S.A. and Forum Energii.

As regards natural gas, it is assumed that its domestic production will decrease from the current level of 4.5 billion m^3 to 1.5 billion m^3 in 2050.

Renewable energy balance

The main energy carrier for increasing the share of RES in heating is biomass, in particular wood biomass and straw, although it also has its limitations related to its sustainable harvesting. There is also significant potential for geothermal energy and biogas in the country. Solar energy is also a huge resource and its popularity will increase with the decrease in production costs. Data on annual resources of other energy carriers that can be used for power purposes are shown in Table 8.2.

Table 8.2. Annual energy resources usable for power purposes (PJ/a)

National primary energy sources for energy purposes (PJ/a)										
Biomass				Biogas			Geother-mal ener-gy	Munici-pal waste	Indu-strial waste heat	Solar col-lectors
Straw	Perma-nent pastures	Energy crops	Wood biomass	Landfills	Agricul-ture	Waste-water treat-ment plant				
247	42	46	360	17	80	2	184	38	25	7200

Source: KAPE S.A. own study.

Cost of fuels and energy

Tables 8.3. and 8.4. contain forecasts of gross fuel and electricity costs (including transmission and distribution tariffs). The cost of electricity reflects the average energy price based on Eurostat data, which roughly corresponds to G11 tariff prices. For the analysis of the effects of using electric furnaces with the possibility of heat accumulation, the reduced heat costs corresponding to the prices in tariff group G12 were used.

Table 8.3. Projection of unit costs of household energy carriers (including VAT and transmission costs)

		2016	2020	2025	2030	2035	2040	2045	2050
electricity	PLN/MWh	590	583	679	755	825	834	858	900
fuel oil	PLN/GJ	86	125	174	197	216	233	250	266
natural gas	PLN/GJ	53	63	80	88	91	96	102	107
pellet	PLN/GJ	54	54	56	57	59	61	63	66
hard coal	PLN/GJ	29	37	42	43	44	44	45	46
hard coal for V class boilers	PLN/GJ	32	40	46	47	48	49	49	50

Source: KAPE S.A. own study based on Energy Analyses data, 2015; IEA, 2017; Polish Mining Group; Eurostat, 2017.

Table 8.4: Projection of unit costs of energy carriers for heating companies (including VAT and transmission costs), the cost of CO_2 emissions from the electricity sector and the costs of the emission allowances in the ETS 2016

		2016	2020	2025	2030	2035	2040	2045	2050
electricity	PLN/MWh	341	352	440	511	575	583	606	645
oil	PLN/GJ	60	87	121	138	151	162	174	186
natural gas	PLN/GJ	41	36	45	50	51	54	58	61
pellet	PLN/GJ	38	40	41	42	43	44	45	47
hard coal	PLN/GJ	13.4	16.2	18.3	18.7	19.2	19.4	19.7	20
CO_2 emissions from electricity	kg/MWh	791	745	709	613	401	332	265	210
purchase price of the right to emission of CO_2	PLN/t	23	56	113	184	221	258	295	332

Source: KAPE S.A. own study based on Energy Analyses data, 2015; IEA, 2017; Polish Mining Group; Eurostat, 2017.

External costs

As we wrote earlier, it is also important to take into account the external costs arising from the negative impact of energy processes on human health and the environment. The following methodologies were used for their estimation

developed within the ExternE project, which allows the quantification of the cost associated with the specific emissions of basic harmful substances in areas inhabited by society. The calculated costs have been adjusted to Polish conditions and are indexed at the level of 1.5% annually due to inflation and rising health care costs. In order to determine the impact of heating on the climate, we used the values resulting from emissions from the Emissions Trading System (ETS), i.e. the costs of greenhouse gas emission allowances are represented by CO_2 equivalent (Table 8.5).

Table 8.5 Specific external costs related to emissions of substances in energy processes (PLN/kg)

CO_2	NO_x	SO_x	PM2,5	PM10	BaP
0.023	28	30	105.5	5	2,2

Source: KAPE S.A. own study based on D. Štreimikiene, I. Mikalauskas, Internalisation of external costs in Lithuania and Poland, „Journal of International Studies", 2015

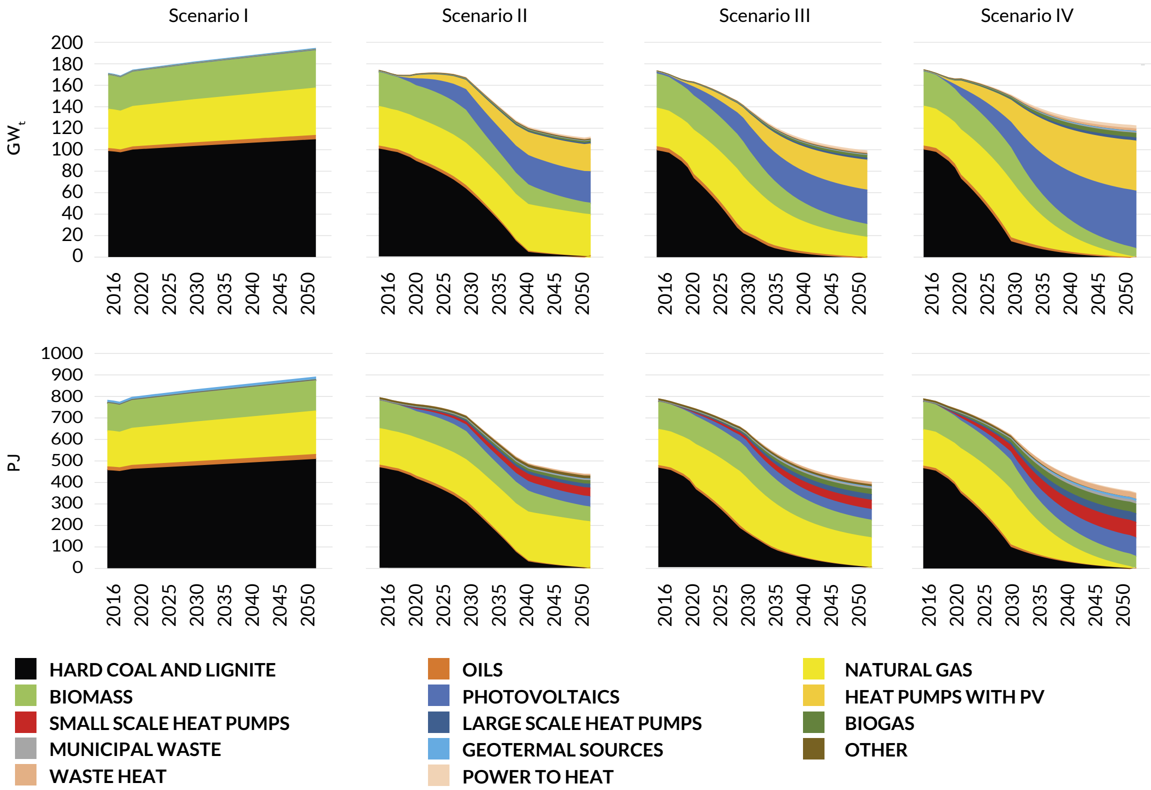
8.4. Results of analyses of scenarios for modernization of heating system

This chapter contains collective results for all heating (individual heat sources and district heating systems). The annex to this report presents analogous results broken down into individually heated buildings and district heating systems.

Power of heat sources and energy production

Depending on the adopted scenario (Table 8.1.), the structure of power and heat production changes. In the first scenario (unchanged), the demand for power in buildings increases due to slow progress of thermal modernisation activities and connecting new buildings (Fig. 8.4.). According to the assumption, the fuel structure of heat sources does not change. Scenarios III and IV assume a faster rate of thermomodernization and a higher number of buildings supplied with district heat than in the second scenario, which clearly reduces the demand for power and energy.

Fig. 8.6. Thermal power (upper graphs) and energy consumption of heat sources (lower graphs) in four scenarios



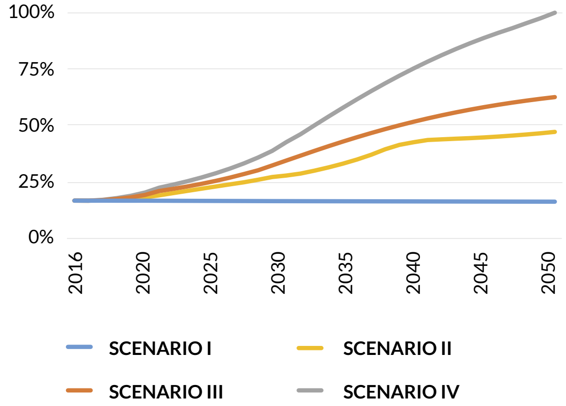
Source: own elaboration of KAPE S.A.

The energy consumption in the different scenarios is the result of thermomodernization measures and different overall efficiency of heat sources, hence the visible differences in energy consumption in 2050.

However, it should be noted that the usable heat volume is the same in modernisation scenarios due to the same final energy efficiency level of buildings.

Share of RES in energy consumption

Fig. 8.7. RES share in energy consumption for the whole heating sector in Poland (graph) and the amount of energy from RES in scenarios divided into areas of individually heated buildings (NSC) and district heating networks (SC)



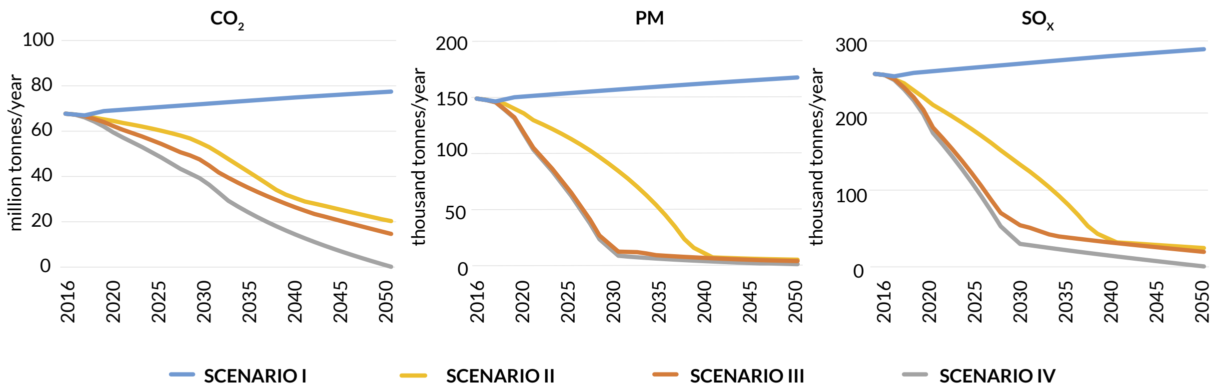
RES SHARE IN ENERGY CONSUMPTION (PJ)	2016		2030		2050	
	NSC	SC	NSC	SC	NSC	SC
SCENARIO I	112	21	118	21	124	23
SCENARIO II	112	21	143	50	98	108
SCENARIO III	112	21	146	62	88	163
SCENARIO IV	112	21	155	88	151	202

Source: KAPE S.A. own study.

Improving air quality

The introduction of a mix of renewable energy, electricity and gas generation technologies in the modernisation scenarios (from second to fourth) (with the exception of gas in the fourth scenario) will lead to a significant reduction in CO_2 emissions[6]. This has a major impact not only on climate protection, but also on the cost of heating for households. It is worth noting that the reduction of SO_x emissions and dusts (directly affecting the air quality in Poland) will be achieved mainly due to the modernisation of individual heating system. The current share of individually heated buildings in total SO_x and dust emissions is about 88%-90%. Therefore, efforts to improve air quality should primarily focus on this group of facilities.

Figure 8.8: Change in CO_2, dust and SO_x emissions in modernisation scenarios



Source: KAPE S.A. own study.

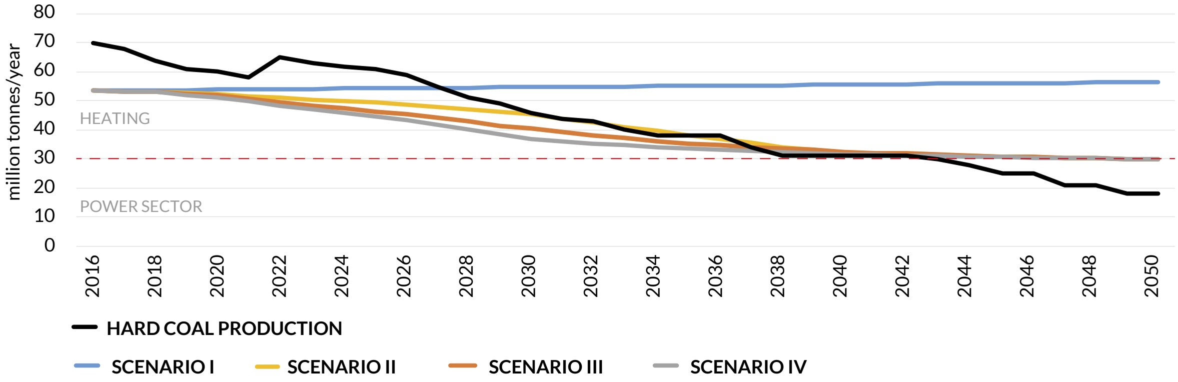
6 The emission from energy supplying heat pumps and electric boilers was calculated using a diversified scenario without nuclear power, developed by the Forum Energii in the report „Polish energy sector. 4 scenarios." - kliknięcie powinno przenosic do- http://forum-energii.eu/en/analizy/polska-energetyka-2050-4-scenariusze

Improvement of the fuel balance of the country

As indicated by the Ministry of Energy, in the Poland's Energy Policy until 2040 draft (December 2018), the consumption of hard coal for electricity generation will remain unchanged. The maintenance of an unchanged stream of coal for industrial purposes, is also envisage.

Due to the prospect of falling domestic mining, the only way to limit the growth of coal imports is to reduce its use in the heating industry. First of all, individual heating should be modernised in such a way that by 2030, coal will have been replaced by other energy sources. At the same time, the process of modernization of district heating should be continued to replace coal with other fuels by 2050. Fig. 8.9. presents the balance of domestic coal supply and the demand for energy and heating. As you can see, thanks to the modernization of heating system we can achieve a balance at the level of energy and heating needs.

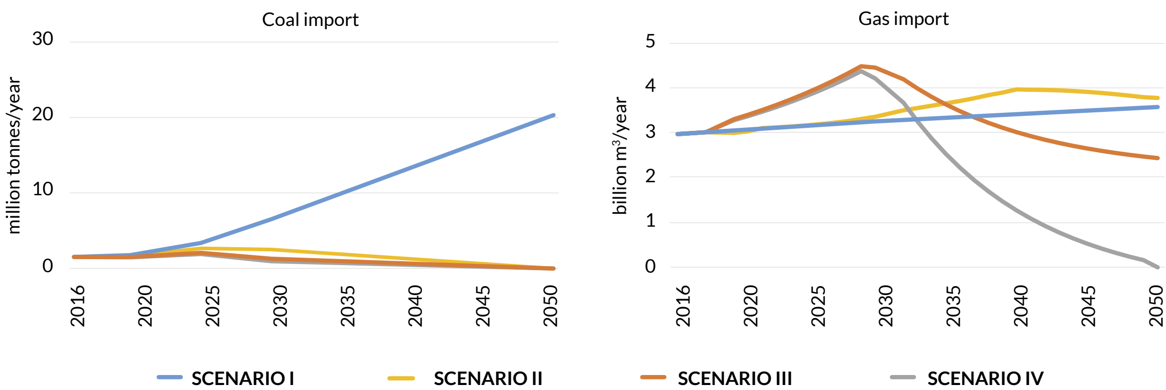
Fig. 8.9. Hard coal consumption by commercial power industry and heating in scenarios in relation to domestic production



Source: KAPE S.A. own study and Forum Energii.

The modernisation of heating in scenarios 2, 3 and 4 allows a reduction in fuel imports, as shown in Figure 8.10. Gas imports can be reduced in scenario 4 assuming full decarbonisation of heating.

Fig. 8.10. Imports of coal and natural gas for heat supply by scenario



Source: KAPE S.A. own study.

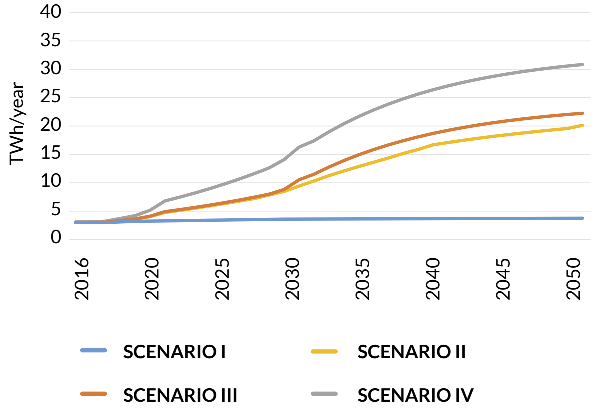
Heat electrification - how much electricity must be supplied by the National Power System?

In the modernisation scenarios, we assumed that a certain amount of heat will be produced using electricity. The basic production equipment is heat pumps with capacities depending on the target group of heat consumers. We also assumed that part of the electricity will come from self-produced photovoltaic (PV) sources and the remaining part will be purchased at market prices - as shown in the table with energy and fuel price projections. Based on historical data on wholesale prices on the markets, we have calculated the volume of electricity used in the PtH technology (e.g. in electric boilers). We have assumed that the market price must guarantee that the cost of heat production is maintained at a lower level than that of alternative heat sources.

Figure 8.11. shows the amount of electricity needed to produce heat, while the table shows the distribution of the energy stream into that obtained from own production, mainly by means of photovoltaics and power grids.

In households, we have assumed partial coverage of electricity demand from domestic photovoltaic installations at about 2%, 28%, 37% and 32% of total electricity demand respectively, the remaining part has to be supplied from the grid.

Fig. 8.11. Electricity demand for heating in scenarios (graph) and sources of electricity in 2050 (table)



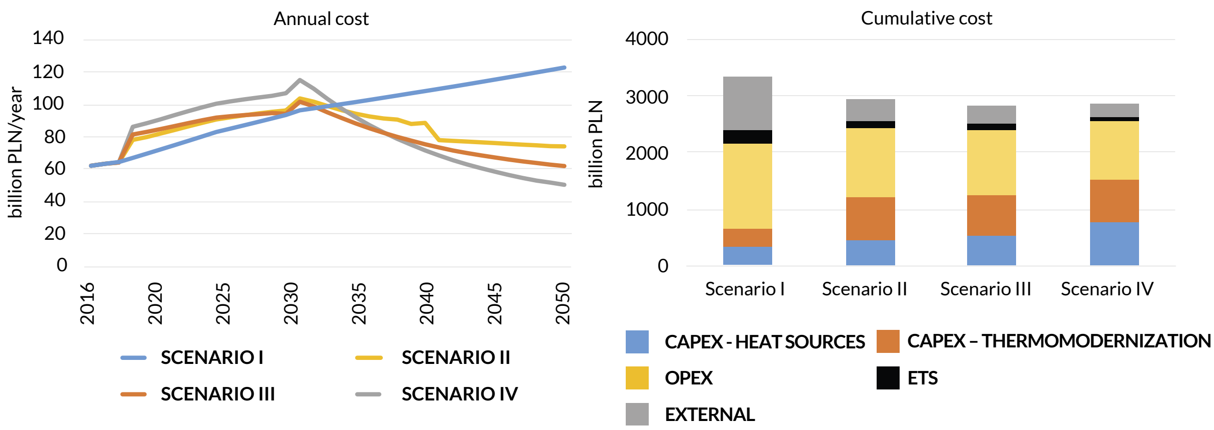
	2050		
	Total demand (TWh)	Self-production (TWh)	From the grid (TWh)
SCENARIO I	4	0	4
SCENARIO II	20	5	15
SCENARIO III	22	6	16
SCENARIO IV	31	10	21

Source: KAPE S.A. own study.

Total costs of heat supply

The analyses show that the total expenditure (CAPEX, OPEX and external costs) that society has to bear in order to ensure thermal comfort is highest in the first scenario. This is mainly due to high fuel costs and very high external costs. The third scenario is the most favourable from the perspective of aggregated total costs. It is also the most efficient in terms of the unit cost of reducing emissions of greenhouse gases and other air pollutants. The increase in annual expenditure in scenarios 2, 3 and 4 compared to scenario 1 in the period to 2035 is due to increased CAPEX expenditure on new generation technologies and thermo-modernisation. After a period of intensive investments, annual heating costs in these three scenarios fall sharply compared to the first scenario.

Fig. 8.12. Annual and accumulated costs of heat supply until 2050 (CAPEX, OPEX, ETS, EXTERNAL) for four scenarios

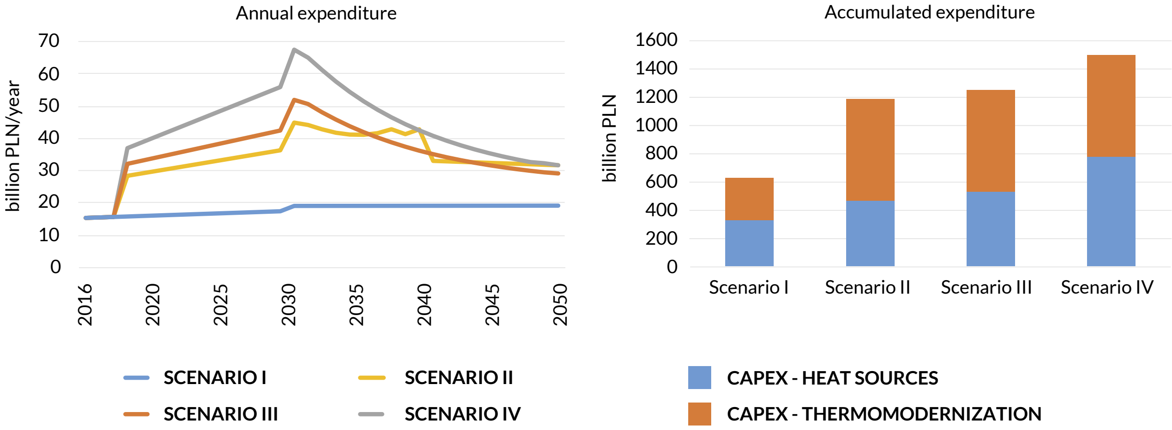


Źródło: opracowanie własne KAPE S.A.

CAPEX expenditure

In order to carry out a low-emission transformation of the heat supply sector in Poland, significant funds are needed for the construction of new heat sources and thermal modernisation. CAPEX expenditure is higher in the modernisation scenarios than in the reference scenario. However, they bring benefits by reducing fuel costs and external costs, as shown in the following graphs.

Fig. 8.13. Annual expenditure (CAPEX) and cumulated expenditure up to 2050 in four scenarios

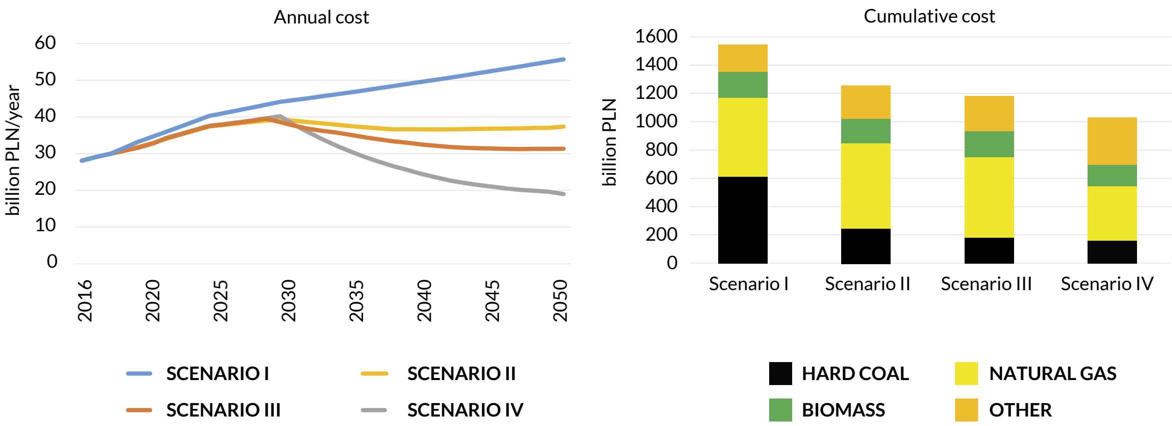


Source: KAPE S.A. own study.

Costs of fuel supply

In terms of fuel costs, the first scenario is the least favourable. Due to a small improvement in energy efficiency and an increase in market prices, fuel costs are on an upward trend. The fourth scenario is the most favourable, which is a consequence of the thermomodernization measures carried out and an increase in the share of renewable energy sources.

Fig. 8.14. Annual fuel costs and cumulative fuel costs up to 2050 for heat supply sector transformation scenarios in Poland

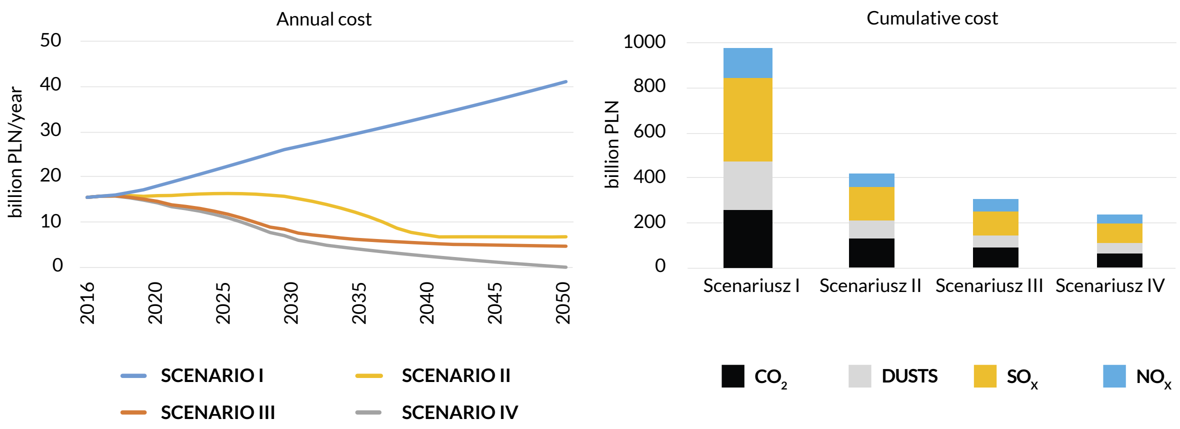


Source: KAPE S.A. own study.

External costs

Cumulative external costs in the first scenario are more than twice as high as in the other scenarios. Following that scenario, it is likely to contribute to a significant worsening of air quality and increase the health costs of society. In particular, the inhabitants of regions without access to the district heating network will be at risk, as the problem of low emissions is the greatest there. It should be emphasised that the analysis made rather conservative assumptions about the level of external costs. For 2016, they amount to approximately PLN 15 billion, in subsequent years they increase due to the accumulation of factors worsening the quality of the environment. However, we believe that they can be much higher. For comparison, in a report published by the Ministry of Enterprise and Technology, the health cost resulting from poor air quality in Poland (smog) is estimated at between PLN 54 and 126 billion. Taking into account the fact that all heating system is half responsible for smog formation, it can be assumed that the accompanying external cost amounts to PLN 27-63 billion.

Fig. 8.15. Annual external costs and cumulative external costs up to 2050

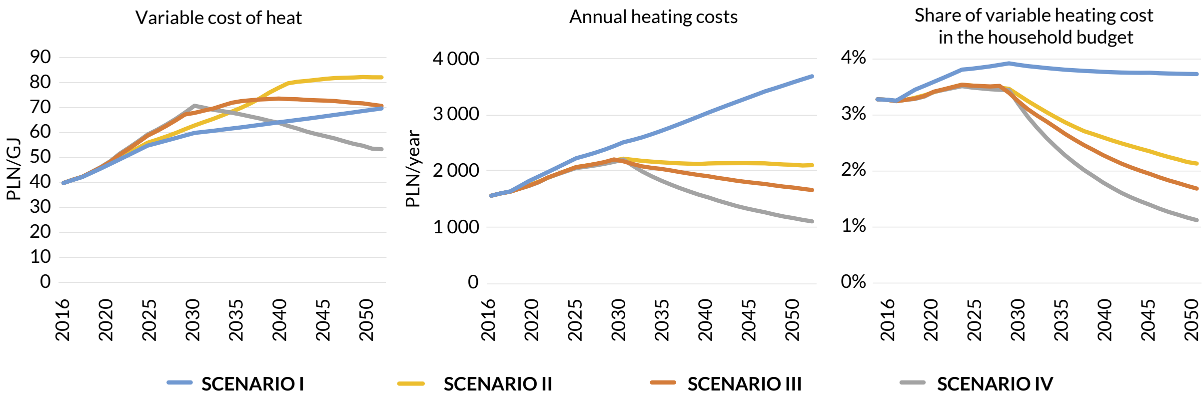


Source: KAPE S.A. own study.

Variable heating costs

Modernisation of heating is connected with an increase in the unit variable cost of heat. The reason for this is the projected increase in fuel (gas, biomass, coal) and electricity costs (e.g. for heat pumps). The lowest variable cost occurs in the first scenario as it only reflects the cost of fuel (mainly coal) without entailing environmental costs. In the fourth scenario, the share of solar energy (with almost zero variable costs) increases, resulting in a reduction in the variable heat cost around 2040 below the level generated in the first scenario. It will not be possible to keep the price of heat unchanged, but we must strive to maintain a constant relationship between the cost of heating and the disposable budget of the household. As can be seen from Figure 8.16, the annual variable cost of heat for a household will initially increase in all scenarios, but in the modernisation scenarios around 2030 there is a slow-down and then a decrease. Cost reductions are a result of thermal modernization of buildings, exchange of heat sources and gradual increase in the share of energy from renewable sources. The first scenario does not assume a similar level of energy efficiency and modernisation of sources, which translates into a steady increase in the cost of heating and its share in the household budget. As can be seen from the diagram in Fig. 8.16., thanks to the modernization activities, the share of the variable the cost of heating in the household budget is significantly lower in scenarios 2, 3 and 4 than in scenario 1.

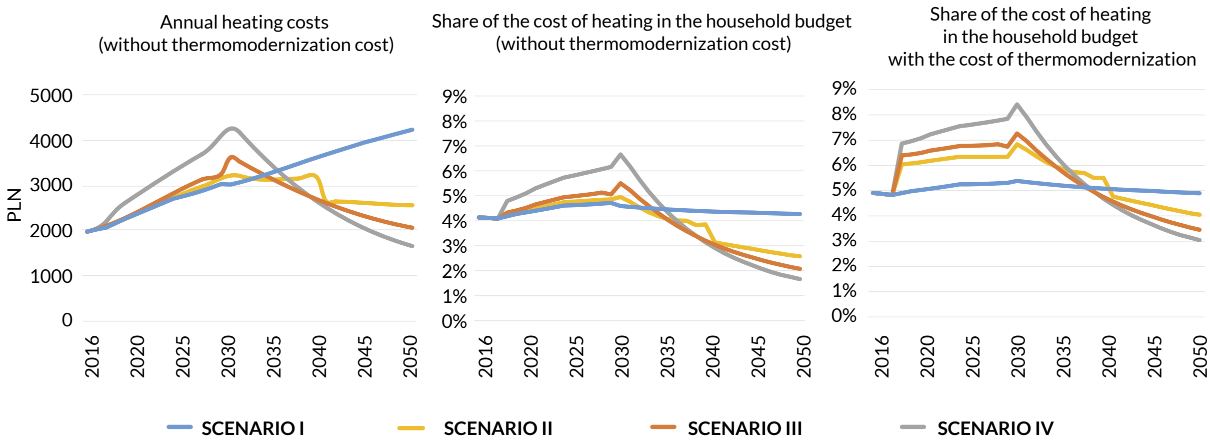
Fig. 8.16. Unit variable cost of heat, annual variable cost of household heating and share of variable cost of heating in household budget



Source: KAPE S.A. own study.

The above heat costs only reflect the variable cost of heating. This will be the case, for example, when the household receives a non-refundable subsidy. In practice, not all households will benefit from this, so we have calculated the cost of heating including investment costs, capital costs and fuel costs. The diagrams in Figure 8.17 show the total annual cost of heating and the share of the cost of heating in the household budget. The share of the annual cost of heating in the household budget was shown in two steps. The first one, without taking into account the cost of thermomodernization and the second one with the cost of thermomodernization included in the price of heat.

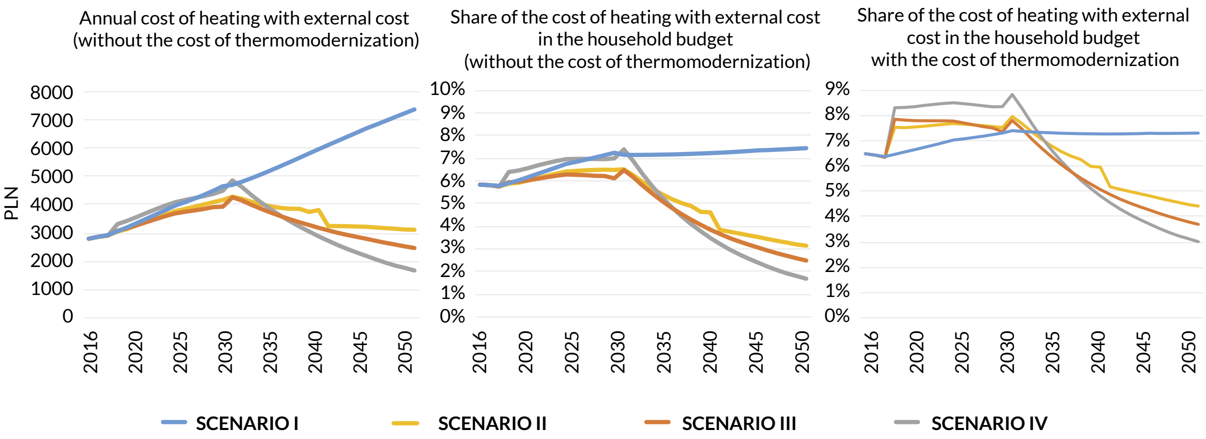
Fig. 8.17. Annual cost of heating, share of heating costs (without costs and with costs of thermomodernization) in household budget



Source: KAPE S.A. own study.

In the initial period, in modernisation scenarios, the cost of heating rises, to then fall below the cost generated in the reference scenario around 2032. This is a result of the investment expenditures, which only after some time begin to have effects in the form of lower heating costs. The same graph shows the share of the cost of heating in the household budget (middle graph). However, when we add the cost of thermal modernisation (calculated per unit of heat) to the cost of heating, it turns out that by 2037 the share of all costs related to heating and thermal modernisation in the household budget is higher than in the reference scenario. The conclusion is clear. From the perspective of the investor (household), activities related to modernization of heat sources and improvement of energy efficiency of buildings are not profitable. Other conclusions can be drawn from a social perspective, i.e. a situation in which the price of heat also includes the external costs (depending on the type of heat source). The diagrams in Figure 8.18. show (as before) the annual cost of heating and the share of the cost of heating in the household budget (without and with the cost of thermomodernisation).

Fig. 8.18. Annual cost of heating with external cost and share of heating costs (without and without heating costs) with external costs in the household budget



Source: KAPE S.A. own study.

The inclusion of external cost increases the share of the cost of heating in the household budget in the reference scenario and provides a natural incentive for action on heat exchange and thermomodernisation. Calculations show that even after the inclusion of expenditure on thermomodernisation, the share of the cost of heating in the household budget slightly increases, so that when the investment is completed, it starts to bring measurable benefits.

Level of investment support

The analyses carried out indicate that from the perspective of all heating costs (including external costs), as a society we will pay less if the heating system is modernised and buildings consume less energy (Fig. 8.12.). There is therefore a legitimate need to implement intervention mechanisms that will encourage households to modernise. This could be the introduction of investment support schemes (e.g. subsidies, tax breaks, cheap loans, etc.) or operational support schemes (subsidies for more expensive primary energy - gas, electricity), or the generally applicable „polluter pays" principle, e.g. in the form of emission tax.

The practice of different countries shows that different combinations of these incentives are possible. In our analysis of the necessary level of investment support, we assumed that the external cost is not included in the price of heat. We then calculated the level of a subsidy for investment, after which the household will benefit from modernisation. This is because the share of heating costs (including expenditure on thermo-modernisation) in the household budget will not be higher than in the reference scenario throughout the analysis period (Table 8.6.).

Table 8.6. Amount of subsidies needed to reduce the share of the cost of heating (including the cost thermal modernisation) in the household budget below the share in the first scenario

Scenario	Level of subsidies (billion PLN)	Share of the scenario in total CAPEX expenditure (%)
II	**167**	**14**
III	**137**	**11**
IV	**253**	**17**

As it can be seen in the third scenario, the amount of the calculated subsidy is similar to the current declarations of the government regarding support for thermomodernization. The subsidy is particularly important during the first 20 years of the analysis. In the subsequent years, the increase in fuel costs, emission costs and technical requirements for conventional sources will significantly increase the competitiveness of alternative sources.

9. Energy poverty

Assumptions for analysis

In the Diagnosis chapter we described the phenomenon of energy poverty. When planning to modernise district heating, it should be taken into account that the potential increase in heat costs does not affect everyone in the same way. What is most relevant:

(a) the amount of investment needed to raise the standard of buildings and replace the heat source;

(b) the household's well-being.

There is a risk that an incoherent transformation of heating will increase the proportion of energy-poor people. Protective measures must be planned to prevent this phenomenon. Below we evaluate how the planned investments will affect household budgets. We assume that the expenditure for these purposes will be directly borne by households and will be spread over 20 years. The costs of heat source replacement will depend on the degree of thermomodernization of the building, therefore we count them separately.

We analyze the cost of thermomodernization of single and multi-family buildings, while heat source replacement only for single-family houses (including semi-detached). After taking into account the savings in heating costs resulting from these investments, we calculate the net costs for households understood as the sum of investment costs and changes in heating costs over the period of 20 years. We present them in current values and in the form of monthly net costs.

Costs of heat transformation for different types of households

Thermomodernization of buildings will burden households in single-family buildings more financially than in multi-family buildings (Table 9.1). The median net cost of thermomodernization incurred by this household is PLN 176, and in a multi-family building PLN 54, which translates into 4.6% and 1.5% of total disposable income, respectively. However, for many households it will be much more - for 1/4 of households located in single-family houses this indicator would exceed 7%. The net costs will increase if heat sources are replaced in addition to thermomodernization. Installation of a gas-fired boiler is an additional net cost of PLN 101 per month (PLN 277 with thermomodernization), and heat pumps with PV installation - PLN 238 (PLN 414 with thermomodernization). For half of the households, the net cost of investment in thermal modernisation and heat pump will exceed 10% of total income (and for about 1/4 - 17% of income). Self-financing of such investments is unlikely in the case of these households, even if the costs are spread over 20 years. The amounts presented in Table 9.1 show what level of support for different types of households is needed to cover the additional costs (monthly, for 20 years).

Tab. 9.1. Monthly net costs [a)] investments in thermomodernization or exchange of heat sources in all households and the share of these costs in disposable income

Category	Type of investment	Type of building	First quartile	Median	Third quartile
Monthly net costs (PLN)	Thermomodernisation	Multi-family	44	54	65
		Single-family	141	176	229
	Replacing the heat source with a gas-fired boiler	Single-family	89	101	118
	Replacing the heat source with a heat pump with a PV	Single-family	234	238	245
Share of costs in disposable income of the household (%)	Thermomodernisation	Multi-family	1.1	1.5	2.3
		Single-family	3.1	4.6	7.0
	Replacing the heat source with a gas-fired boiler	Single-family	1.8	2.6	4.0
	Replacing the heat source with a heat pump with a PV	Single-family	4.1	6.0	9.7

[(a)] Monthly net costs are, for the chosen investment, the difference between the investment cost and the sum of the changes in costs of 20 year old heating system - expressed in present value and shown on a monthly basis.

Source: IBS own calculations based on KAPE projections and data from GUS household budget survey.

Impact on the risk of energy poverty

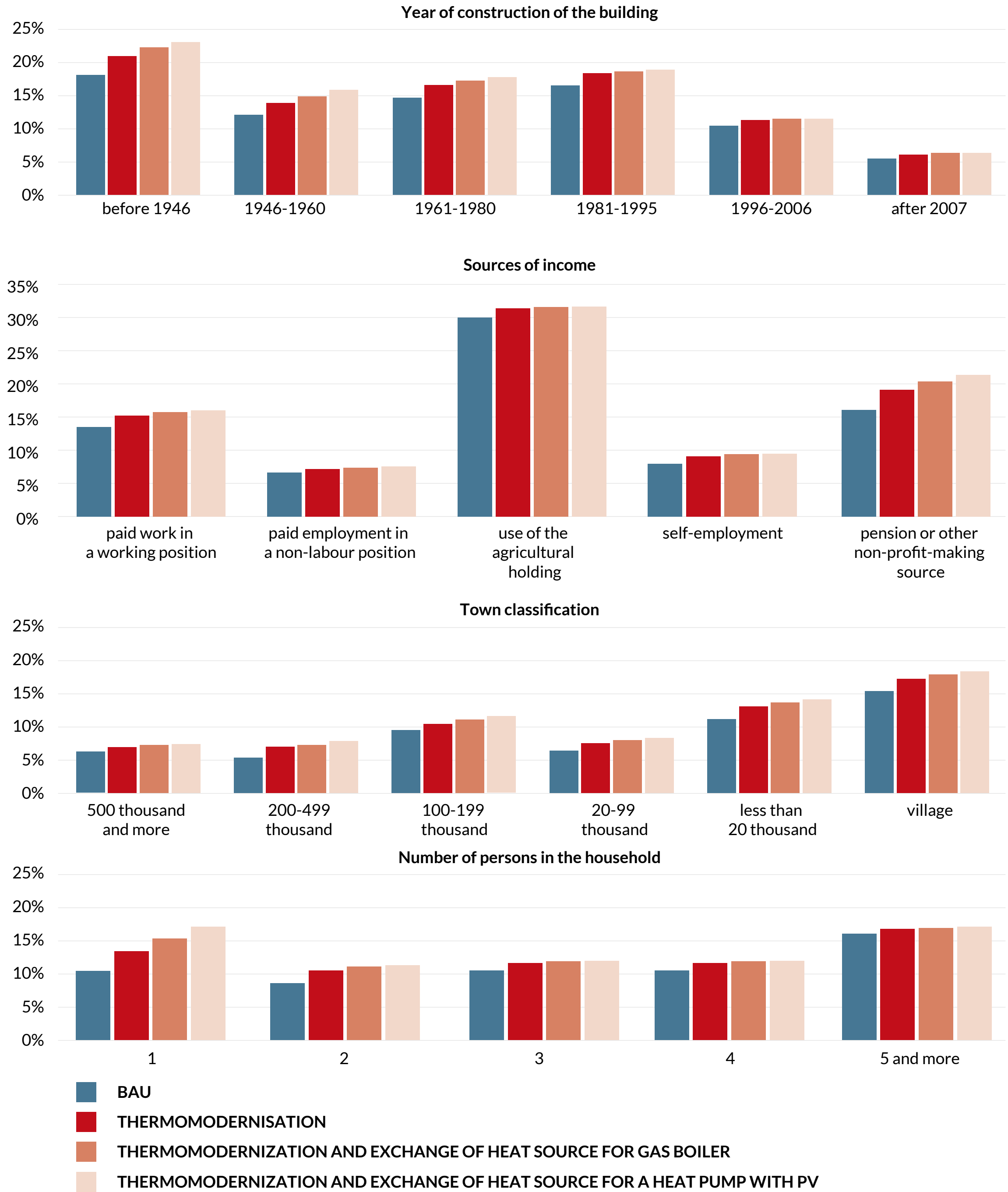
In 2016, the risk of energy poverty was nearly 10% on average (this was the percentage of energy-poor households (cf. the diagnosis in chapter 6). We have made an assessment of how this risk will change if thermal modernisation of houses not yet insulated is carried out and heat sources (gas boilers or heat pumps connected to a photovoltaic installation)[7] are to be replaced. We focused on households located in single-family buildings, which are most at risk because they will incur higher transformation costs.

Conclusions:

- Thermomodernisation without protective measures increases the risk of energy poverty in an average household in Poland by 1.3 percentage points (i.e. by over 10% increase in the number of energy-poor households).
- The households in single-family houses built before 1946 (increase in risk by almost 3 percentage points) and in the years 1960-1995 (increase by 2 percentage points) are the most exposed to the increase in energy poverty. This is due to the low energy efficiency of these buildings and thus the high costs of thermomodernization.
- Thermomodernisation combined with the exchange of heat sources into zero-emissions heat pumps (associated with photovoltaic installations) means that the risk of energy poverty increases by 3 percentage points on average.
- Pensioners and people living from other non-profit sources are more at risk of increasing the risk of energy poverty (by about 3 percentage points in the case of thermomodernisation, by almost 5 percentage points in the case of heat pump heat source exchange) than households living off work.
- From the point of view of the size of a household, single-person households are the most exposed to the increased risk of energy poverty (more than 3 p.p. in the case of thermomodernization, 6 p.p. in the case of gas boilers, 8 p.p. in the case of heat pumps and PV).
- The risk of energy poverty may increase mainly among the inhabitants of small towns and villages, i.e. groups of the population which are already most at risk of poverty (17% for rural areas and 11% for small towns). This means that if modernisation measures were carried out without protective mechanisms, the observed differences between rural areas and small towns and the rest of the cities would increase, which could have negative repercussions for social cohesion.

7 The scale of implementation of the proposed solutions varies from scenario to scenario, but it does not matter for the analysis of changes in the risk of energy poverty - a change in the scale of implementation of a solution affects only the probability of implementing a given solution, while the estimation of the change in the risk of energy poverty, provided that the solution is implemented, remains the same.

Fig. 9.1. Risk of energy poverty in single-family houses according to particular characteristics



Source: IBS on the basis of KAPE projections and GUS household budget survey data.

10. Sources of financing of heat transformation

As the calculations show that Scenario 3 generates the lowest cumulative costs by 2050, the analysis of the availability of funding refers to this scenario. Investments in heat supply can be financed using instruments such as own resources, grants, credit subsidies, loans (preferential), bonds, guarantees and capital investments and investments in the Energy Service Company (ESCO) formula. The choice of financial instruments depends on the financial condition of the investor, economic parameters of the investment and the type of heat supply (heat from individual sources or district heating). Resources can be national or international, mainly from the EU and the World Bank.

Gross balance of needs for financial resources

A low emission strategy of transforming district heating requires, in all scenarios, significant financial expenditure. The demand for these measures depending on the scenario is presented in Table 10.1.

Table 10.1. Balance of gross demand for funds necessary to implement the heating transformation in buildings powered by district heating networks (SC) and individually (NSC)

Scenarios	Area	Scope of investment	CAPEX (billion PLN)	
			2019–2030	2031–2050
Scenariusz I	SC	Thermomodernisation	25	58
	SC	Heat sources	46	79
	SC	District heating network	13	23
	NSC	Thermomodernisation	60	138
	NSC	Heat sources	56	86
	Total	–	**200**	**383**
Scenariusz II	SC	Thermomodernisation	67	182
	SC	Heat sources	29	75
	SC	District heating network	14	29
	NSC	Thermomodernisation	153	297
	NSC	Heat sources	126	166
	Total	–	**389**	**749**
Scenariusz III	SC	Thermomodernisation	86	224
	SC	Heat sources	38	99
	SC	District heating network	14	33
	NSC	Thermomodernisation	166	223
	NSC	Heat sources	144	174
	Total	–	**448**	**753**
Scenariusz IV	SC	Thermomodernisation	83	218
	SC	Heat sources	57	109
	SC	District heating network	14	32
	NSC	Thermomodernisation	169	229
	NSC	Heat sources	235	308
	Total	–	**558**	**895**

Source: KAPE S.A. own study.

Financial expenditure for the implementation of heat supply transformation scenarios based on renewable energy sources emissions are high. The higher the share of renewable energy sources, i.e. lower emission of CO_2, dusts and other harmful substances, the higher the expenditure. However, significant investment returns in the form of reduced variable costs - less heat demand translates into lower fuel expenditure and, if you also take into account changing the fuel used - less external costs. Despite the much lower financial expenditure, the first scenario does not appear to be the most favourable in terms of technical, social and economic aspects, as shown in the analysis of scenarios.

Sources of funding and volume of resources needed to implement Scenario 3

Table 10.2 summarises the sources of funding and the volume of resources needed to implement Scenario 3.

Table 10.2. Sources of financing and size of funds necessary for the implementation of Scenario III (PLN billion)

No.	Title of source of funding	2019–2030	2031–2050
1.	ETS resources for heating + Modernisation Fund	18	35
2.	The new financial perspective	15	20
3.	European Investment Bank	5	0
4.	National Fund for Environmental Protection and Water Management (Clean Air programme, other funds)	123	120
5.	Budgetary grants and/or tax credits	60	200
6.	Loans	166	218
7.	Investors' own resources (e.g. household budgets, renovation funds of cooperatives and EBITDA of heating companies)	20	100
8.	Instruments to support energy efficiency (e.g. white certificates)	10	0
9.	Support for cogeneration for 15 years	15	30
10.	Resources of local and regional governments, including the Provincial Fund for Environmental Protection and Water Management	15	30
11.	Norwegian Fund	1	0
	Total	**448**	**753**

Source: KAPE S.A. own study.

Cofinancing mechanism

The mechanism of co-financing by area is shown in Table 10.3.

Table 10.3. Sources of financing and size of resources necessary to implement Scenario III

Source of financing	Buildings not connected to the network	Buildings not connected to the network	Buildings connected to the network	Buildings connected to the network	District heating companies	District heating companies
	Poor	Non-poor	Poor	Non-poor	Inefficient systems	Efficient systems
ETS for district heating					Loan	Loan
Modernization Fund					Loan	Loan
The new financial perspective			Grant	Loan + grant		
European Investment Bank					Credit	Credit
NFOŚiGW - Clean air programme	Grant 90%	Grant 30%				
NFOŚiGW - other funds outside the Clean Air programme					Loan	Loan
Budgetary grants and/or tax credits	Grant	Tax relief	Grant	Tax relief		
Kredyty		Credit		Credit	Credit	Credit
Norwegian Fund					Loan/Subsidy	Loan/Subsidy
Investors' own resources, e.g. renovation fund of housing cooperatives	Own resources	Own resources	Own resources	Own resources	Own resources	Own resources
Own resources of local and regional governments, including WFOŚIGW	Grant		Grant		Loan	Loan

Source: KAPE S.A. own study.

11. Activities

The following proposals for detailed actions are a continuation of the recommendations listed in the introduction.

1. Improvement of energy efficiency of buildings and increase in the share of renewable energy sources

1. Setting a national target for the reduction of non-renewable primary energy consumption in buildings

The analyses carried out indicate that by 2050 the reduction of non-renewable primary energy consumption in buildings should reach 80%.

This goal can be achieved as a result of thermal modernization of buildings and reduction of final energy consumption by about 56% and increasing the share of energy from RES to a minimum of 60%. A specific target should be included in strategic government documents, e.g. in the National Energy and Climate Plan 2021-2030.

2. Introduction of new requirements of the Energy Performance of Buildings Directive into the legal regulations

In order to implement the key decisions of the amended Directive on the energy performance of buildings, it is necessary to:

- review the national building stocks in order to prioritise building modernisation to include the worst energy performance buildings, buildings used by socially vulnerable groups at risk of energy poverty and buildings owned or operated by public authorities and organisations,
- define the cost-effective scope of building modernization, taking into account the type and location of buildings,
- provide support schemes and incentives for thermal modernisation,
- introduce requirements concerning energy performance, rules of selecting the size, arrangement and automatic equipment of technical building systems so as to achieve decarbonisation of Polish building resources in 2050.

3. Development of a national database identifying the technical parameters of buildings together with advisory tools.

The database would include tools for advising building owners (especially single-family houses). It would allow the monitoring of the progress of the low-carbon transition strategy.

Its structure should be in place by the end of 2020. (e.g. within the framework of the ZONE project), and by 2030 to cover all buildings in Poland.

4. Legally requiring nearly zero-energy building standards[8] for all new buildings from 2025 onwards and for all new public administration buildings (including those under construction) from 2021 onwards in the program Apartment +) after 2021.

The introduction of the net zero energy standard for all new and deeply thermomodernized buildings would make it possible to achieve decarbonization of the heating area in the perspective of 2050. Such a change could be incorporated into the regulation of the minister in charge of construction on technical conditions to be met by buildings and their location.

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8 The nearly zero-energy building defined in the Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings is: „a building that has a very high energy performance, as determined in accordance with Annex I. The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby;”.
A building with low energy consumption, defined in the National Plan to increase the number of buildings with low consumption, is a building that meets the requirements related to energy saving and thermal insulation included in the technical and building regulations. Certain technical conditions have been in force since 1 January 2021, and for buildings occupied by the authorities public and owned by them as from 1 January 2019.

5. **Change of the energy audit procedure.**

   In the ordinance of the minister in charge of construction on the methodology of energy audit it is necessary to change the criteria and optimisation algorithm in the audit procedure. This procedure should be based on multi-criteria methods, and one of them should be to minimize the external costs of heat supply to the building and any costs over the life cycle of the building, rather than minimising a simple payback period. The introduction of external cost analysis has a significant impact on the choice of thermomodernization technology and enables the parameters of deep thermomodernization to be achieved..

6. **Promotion and support of deep thermomodernization of buildings.**

   The National Centre for Research and Development should launch research programmes to implement the new insulation technologies for building envelope, window, ventilation and heating systems. It is also necessary to conduct information campaigns on the effects of deep thermal modernisation.

2. Replacement of coal-fired heat sources in households (and chimney height installations up to 40 m) from sources using other primary energy sources.

1. **Strengthening of educational activities and shaping of social attitudes**

   Continuation by the National Fund for Environmental Protection and Water Management (NFOŚiGW) of long-term projects programmes within which it will be possible to finance educational projects on the negative effects of smog on health and its prevention.

2. **Targeting of investment activities.**
   - Creation of a register of buildings in Poland in the perspective of 2020, together with information on sources of energy supply to facilitate the development of energy supply plans, taking into account environmental perspective.
   - Appointment of a group of certified energy advisors operating in municipalities.
   - Restrictions (by 2022) of construction permits for individual buildings heated with solid fuels, if these can be connected to the district heating or gas network.
   - Making it compulsory to connect existing buildings to the district heating or gas network, provided that there is technical capacity and socio-economic benefit.

3. **Heat electrification.**
   - Facilitating the use of electricity for heating purposes through a system of dedicated tariffs.
   - Implementation of mechanisms supporting the use of heat pumps powered from the power grid, as well as domestic photovoltaic installations.
   - Developing a concept for integrating heating with the power sector (sector coupling) in order to reduce the cost of heating by means of electricity.

4. **Development of small heating systems using waste energy and RES.**
   - Establishment of municipal or district heating clusters based on existing small heating enterprises.
   - Developing in rural areas the idea of energy cooperatives as an effective form of mobilization of local community activity and optimization of costs of heat and electricity production.
   - Supporting the local use of biomass and biodegradable waste primarily in small heat plants and cogeneration units (excluding large power generation units).

- Strengthening the process of transforming small heating systems into efficient ones (as defined by law).
- Creating mechanisms and incentives for „heating" of power plants, i.e. wider use of waste heat from electricity generation and industry.

5. **The implementation of effective economic incentives.**
   - Focusing the Modernization Fund on activities related to heating.
   - Giving priority to financing the modernisation of heating from the new financial perspective of the EU after the 2020 r.
   - Financing thermomodernization activities under the Clean Air Programme, the Thermomodernization Act, own funds of investors benefiting from a dedicated income tax relief.
   - Financing investments in the energy cluster from the programmes of the National Fund for Environmental Protection and Water Management (NFOŚiGW), Voivodship Fund for Environmental Protection and Water Management (WFOŚiGW) and EU and EEA funds.
   - Financing investments in heating companies from the energy efficiency and low-emission economy development fund established in the National Fund for Environmental Protection and Water Management (NFOŚIGW) as part of the amendment to the Energy Efficiency Act.
   - The gradual introduction, from 2022 onwards,, of an environmental tax on fuel for heating depending on the type of fuel sold to households.

6. **Control of compliance with existing legislation.**
   - During a transitional period, until coal is fully replaced by other energy sources, the effective quality control of solid fuels and heating appliances using them should be ensured..
   - Improvement of the process of control of air pollution emission sources in order to reduce pollution.
   - Revision of the quality standards for solid fuels for heating installations by type of fuels, their parameters and emission levels.

3. Implementation of protective programmes dedicated to sensitive groups

1. **Co-financing of the purchase of energy carriers for energy-poor households that use clean energy sources.**

   It can be redeemed for example in the form of an energy voucher intended only for payment of bills for district heating, gas or electricity (a similar solution exists in France). It should be implemented by the social welfare system and be linked to the reform of existing energy allowances.

2. **Establishment of a targeted energy poverty allowance, granted as part of social assistance during the heating season and depending on the condition of the building, size and type of heating, irrespective of the number of persons in the household.**

   The allowance should be granted primarily to poor people whose homes are not suitable for thermo-modernisation and who live in dense human settlements. This allowance should replace the current special purpose heating allowance.

3. **Enabling energy and income poor households, especially those located in dense human settlements, to obtain public funding without own contribution necessary to undertake thermomodernization activities under the Clean Air Programme.**

4. **Creation of a network of advisors working in the municipalities and offering information on minor energy improvements and thermal modernisation to energy-poor households.**

5. **Creating a post for a person dealing with the problem of energy poverty in social welfare centres.**

6. **Identifying social groups falling within the definition of energy and income poor groups**

   Deeper and updated knowledge about social groups requiring different forms of support is necessary to create dedicated support programmes and to optimise the cost of public aid.

4. Development of district heating systems

1. **Modification of the methodology and the standards for the development of energy plans.**

   - A new energy planning standard should be introduced. It should combine the plans for the supply of heat, electricity and gas fuels, low-emission economy plans and low emission reduction plans. It should move towards the adoption of a national sustainable system energy management involving all levels of government.
   - Computer-aided development of assumptions and plans for the supply of heat, electricity and gas fuels in small municipalities should be started. Many of these municipalities, due to the lack of their own professionals and the lack of funds to hire external consulting companies, do not implement the assumptions for these plans. In order to help them, the National Centre for Research and Development should launch a competition for an IT expert system for computer-aided development of these plans. The expert system should be hosted on a government server and be made available to municipalities free of charge.

2. **Increasing the planning and decision-making role of local authorities in the implementation of heat supply policy.**

   It is necessary to amend the provisions of the Energy Law to increase the decision-making role and responsibilities of local authorities, that should:

   - create a heat supply plan (not just a draft of the assumptions for the heat supply plan);
   - decide on the choice of heat source for new and modernised buildings. The above change is necessary to increase the efficiency of the process of modernization of the entire supply area.

3. **Undertaking legal regulations related to investments in heating infrastructure.**

   The legal status of the areas in which the power line infrastructure is operated, including district heating networks, is not sufficiently regulated. The connection of new residential areas or even new single buildings often requires the network to pass through many (even several hundred) properties belonging to different owners. The problem of obtaining approvals and the issue of compensation for the use of property should be regulated. It is necessary to adopt the Act on Transmission Corridors, which will introduce an algorithm for determining the amount of compensation depending on from the type of network and the area through which it runs.

4. **Introduction of an obligation to connect new and thermomodernized buildings to energy-efficient district heating networks.**

   The Construction Law Act should introduce a provision obliging investors to connect new and thermomodernized buildings to the energy-efficient district heating network, if there are technical conditions to do so. This obligation should be preceded by a local analysis of the economic efficiency of the investment throughout the life cycle of buildings, taking into account the external costs of the considered energy technologies. Net zero energy buildings would be excluded from this condition.

5. **Change of the regulation model in heating and implementation of support mechanisms.**
    - Implement tariffs to enable energy services to be offered. The objective of regulatory policy should not be to be an absolute aspiration to minimize the price of a heat unit. We need to introduce a criterion minimizing costs, but at the same time achieving specific technological standards of quality and reliability of supply as well as meeting specific environmental requirements.
    - Ensure the development of small cogeneration units, including in particular those using biogas, or biomass by reducing the risk of an increase in the cost of fuel.
    - Establish an obligation to recover waste energy from industrial processes and waste management if it is economically justifiable.
    - Implement support mechanisms for heat produced in RES installations and directed to the heating systems (especially to those classified as inefficient).

5. Implementation of effective mechanisms for financing the modernization of heating

1. **Establishment of an obligation to quantify the external cost associated with the selection of the heat source.**

    A standard method for assessing the external cost of different groups of heat production units should be developed and made mandatory for obtaining building permission. As a result of the analysis of alternative technical solutions, local authorities should give their consent to a project with better socio-economic evaluation parameters.

2. **Mobilisation of resources from the Modernisation Fund**

    The Modernization Fund may be an important source of financing the heat transformation. Poland will be receiving 2-5 billion euros from it. The heating sector will have to share these funds with the power sector. In the heating sector, low-interest loans should be used to modernise heat sources (in order to use RES) and development and modernization of network infrastructure. They should also be closing a financial gap and support integrated projects and be linked to other support mechanisms forseen in the energy policy of the state.

3. **Obtaining EU funding for heating.**

    In order to obtain EU funding for heating, appropriate measures and priorities need to be put in place:

    - in the Infrastructure and Environment Operational Programme 2021-2027,
    - in regional operational programmes for the period 2021-2027,
    - in the Intelligent Development Operational Programme 2021-2027.

4. **Establishment of the Energy Efficiency and Low-Emission Economy Development Fund, which would be established pursuant to Article 20 of the Energy Efficiency Directive and would be located in the National Fund for Environmental Protection and Water Management (NFOŚiGW).**

    The fund would be funded from:

    - substitution fees from the white certificates system,
    - revenues (25%) from the emissions trading scheme in the ETS sector,
    - tax on retail sales of fossil fuels.

    The financial resources gathered in this fund would be allocated to:

    - thermo-modernisation programmes,
    - modernisation and replacement of heat sources,
    - RES use,

- modernisation and expansion of heat distribution networks including heat sources,
- environmental education,
- purchase of liabilities of the beneficiaries towards energy service companies (ESCOs),
- providing guarantees for loans for energy efficiency investments in households and small and medium-sized enterprises of entities.

Support would be provided in the form of low-interest loans or grants to any entity, excluding individuals.

5. **Support of the process of transformation of inefficient heating systems into energy efficient ones.**

   It is necessary to strengthen the financial capacity of small heating companies (PEC) and facilitate their access to funding to support investments in RES and CHP in heating, for example by setting up a dedicated loan guarantee fund. It is also necessary to set up a system of technical assistance for the preparation of such projects, for example using the ELENA (European Local Energy Assistance) mechanism.

6. **Creation of a fund to cover the liabilities of beneficiaries towards energy service companies**

   ESCOs have limited investment funds from equity or external sources. Due to the spread of payments for completed projects over many years, companies face a financial barrier hindering the implementation of further projects. In order to increase their effectiveness, it is necessary to establish a fund that would purchase financial liabilities of their beneficiaries (e.g. under the Energy Efficiency and Low-Emission Economy Development Fund).

7. **Facilitating owners of single-family houses' access to funds earmarked for thermomodernization of buildings.**

   It is necessary to support the process of preparing the documentation required to apply for co-financing for thermal modernisation (energy audits, technical projects, etc.). It seems appropriate to separate in WFOŚiGW the financial resources which would be allocated to the co-financed energy audits, regardless of whether the investor intends to apply for co-financing of the investment or to finance it from his own resources in order to obtain income tax relief. The amount of co-financing should be about 50% of the market price of an energy audit or/and a technical project for thermal modernization. Preference should be given to group proposals for co-financing submitted by low emission investors. The subsidy should then amount to approximately 75% of the market price of the energy audit or the technical design of the thermomodernization. The Energy Efficiency and Low-Emissions Economy Development Fund would be used to secure a loan or credit for energy efficiency investments and to provide legal advice on the ownership problems of detached houses.

8. **Establishment of programmes within the framework of the European Economic Area (EEA)**

   In 2012-2018, within the framework of programmes from the European Economic Area (Swiss Programme and Norwegian funds), it was possible to finance such projects as the exchange of collective heat substations to individual building heat substations or the use of geothermal energy in heating in health resorts. It is advisable to continue financing the transformation of heating from Norwegian and Swiss funds, in particular projects related to the development of smart heating networks, transformation of existing heating systems into fourth generation systems, wind-to-heat technology, or construction of seasonal heat storage facilities, etc.

9. **Launch or continuation of national financial support schemes.**

   Financial support programmes for heating should be maintained in the National Fund for Environmental Protection and Water Management. As in the case of energy efficiency and smog prevention, the new Energy Efficiency and Low-Emission Economy Development Fund should provide financial support in the form of low-interest loans (partially amortizable) for investments in energy-efficient heating. The regulations of this fund should envisage that a minimum of 20% of annual resources to support investments must be allocated to investments in RES and cogeneration in heating.

6. Implementation of educational programmes

1. Conducting a social campaign on negative environmental and health effects of burning waste and low quality fuels.
2. Incorporating into physics programs in primary and secondary schools the content on how to choose heat sources at home.
3. Change the appearance of the energy performance certificate of the building so that it is easily understood
4. Establishment by the National Fund for Environmental Protection and Water Management of long-term programmes enabling financing of educational projects on the need to increase energy efficiency and the use of RES.
5. Continuous education of various professional groups, e.g. architects or designers in the construction industry.
6. Launching the process of certification of installers and contractors of construction works in terms of energy efficiency and renewable energy sources.

12. Summary

- Scenarios of heat modernization combined with thermal modernization of buildings allow to reduce the annual cost of heat supply below the level of the reference scenario. Around 2033, after the end of the modernization investment period, there is a clear decrease in heating expenses. The third, most cost effective, scenario of modernization of heating allows for a 15% reduction of aggregate heating costs in Poland by 2050, compared to the reference scenario. In addition to economic benefits, environmental and climate benefits are also achieved by reducing dust and gas emissions. An additional advantage is the reduction of Poland's dependence on imports of resources - thanks to the decrease of annual coal imports by 20 million tonnes and gas imports by 1 billion m^3 in 2050 (compared to the reference scenario).
- Achievement of the objectives set out in the strategy for heating in the area of CO2 emission reduction, decrease in the consumption of non-renewable primary energy and increase in the share of energy from RES requires, in the third scenario, spending about PLN 448 billion by 2030. The cost of thermal modernization of buildings is estimated at PLN 252 billion. The exchange of heat sources and the development of district heating networks represent an expense of approximately PLN 196 billion. The analysis of potential sources of financing showed that in Poland there will be funds to cover the required expenditures. Some of them should be addressed to society (investors) in the form of low-interest loans and grants. This will allow to break the investment barrier, which today is the lack of profitability of modernisation projects, which is a consequence of the distorted market relationship between the cost of heating and high expenditures on thermomodernization investments and exchange of heat sources. The level of necessary investment support amounts to approximately PLN 138 billion.
- The inclusion of an external cost in the cost of heat generation will create market incentives to encourage the use of heating technologies with a low environmental and health impact. Extension of the „polluter pays" principle to the whole heating area (district heating and individual), by making the cost of heat generation realistic and improving the profitability of modernisation projects will reduce the level of necessary investment support. The goal is to develop and implement a methodology to assess the profitability of heating projects, including their external costs.
- Modernisation of heating combined with thermal modernisation of buildings is inseparably connected with an increase in the unit cost of heat generation. This is the result of investment expenditures incurred and higher variable costs per reduced (as a result of thermomodernization) heat stream. Regulatory policy should therefore move away from the principle of minimising the price of heat to the principle of keeping the cost of domestic heating at a fixed level. Maintaining the principle of heat price minimization for the end user may become a brake on the process of heat transformation.
- It is possible to achieve an 80% reduction in the consumption of non-renewable primary energy in buildings by 2050, if a dedicated programme for the thermal modernisation of buildings is implemented. The analyses carried out indicate that an optimal thermo-modernisation programme may lead to reduce final energy consumption by approximately 56%. Further reduction of non-renewable primary energy consumption can be achieved by increasing the share of RES in heating to at least 60% in 2050. The current pace of thermal modernization of buildings in Poland is insufficient, to make a significant contribution to the objectives of energy and climate policy and to the improvement of the air quality.
- The implementation of the thermomodernization programme (without modernization of heat sources) will allow to reduce the consumption of coal and gas by 2050 by 7.2 million tonnes and 1.7 billion m^3, respectively, in relation to the consumption of these fuels in 2016. This means, as a consequence, an annual reduction of dust emission by 50 thousand tonnes (34%) and CO2 by 21 million tonnes (30%). Low emissions will be strongly reduced, air quality will improve and negative impacts on the climate will be reduced. Additionally, thanks to the thermomodernization, the total annual heating cost, including the external cost, in 2050 will be lower by PLN 28 billion than in the option without thermomodernization (PLN 57 billion in 2050 instead of PLN 85 billion).

- A multiannual strategy for thermal modernisation of buildings should be developed in view of the importance of this process for the final effects of the heat transformation. The strategy should include priorities, a roadmap and measurable targets to be achieved by 2030 and 2050, as well as an analysis of potential sources and funding mechanisms. Without thermomodernization, it will not be possible to reduce the cost of heating for households, especially when using better quality fuels.
- The condition for air quality improvement in Poland is the implementation of modernisation programmes in buildings which use individual heating sources, which are responsible for 90% of gas and dust emissions from the entire heating sector. One of the most important steps is the replacement of coal with alternative sources of primary energy. In this way, annual dust emission may be reduced by 120 thousand tons and SOx by 141 thousand tonnes until 2030. Coal consumption will fall by 11-12 million tonnes per year.
- When planning a strategy for heating, it is necessary to look at the whole value chain and seek synergies with other sectors of the economy. Modernisation of heating can be a strong stimulus to boost domestic industry, create new jobs and encourage the use of local resources. Modern heating also allows to increase the share of RES in the national power system, for example thanks to the technologies of heat generation from electricity, energy accumulation technologies and the possibility of quick reaction of heat generating devices to the volatility of wholesale electricity prices (caused by temporary changes in supply and demand). The service of balancing the domestic power system by heating may constitute an additional source of revenue allowing for the reduction of the heat price.
- The success of the heat transformation process depends to a large extent on the proper diagnosis of energy poverty and addressing the problem. The size of this group of society and its needs should be assessed and dedicated investment and operational support programmes should be developed.

Notes

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Clean heat 2030.
Strategy for heating

FORUM ENERGII, ul. Chopina 5A/20, 00-559 Warszawa

NIP: 7010592388, KRS: 0000625996, REGON:364867487

www.forum-energii.eu