Ministry of Energy

National Energy Efficiency Action Plan for Poland 2017

Warsaw, December 2017

INTRODUCTION

The National Energy Efficiency Action Plan, hereinafter referred to as the "National Action Plan", has been prepared pursuant to Article 4 of the Act of 20 April 2016 *on energy efficiency* (Journal of Laws, item 831). In accordance with Article 24(2) and Annex XIV to Directive 2012/27/EU of the European Parliament and of the Council of 25 October 2012 *on energy efficiency* (OJ L 315, 14.11.2012, p. 1, as amended), hereinafter referred to as "Directive 2012/27/EU", Member States are required to submit to the European Commission National Action Plans, including information on energy efficiency improvement measures already adopted or to be adopted.

The National Action Plan includes a description of energy efficiency improvement measures by end-use sectors and calculations related to final energy savings realised in 2008-2015, as required by Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 *on energy end-use efficiency and energy services* (OJ L 114, 27.04.2006, p. 64, as amended) and expected to be realised in 2020 in connection with the implementation of Directive 2012/27/EU. This document has been prepared by the Ministry of Energy with input from the Ministry of Infrastructure and Construction and the Central Statistical Office (GUS) [1)].

The Minister of Infrastructure and Development is responsible for reporting as regards Directive 2010/31/EC of the European Parliament and of the Council of 19 May 2010 *on the energy performance of buildings* (OJ L 153, 18.06.2010, p. 13), and pursuant to Articles 4 and 5 of Directive 2012/27/EU, for reporting on the strategy for the refurbishment of buildings and the exemplary role of public bodies' buildings in this respect.

The energy savings calculations are based on data provided by GUS and Eurostat and information obtained from the "ODYSSEE-MURE 2015" project, which has been implemented under the EU programme Horizon 2020.

[1)] This document uses statistical information and data from the publication of the Central Statistical Office entitled *Energy Efficiency in 2005-2015* (Efektywność wykorzystania energii w latach 2005-2015), Warsaw 2017.

Contents

1. Introduction

The National Action Plan includes an updated description of:

- the energy efficiency improvement measures which provide for actions towards improving energy efficiency across the sectors of the Polish economy adopted in connection with the pursuit of the national energy efficiency target for 2016;
- additional measures intended to contribute to the overall energy efficiency target understood as arriving at 20% primary energy consumption savings in the European Union by 2020.

The First National Energy Efficiency Action Plan was prepared and forwarded to the European Commission in 2007. The document presented a calculation of the national energy efficiency target for 2016. The target requires achieving by 2016 final energy savings of at least 9% of the nationwide average annual consumption (i.e. final energy savings of 4.59 Mtoe[2] by 2016).

The Second National Energy Efficiency Action Plan for Poland 2011 presents information on the progress made in the pursuit of the national energy efficiency target and on measures taken in order to remove obstacles to the achievement of the target. The document was adopted by the Polish Council of Ministers in April 2012 and forwarded to the European Commission.

The Third National Energy Efficiency Action Plan for Poland 2014, which was the first plan prepared in line with Directive 2012/27/EU, was approved by the Council of Ministers in April 2014, following which it was forwarded to the European Commission. It laid down, inter alia, energy efficiency measures for buildings, public bodies, industry, small and medium-sized enterprises, transport, and measures regarding the efficiency of energy generation and supply. The document also specified the national energy efficiency targets for 2020.

This National Action Plan is the fourth national plan. It provides for the continuation of the measures taken in accordance with Directive 2006/32/EC and additional policy measures introduced as a result of the implementation of Directive 2012/27/EU. Therefore this document relies on information and data on energy efficiency improvement measures included in the previous national plans.

This National Action Plan is based on the following assumptions:

- the policy oriented to increasing energy efficiency of the economy will be continued with a view to reducing its energy intensity;
- the measures envisaged by the Plan will be market-based to the maximum extent, and will rely on funding from the state budget to the minimum extent;

[2] Mtoe – million tonnes of oil equivalent, 1Mtoe = 11 630 GWh

- the targets will be achieved following the minimum cost principle, that is by maximising the use of existing mechanisms and organisational infrastructure;
- the national potential for improving energy efficiency will be exploited.

The final energy savings achieved by 2016 are estimated in two ways. On the basis of national statistics and assessment models, the total final energy savings are calculated for the national economy as a whole and by end-use sectors (top-down method)[3]. In addition, final energy savings are determined for selected measures using the bottom-up method[4]. The latter method permits demonstrating the direct relationship between the implementation of these measures and the State's energy policy. Measures monitored by the bottom-up method represent a significant share of the total final energy savings, which – as it must be stressed – exceeds the 30% share of energy savings calculated by the bottom-up method in total savings, as required by Directive 2006/32/WE. The results obtained are presented in section 2.3, which presents final energy savings by end-use sectors. Energy savings realised by 2015 and savings expected to be achieved by the end of 2016 are indicated (*top-down* and *bottom-up*).

The national context of energy efficiency

Poland actively participates in the shaping of the Community energy policy and in legislative work in the area of energy efficiency, taking into consideration the national context, the need to protect consumer interests, its energy resources, and the technological conditions of energy generation, transmission and distribution**.**

Poland overachieved its national energy efficiency target understood as realising by 2016 final energy savings of at least 9% of the average inland consumption of such energy in 2001-2005. Poland has seen a steady decrease in the energy intensity, and 2010 was the only year when energy intensity showed an upward trend. **The decreasing primary and final energy intensity is attributable to the** fact that Polish GDP has been growing faster than the rate of energy consumption. **In 2006-2015, the average annual rate of improvement in energy intensity exceeded 3%.** When adjusted for climate conditions, the rate was slightly lower.

[3] The top-down method (from general concept to details) relies on aggregated data, and therefore it is referred to as a method of "energy performance indicators".It can be used to determine correct indicators of how the situation develops, but it does not produce precise energy savings calculations exactly because of its indicative nature.

[4] The bottom-up method (from details to general concept) is a more precise way of calculating energy savings gained as a result of improved energy efficiency.First, energy consumption is calculated for an individual energy efficiency improvement measure over a specified period of time before the implementation of the energy efficiency improvement measure, which provides "reference values". Then, the thus obtained consumption level is compared with the consumption of energy determined for a time period of the same length, but following the implementation of the energy efficiency measure. The difference between the two results measures the improvement in energy efficiency.

The years 2005-2015 saw an increase in the share of the transport and service sectors in the final energy consumption, and a drop in the share of industry, households and agriculture. The share of transport grew from 22% to 28%, and that of services from 12% to 13%. Households remained the largest consumer despite a drop in their share from 35% to 31%. The share of industry declined from 26% to 24%, and that of agriculture from 8% to 5%. The above changes reflect the prevailing trends in the development of the Polish economy (e.g. rising foreign trade), as well as measures taken by the industrial sector (rationalisation of energy consumption in response to growing prices of energy carriers). The most noticeable change was observed in the transport sector, where the increased demand for energy resulted from a high growth in the volumes of both goods transport (as a result of growth in economic activity) and passenger transport (increased prosperity of the population and growing saturation of the passenger car market). The gap between Poland and the European average as regards the key energy performance indicators has decreased to a dozen or so percent, but the most efficient economies remain well ahead.

The most important financial instruments supporting the delivery of energy efficient investments in Poland include programmes implemented by the National Fund for Environmental Protection and Water Management (NFOŚiGW) and Regional Environmental Protection Funds, funds of the Operational Programme Infrastructure and Environment (OPI&E), Regional Operational Programmes (ROPs), as well as BOŚ Bank, and the Thermomodernisation and Repairs Fund. The programmes are described in detail in section 3 and Annex No 3 (buildings).

Since 2010, the "Polish Energy Policy until 2030" has been implemented in Poland. As a result of the implementation of the measures set out in this document, Poland has significantly improved its energy efficiency, and thus also the energy security of the state. Ensuring stable energy supplies for the economy at an economically acceptable price and increasing the efficiency of energy use by enterprises, the public sector, and households is one of the key development challenges for Poland in the coming years. Improving energy efficiency will continue to be one of the priorities of the national energy policy. Activities in this respect will focus on limiting the energy intensity of the economy, which means investments in enterprises, in the district heating sector, and the end use of energy (thermomodernisation in the construction sector, fuel efficiency in transport, and rational use of energy by final consumers). With regard to enterprises, the focus will be on reducing the losses of electricity, heat and warm service water. The development of competitive fuel and energy markets will also contribute to improving energy efficiency.

2. Review of national energy efficiency targets and of realised energy savings

2.1. National energy efficiency targets for 2020

Pursuant to Article 3(1) of Directive 2012/27/EU, Poland has set its national energy efficiency target for 2020. It is defined as reducing primary energy consumption in the years 2010-2020 by 13.6 Mtoe, which will ultimately also translate into increased energy efficiency of the national economy.

In addition, the above target has been expressed in terms of the absolute level of primary and final energy consumption in 2020. The energy efficiency target for 2020 has been calculated on the basis of data produced by analyses and forecasts conducted for the government's document entitled "Poland's Energy Policy until 2030". The above analyses indicate that reducing primary energy consumption is possible thanks to the effects of already implemented projects, as well as the delivery of other measures planned with a view to improving energy efficiency.

Table 1 below presents a summary of energy efficiency targets for 2020.

Table 1. Energy efficiency targets for 2020 – pursuant to Directive 2012/27/EU

	Energy efficiency target	Absolute energy consumption in 2020	
	Reduction of primary energy consumption in 2010-2020 [Mtoe]	Absolute final energy consumption [Mtoe]	Absolute primary energy consumption [Mtoe]
2020	**13.6**	**71.6**	**96.4**[5]

[5]) In accordance with the reference values for Poland included in a forecast prepared for the European Commission (PRIMES - Baseline 2007), the primary energy consumption is expected to amount to 110 Mtoe in 2020. With the reduction in energy consumption of 13.6 Mtoe, the following result is obtained: 110 Mtoe – 13.6 Mtoe = 96.4 Mtoe.

2.2. Primary energy savings

The obligation to provide general information about primary energy savings applies to energy efficiency measures put in place in order to implement Directive 2012/27/EU. This document calculates the primary energy savings obtained by the end of 2015 and estimates the primary energy savings expected to be achieved at the end of 2016 and 2020 (forecast).

The calculations are based on an approach whereby energy savings are measured for the adopted energy efficiency improvement measures described in section 3 and Annex No 3 (buildings). No harmonised method for calculating primary energy savings is available.

Detailed data on primary energy savings achieved and forecast is presented in Table 2.

Table 2. Overview of primary energy savings

Primary energy savings	2015 [Mtoe]	2016 [Mtoe] – forecast	2020 [Mtoe] – forecast
Public bodies	0.38	0.60	1.01
Housing	0.94	1.02	1.30
Industry	2.70	3.07	4.50
Transport	1.27	1.65	4.90
Information campaigns	0.08	0.12	0.26
Total	**5.37**	**6.46**	**11.97**

The primary energy savings have been estimated by means of a bottom-up method based on the calculation methodology presented in subsection 2.2.1.

The primary energy savings are calculated by the following sectors: public bodies, the housing sector, industry and transport. Primary energy savings generated as a result of information campaigns are also presented.

By the end of 2015, the industry sector generated the greatest primary energy savings. As is shown by the forecast of energy savings at the end of 2016, energy savings in the transport sector are bound to increase significantly from this year onwards. Information campaigns have the lowest share in energy savings.

2.2.1. Primary and final energy savings calculations using the bottom-up method

A detailed bottom-up methodology for the calculation of final and primary energy savings is applied to each of the energy efficiency improvement measures described in section 3 and Annex No 3 (buildings). For the energy efficiency improvement measures adopted, the energy savings have been identified on the basis of available data sources and expertise. A table presenting the calculation algorithms applied is included in Part II of Annex No 2 to this document (Table 15).

The data sources and calculation methodology used are summarised below:

- for the energy efficiency improvement measures where only information on the reduction of CO_2 emissions is available, CO_2 emissions are converted into MWh by means of an emission benchmark. In this way, the final energy savings are obtained,
- use is made of data on realised energy savings published in the report entitled "Summary of the effects of the implementation of energy sector projects under Priorities IX-X of OPI&E 2007-2013" (Podsumowanie efektów wdrażania projektów w sektorze energetyki priorytetów IX-X POIiŚ 2007-2013),
- energy savings under programmes delivered by NFOŚiGW are calculated on the basis of the indicators for achieving the objectives of the priority programmes, which are available, inter alia, on the website www.nfosigw.gov.pl (for some programmes it was necessary to estimate energy saving on the basis of amounts of co-funding by dividing them by a conversion ratio of PLN 3721.76/1 Mg of CO_2, and then multiplying the result by a primary energy savings benchmark for emissions of 12.00426 MWh/Mg CO_2,
- for some energy efficiency improvement measures, use is made of data included in the previous National Action Plan,
- the final energy savings generated by programmes of the Thermomodernisation and Repairs Fund are calculated on the basis of the number of thermomodernisation bonuses awarded, which is multiplied by the average annual energy savings per one thermomodernisation bonus, which is equal to 0.195 GWh[6],
- energy savings are always generated in the first full year after the completion of an investment,
- energy savings produced by individual energy efficiency improvement measures accumulate over time, which means that, for example, energy savings in 2016 include energy savings from 2015 plus those produced by new activities completed in 2016.

Table 3 presents data on primary and final energy savings in 2016 and a forecast for the end of 2020 calculated by the bottom-up method (final energy savings calculated with the top-down method are presented in section 2.3).

Table 3. Overview of primary and final energy savings calculated by the bottom-up method

	Primary energy savings [Mtoe]	Final energy savings [Mtoe]
2016	6.46	4.10

[6] Value adopted on the basis of energy audits database verified by KAPE S.A.

2020 – forecast	11.97	7.51

A vast majority of the energy efficiency improvement measures identified produce final energy savings. Consequently, it was necessary to recalculate (convert) final energy savings into primary energy savings.

Final energy savings were converted into primary energy savings by dividing the amounts of energy saved, as presented in an aggregated form in table 15 in Annex No 2 by the conversion factors included in table 4. The value of the conversion factor depends on the energy carrier relevant for the respective measure (programme).

For programmes comprising several industries, the average conversion factor for the economy was applied (see table 4).

Table 4. Final/primary energy conversion factors

	Conversion factor
District heating	0.830[7)]
Electricity	0.330[8)]
Transport	0.350[9)]
Average for the economy	0.627[10)]

[7)] Regulation of the Minister of Economy of 4 September 2012 on the method for calculating the amount of primary energy corresponding to the value of an energy efficiency certificate and on the level of the unit compensation fee (Journal of Laws item 1039).

[8)] As provided for by the Regulation, see above.

[9)] The efficiency is based on the conversion of primary energy into usable energy (vehicle diesel engine efficiency), in accordance with W. Salejda et al., *Termodynamika*, Politechnika Wrocławska, Wrocław 2001.

[10)] Calculations based on a GUS study entitled "Energy Efficiency 2004-2014, Warsaw 2016.

2.3. Final energy savings

Table 5 presents an overview of the realisation of the final energy savings target calculated in accordance with Directive 2006/32/EC *on energy end-use efficiency and energy services*, which is to obtain by 2016 energy savings amounting to **9% of the 2001-2005 inland average final energy consumption**.

As the overview demonstrates, both the amounts of the final energy savings realised and planned are greater than the calculated target.

Table 5. Overview of final energy savings targets realisation

	Final energy savings target		**Final energy savings realised in 2010 and planned to be achieved in 2016 (top-down)**	
	In absolute values [Mtoe]	As a percentage of average consumption in 2001-2005	In absolute values [Mtoe]	As a percentage of average consumption in 2001-2005
2010	1.02	2%	4.81	9%
2016	**4.59**	9%	10.20	20%

2.3.1. Top-down calculations of final energy savings

Below are presented final energy savings calculated using the top-down model, according to the methodology published by the European Commission in its *Recommendations on measurement and verification methods in the framework of Directive 2006/32/EC on energy end-use efficiency and energy services*. According to the document, 2007 was adopted as the base year. On the basis of analysis of data available, the indicators which can be employed to calculate final energy savings were determined for the individual sectors of the economy, as shown in table 6. The preferred indicators are marked with the letter P, and the minimum indicators with the letter M.

Table 6. Indicators used to calculate final energy savings

No.	**Sector of the economy**	**Indicator**
1.	Households	P1
2.	Services	M3, M4
3.	Transport	P8, P9
4.	Industry	P14

The individual indicators and their calculations are described in Annex No 2 to the National Action Plan. On the basis of the indicators calculated, the final energy savings in the different sectors and subsectors of the Polish Classification of Activity (PKD) were determined as the difference between these indicators, as required by the above recommendations of the European Commission.

The calculations were made on the basis of data published by GUS and Eurostat, and information from the ODYSSEE-MURE 2015 project, which has been implemented under the EU programme Horizon 2020. For the last several years, GUS and Krajowa Agencja Poszanowania Energii S.A. (KAPE) have participated in a series of projects aimed at assessing energy efficiency and describing energy efficiency improvement measures put in place ("Monitoring of European Union and national energy efficiency targets" or ODYSSEE – MURE 2015). The following are built and developed under the project: the ODYSSEE[11)] and MURE[12)] databases, which contain information concerning energy efficiency indicators and energy efficiency improvement measures.

3. Energy efficiency improvement measures

This part describes the key energy efficiency improvement measures which have already been adopted or are to be adopted, and the energy savings achieved as a result of the implementation of these measures. The energy savings resulting from the application of energy end-use measures were calculated using the bottom-up method. After conducting an analysis of the programmes and energy efficiency improvement measures already in place, priority measures were selected for the needs of the National Action Plan, and new measures were introduced with a view to ensuring that the energy efficiency targets for 2020 are achieved.

As a result, the following energy efficiency improvement measures were defined:

1. Horizontal measures:

1) Energy efficiency obligation scheme (white certificates);
2) Operational Programme Infrastructure and Environment 2014-2020 (Measure 1.3.3 – Nationwide system of advisory support in the field of energy efficiency and RES for the public, housing and enterprise sectors);
3) Information and educational campaigns.

2. Energy efficiency measures for buildings and public bodies:

11) www.odyssee-indicators.org
12) http://www.odyssee-mure.eu

1) PL04 Operational Programme – "Saving energy and promoting renewable energy sources" under the EEA Financial Mechanism in 2009-2014;
2) Green Investment Scheme – GIS. Part 5 – Energy management in buildings of selected public finance sector entities;
3) Green Investment Scheme – GIS. Part 6 – SOWA – Energy Efficient Street Lighting;
4) Operational Programme Infrastructure and Environment 2014-2020 (Measure 1.3.1 – Supporting energy efficiency in public buildings);
5) Operational Programme Infrastructure and Environment 2014-2020 (Measure 1.3.2 – Supporting energy efficiency in the housing sector);
6) Operational Programme Infrastructure and Environment 2014-2020 (Measure 1.7.1 – Supporting energy efficiency in residential buildings of the Śląskie Province);
7) Regional Operational Programmes for 2014-2020.

3. Energy efficiency measures in industry and SMEs:

1) Support for entrepreneurs as regards low-emission and resource-efficient economy. Part 1 – Energy/electricity audit of enterprises;
2) Support for entrepreneurs as regards low-emission and resource-efficient economy. Part 2 – Improving energy efficiency;
3) Financial facility for SMEs (PolSEFF);
4) Operational Programme Infrastructure and Environment 2007-2013 (Measure 9.1) – High efficiency energy generation;
5) Operational Programme Infrastructure and Environment 2007-2013 (Measure 9.2) – Efficient energy distribution;
6) Improving energy efficiency. Part 3 – Energy efficient investments in small and medium-sized enterprises;
7) Operational Programme Infrastructure and Environment 2014-2020 (Measure 1.2) – Promoting energy efficiency and use of renewable energy sources in enterprises;
8) Supporting projects related to low-emission and resource-efficient economy. Part 4 – Energy efficiency in enterprises.
9) Regional Operational Programmes for 2014-2020.

4. Energy efficiency measures in transport:

1) Operational Programme Infrastructure and Environment 2007-2013 (Measure 7.3) – Urban transport in metropolitan areas and (Measure 8.3) – Development of intelligent transport systems;
2) Green Investment Scheme – GIS. Part 7 – GAZELA – Low-emission urban transport;

3) Green Investment Scheme – GIS. Part 2 – GEPARD – Zero-emission public transport;
4) Operational Programme Infrastructure and Environment 2014-2020 (Measure 6.1 – Developing public transport in cities);
5) Regional Operational Programmes for 2014-2020.

5. Efficiency of energy generation and supply (Article 14 of the Directive)

1) Operational Programme Infrastructure and Environment 2014‑2020 (Measure 1.5) – Efficient distribution of heating and cooling;
2) Operational Programme Infrastructure and Environment 2014-2020 (Measure 1.6) – Promoting the use of high‑efficiency cogeneration based on the demand for useful heat.
3) Operational Programme Infrastructure and Environment 2014-2020 (Measure 1.7.2 – Efficient distribution of heating and cooling in the Śląskie Province);
4) Operational Programme Infrastructure and Environment 2014-2020 (Measure 1.7.3 – Promoting the use of high‑efficiency cogeneration in the Śląskie Province).
5) Supporting projects related to low-emission and resource-efficient economy. Part 3 – Efficient heating and cooling systems.

3.1 Horizontal measures

3.1.1 Energy efficiency obligation scheme (white certificates)

The scheme of energy efficiency certificates, known as the "white certificates", is the key energy efficiency support mechanism in Poland[13].

Energy companies selling electricity, heat or natural gas to final consumers are required to comply with a statutory obligation to complete an energy efficiency project at a final consumer or generate and present to the President of the Energy Regulatory Office (URE) for redemption a specific amount of final energy savings, as confirmed by a certificate (white certificate). Alternatively, the above obligation can be met by the payment of a compensation fee subject to specific conditions, in which case the proceeds from the fee are allocated for delivering energy efficiency projects at end users, and the entity which manages the revenues from the fee is required to report the amount of funds earmarked for the delivery of such projects and the final energy savings realised to the Minister of Energy.

Energy efficiency certificates are associated with alienable property rights which represent a tradable commodity within the meaning of the Act of 26 October 2000 *on commodity exchange markets* (Journal of Laws of 2016, item 719, as amended), and as such are tradable on a commodity exchange or a regulated market within the meaning of the Act of 29 July 2005 *on trade in financial instruments* (Journal of Laws of 2016, item 1636, as amended). The white certificate scheme supports the implementation, *inter alia*, of such investment projects as: insulation of industrial installations; reconstruction or repair of a building, including its installations and technical equipment; refurbishment or replacement of lighting, equipment and installations used in industrial processes or in energy, telecommunications or IT processes, local district heating networks and local heat sources.

As part of the energy efficiency certificate scheme, to date, the President of the URE has conducted and concluded five tender procedures to select projects improving energy efficiency. The value of energy efficiency certificates for which successful tenderers have bid demonstrates an upward trend.

The fifth invitation to tender for energy efficiency improvement projects for which energy efficiency certificates can be obtained was announced on 21 September 2016.

[13] The white certificate scheme was put into effect by the Act of 15 April 2011 *on energy efficiency* (Journal of Laws of 2015, items 2167 and 2359, and of 2016, item 266) and it operated from 1 January 2013 to 30 September 2016 pursuant to the Act. In 2016, new legislation was passed, i.e. the Act of 20 May 2016 *on energy efficiency* (Journal of Laws, item 831), whereby the scheme was extended until 2020.

Given the noticeably greater interest in the tender, which has translated into a far higher number of bids submitted (2 425) compared to the previous tender (1 120), and in light of the volume of certificates available for issue, it is estimated that the pool of certificates issued under the tender can be much bigger than that issued under the previous bidding procedures.

The results of the tenders are presented in table 7.

Table 7. Results of tenders

Tender	Value of energy efficiency certificates for which successful tenderers were bidding [toe]
First tender	20 698.73
Second tender	57 180.15
Third tender	149 886.17
Fourth tender	495 023.30
Total	**722 788.35**

Table 8 presents aggregate data about energy efficiency certificates issued and total declared savings of final and primary energy.

Table 8. Aggregate data as at the end of 2016 on energy efficiency certificates issued and final and primary energy savings

Accumulated figures as at the end of the month	Number of energy efficiency certificates issued [items]	Value of energy efficiency certificates issued [toe]	Cumulative final energy savings [toe]	Cumulative primary energy savings [toe]
July 2016	1 112	381 052.80	1 924 656.06	3 726 606.24
August 2016	1 516	566 552.88	2 718 048.58	4 886 701.37
September 2016	1 755	677 899.15	3 174 555.83	5 556 198.01
October 2016	1 789	689 639.55	3 206 188.75	5 604 179.36
November 2016	1 800	691 741.37	3 215 270.19	5 617 482.78
December 2016	1 842	702 742.02	3 268 126.00	5 692 200.50

Table 9 presents cumulative primary and final energy savings achieved under the white certificate scheme by the end of 2016.

Table 9. Energy savings under the white certificate scheme

Year	2014	2015	2016
Cumulative primary energy savings [toe]	354 613	2 892 790	5 692 201
Cumulative final energy savings [toe]	**213 184**	**1 660 662**	**3 268 126**

The energy savings produced by the white certificate scheme were calculated with the use of the database of Krajowa Agencja Poszanowania Energii S.A. based on energy efficiency audit sheets, which are annexed to applications for the issue of energy efficiency certificates (Deklaracja o wydanie świadectwa efektywności energetycznej). Audit sheets are available on the publicly accessible website of the Public Information Bulletin of URE (Biuletyn Informacji Publicznej URE). Audit sheets available online include such basic information as: average annual final energy savings [MWh/year or GJ/year] and annual average primary energy savings [MWh/year or GJ/year]. Audit sheets also give energy savings as converted from the above units to tonnes of oil equivalent [toe/year].

The database (1 842 items) contains data from all audit sheets of those projects for which an energy efficiency certificate was issued not later than 31 December 2016.

Table 10. Description of horizontal measures

Name of measure:	**Energy efficiency obligation scheme (white certificates)**
Category	Obligation imposed on operators selling electricity, heat, and natural gas either to complete an energy efficiency project at a final consumer or to generate and present to the President of the Energy Regulatory Office for redemption certified energy savings (white certificate).
Programme objective	Support mechanism for measures aimed at improving the energy efficiency of the economy. Increasing energy savings by final consumers. Reducing losses of electricity, heat or natural gas in transmission or distribution.
Programme actions	The white certificate scheme supports projects generating specific energy savings. The President of the Energy Regulatory Office is entitled to issue and redeem white certificates. The property rights arising under the certificates are alienable and are considered commodities tradable on a commodity exchange or a regulated market. A detailed list of the projects is announced by way of a Notice of the Minister of Energy. The Minister of Energy is also responsible for monitoring the scheme by calculating actual energy savings and for reporting to the European Commission.
Status	Under implementation – four tenders have been completed, the fifth tender is under way – by the end of December 2016, 1 842 certificates were issued.
Timeframe	From 1.01.2013 to 31.12.2020
Type of	Energy companies selling electricity, heat, or natural gas to final consumers

beneficiaries	connected to the grid on the territory of the Republic of Poland, excluding enterprises which sell heat to final consumers where the total thermal power ordered by such consumers does not exceed 5 MW. Entities implementing energy efficiency improvement projects or entities acting on their behalf (authorised entities). Final consumers connected to the grid on the territory of the Republic of Poland which are members of a commodity exchange[14)] for transactions concluded on their own behalf on the commodity exchange; commodity brokerage houses or brokerage houses[15)].
Implementing authority/ body	URE
Budget	approximately PLN 0.7 million per year from funds available to the implementing body.

3.1.2 Energy audits and energy management systems (Article 8 of Directive 2012/27/EU)

Article 8(4) of Directive 2012/27/EU defines large enterprises as enterprises other than small and medium-sized enterprises (SMEs). Such enterprises are required to carry out an energy audit.

In accordance with the definition in Article 2(26) of Directive 2012/27/EU, "small and medium-sized enterprises" (SMEs) are the enterprises referred to in Title I of the Annex to Commission Recommendation 2003/361/EC of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises. This category includes enterprises which employ fewer than 250 persons and which have an annual turnover not exceeding EUR 50 million, and/or an annual balance sheet total not exceeding EUR 43 million.

The obligation to conduct an energy audit by a large enterprise was introduced by the Act of 20 May 2016 *on energy efficiency* (Journal of Laws, item 831). Pursuant to Article 36 and 37 of the above Act, any entrepreneur, as defined by the Act of 2 July 2004 *on the freedom of economic activity* (Journal of Laws of 2016, item 1829, as amended), with the exception of micro, small, or medium-sized enterprises within the meaning of Article 104-106 of the Act, is required to carry out an energy audit or have it carried out every 4 years.

Entrepreneurs which put in place an energy management system, as defined by the Polish Standard on *energy management systems, and on the requirements and recommendations concerning their use*, or an environmental management system, are exempt from the obligation if energy auditing is conducted within the framework of such systems.

An energy audit of an enterprise can be carried out by:

1) an entity with expertise and professional experience in carrying out such audits independent of the audited entrepreneur;

[14)] Within the meaning of Article 2(5) of the Act of 26 October 2000 *on commodity exchanges*.
[15)] As referred to in Article 2(8) and (9) of the Act of 26 October 2000 *on commodity exchanges*.

2) an in-house expert of the audited entrepreneur, if he/she is not directly involved in the audited activity of the entrepreneur.

An energy audit of an enterprise is a procedure intended to carry out detailed and validated calculations for proposed energy efficiency improvement measures, and to provide information on potential energy savings.

An energy audit of an enterprise:

1) is to be carried out on the basis of up-to-date, representative, measured, and traceable data about energy consumption, and for electricity, the demand for power;
2) comprises a detailed review of the consumption of energy in buildings or complexes of buildings, industrial installations, and in transportation representing jointly at least 90% of the total energy consumption by the enterprise;
3) should be based, whenever possible, on a life-cycle cost analysis (LCCA) for the building or group of buildings or industrial installations instead of Simple Payback Periods (SPP) in order to take account long-term energy savings, residual values of long-term investments, and discount rates.

3.1.3 Metering and billing (Articles 9 to 11 of Directive 2012/27/EU)

In order to implement the climate policy and increase the efficiency of energy consumption, consideration is given to introducing tools which enable consumers of electricity to use it consciously, such as smart meters and the accompanying services[16)]. By enabling consumers to monitor actual energy consumption on an ongoing basis and, at the same time, billing them against actual consumption, rational and effective utilisation of the State's energy resources is promoted in a manner as direct as possible. Mitigating the risk of imbalance in the national power system is another argument in support of the use of smart meters, particularly relevant for Poland. It is expected that the introduction of smart metering will contribute to reducing energy consumption, in particular during periods of peak demand.

Act of 26 July 2013 *amending the Energy Law and certain other acts* (Journal of Laws item 984) introduces rules on the planning by distribution companies of investments related to the collection, transmission and processing of measurement data from remotely readable meters, as well as provisions requiring energy companies to ensure an adequate level of safety of data obtained from remotely readable meters. In this respect, cooperation between stakeholders is recommended to

[16)] *Analysis concerning economic evaluation of the justifiability of introducing smart electricity metering in Poland* (Analiza w zakresie ekonomicznej oceny zasadności wprowadzenia inteligentnych form pomiaru zużycia energii elektrycznej w Polsce), study prepared at the request of the Ministry of Economy, 20 August 2012.

ensure effective communication between wireless meters and the telecommunications infrastructure. In carrying out the above activities, efforts must be made to ensure synergy between energy and telecommunications investments.

3.1.4 Consumer information and advisory programmes (Articles 12 and 17 of Directive 2012/27/EU)

Information on energy efficiency improvement measures and financial mechanisms is available to relevant market actors, including final consumers and SMEs. In Poland, there are also many organisations, associations, and institutions which provide information and advisory services related to the promotion of energy conservation issues, including: Krajowa Agencja Poszanowania Energii – "KAPE S.A.", Narodowa Agencja Poszanowania Energii – "NAPE", Fundacja na rzecz Efektywnego Wykorzystania Energii – "**FEWE", Ogólnopolskie Stowarzyszenie "Poszanowanie Energii i Środowiska" SAPE-POLSKA, regional energy agencies, Fundacja Poszanowania Energii, Pomorskie Centrum Termomodernizacji, and other sectoral organisations.** Information campaigns addressed to the public with a view to promoting environmentally-friendly attitudes and demonstrating how energy can be saved are also instrumental in fostering improvement in energy efficiency.

Since 2016, the Ministry of Energy has been a party to an agreement whereby the National Fund for Environmental Protection and Water Management (NFOŚiGW), working together with partners, has implemented the programme named Nationwide system of advisory support in the field of energy efficiency and RES for the public, housing and enterprise sectors (Ogólnopolski system wsparcia doradczego dla sektora publicznego, mieszkaniowego oraz przedsiębiorstw w zakresie efektywności energetycznej oraz OZE).

The scheme is a necessary element of support towards building a low-emission economy in Poland in combination with the so-called "low-emission economy plans"[17], which are prepared by municipalities *inter alia* with co-funding from OPI&E (2007-2013). The initiative is aimed at developing a system of advice on low-emission economy in regions, based on a network of advisers rendering services at regional and local levels to local governments, enterprises, individuals, and housing associations and cooperatives.

The objective of the scheme is to:

[17] Low-emission economy plans cover such issues as combating climate change, improving air quality in areas where air quality standards are exceeded and where air protection programmes are in place, energy supply, energy consumption and ensuring security of supply, as well as promoting "clean" urban transport responsive to growing mobility needs of residents of cities and their functional areas.

- increase public awareness regarding energy efficiency and RES by facilitating exchange of information at local and regional levels and exchange of good practices in the context of the implementation of Directive 2010/31/EU and Directive 2012/27/EU (e.g. creation of uniform standards and guidelines);

- support the preparation of low-emission economy plans and the resulting energy efficiency and RES projects at the local level;

- provide incentives for local governments to appoint municipal energy advisers to promote energy efficiency; This task should be pursued by the creation of a training system to further the qualifications of municipal energy advisers.

The Nationwide programme of advice in the field of energy efficiency and RES implements the provisions of Directive 2012/27/EU (Articles 12 and 17) and Directive 2009/28/EC[18] (Article 14(6)).

The implementation of the programme is financed under the Operational Programme Infrastructure and Environment 2014-2020 by resources from the Cohesion Fund.

Moreover, in the years 2012-2016, the following information and educational campaigns were conducted:

- **Time to Save Energy (Czas na oszczędzanie energii)**

An information campaign promoting rational use of energy under the motto "time to save energy", conducted by the Ministry of Economy in 2008-2014. The objective of the campaign is to present issues connected with the principles and cost-effectiveness of applying energy-saving solutions and to acquaint the Polish public with topics related to improving the energy efficiency of the Polish economy.

As part of the campaign, the following promotional and educational activities were delivered:

1) Publishing:

- information brochures (i.e. a user guide and a guide for manufacturers, distributors and vendors of household appliances and electronics);
- posters promoting rational energy use;
- an information brochure addressed to pre-school children and their parents, promoting rational use of energy.

2) Electronic publications:

[18] Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources (OJ L 140, 5.6.2009, p. 16, as amended).

- two manuals describing ways and methods of improving energy efficiency in the public sector and energy efficiency obligation schemes.

3) Multimedia campaign:

- TV and radio spots promoting change of public behaviour as regards energy savings.

- "**We turn off electricity and turn on saving**" **and** "**A Pole saves heat the more, the more saving pays**"

The Ministry of the Environment has carried out two information and educational campaigns focused on energy efficiency: "A Pole saves heat the more, the more saving pays" (Polak tym bardziej oszczędza ciepło) and "We turn off electricity and turn on saving" (Wyłączamy prąd, włączamy oszczędzanie), which promote energy saving by households. As part of the campaigns, major nationwide TV stations broadcast spots in which well-known personalities encouraged people to engage in simple everyday actions which translate into energy savings and reduce energy bills. In 2014, the following campaign was carried out: "A home that saves for me", financed by the EEA Financial Mechanism under PL04. The campaign illustrated the benefits of building energy efficient houses. Internet users can also use the Savings Calculator available on the Ministry's website: http://oszczedzam-energie.mos.gov.pl/, and design their own house using a mobile application.

- **Free your energy and protect the environment (Uwolnij swoją energię, chroń środowisko)**

The objective of the campaign was to make consumers aware of their rights and the benefits they can gain as well-informed and active participants of the energy market. The spots broadcast by the campaign were watched by 4 million viewers. In connection with the release of the spots, the number of visits to the website dedicated to supplier switching: www.maszwybor.ure.gov.pl increased 10 times.

- **Guide to improving energy performance of buildings**

In 2016, the Ministry of Infrastructure and Construction released the "Guide to improving energy performance of buildings" (Poradnik w zakresie poprawy charakterystyki energetycznej budynków). The guide is a compendium of information on energy efficiency of buildings useful in designing and constructing buildings, as well as in using buildings or their parts.

Table 11. Description of horizontal measures

Name of measure:	**Operational Programme Infrastructure and Environment 2014-2020 (Measure 1.3.3 – Nationwide system of advisory support in the field of energy efficiency and RES for the public, housing and enterprise sectors);**
Category	Funds

Programme objective	The programme supports the implementation of a project to create a nationwide system of advisory support in the field of energy efficiency and RES for the public, housing and enterprise sectors based on a network of advisers providing services at the regional level. The aim of the project is to promote a low-emission economy in Poland. The advice provided covers energy efficiency and RES topics and involves training and consulting activities, as well as measures raising the awareness of the public (including groups receiving support under OPI&E and ROPs). In effect, the project of the nationwide advice system will contribute to creating in the future of a network of energy advisers in municipalities, also referred to as "municipal energy experts", by encouraging municipalities to appoint them.
Programme actions	▪ preparation and delivery of training, and information and educational activities in the field of energy efficiency, RES and low-emission economy development for the public and housing sectors, as well as for entrepreneurs and the public; ▪ training for energy advisers to prepare them to render advice services, ▪ free-of-charge advice services related to the preparation, verification and implementation of low-emission economy plans, and raising public awareness of energy efficiency, RES, and low-emission economy issues; ▪ monitoring the implementation of low-emission economy plans; ▪ advisory services related to the preparation and implementation of investments in the area of energy efficiency and RES, including advice on the use of financial instruments; ▪ promoting a low-emission economy; ▪ building a platform for the exchange of best practices and a knowledge base.
Status	Under implementation – in March 2016, the Ministry of Energy signed an agreement with NFOŚiGW. Ultimately, 50 000 consultation sessions are to be provided, with the advisory support covering 1 200 low-emission economy plans, and 800 investments.
Timeframe	From 2015 to the end of 2023
Type of beneficiaries/Target group	NFOŚiGW in cooperation with 15 Partners/users receiving advisory support for the public and housing sectors, as well as for entrepreneurs and natural persons
Implementing body	Ministry of Energy – Intermediate Body
Budget/Source of funding	EUR 30 million, contribution from the Cohesion Fund

Table 12. Description of horizontal measures

Name of measure:	**Information and educational campaigns**
Category	Information campaigns addressing energy efficiency
Programme objective	Change public behaviour to ensure that people become more saving-focused, through information and educational campaigns addressed to energy users, including households. Increase the public awareness of issues related to energy efficiency, financing (in particular by ESCO funds and under the white certificate

	scheme), low-energy buildings, and other topics linked to energy use and environmental risks.
Programme actions	Nationwide campaigns promoting the use of energy efficiency improvement measures, including the deployment of innovative technologies by public bodies, promoting low-energy buildings, and promoting ESCO funding. Other measures include information and educational actions and training, and the publication of manuals and guides on where and how to apply for funding on the websites of the relevant ministries and programme participants. The campaigns have been organised by the Ministry of Economy, the Ministry of the Environment, URE and other institutions involved in the programme, including local governments and non-governmental organisations, as well as energy producers and distributors. For the most part, the contractors are professional companies providing information campaigns, supported by expertise of consulting firms. The topics cover the area of energy use. As far as monitoring the campaigns is concerned, the Ministry of Economy is in charge of estimating the energy savings achieved in 2016, as well as reporting to the European Commission.
Status	Under implementation – in the years 2012-2016, information and educational activities were carried out by the Ministry of the Environment, the Ministry of Economy, the Ministry of Infrastructure and Construction, and URE
Timeframe	From 2012 to 2020
Type of beneficiaries/Target group	Final consumers of energy, including households, entrepreneurs and public finance sector institutions
Implementing body	Ministry of Energy, Ministry of the Environment, Ministry of Infrastructure and Construction
Budget	approximately PLN 2 million annually from funds available to the implementing bodies

3.1.5 Qualification, accreditation and certification schemes (Article 16 of Directive 2012/27/EU)

Pursuant to Article 16 of Directive 2012/27/EU, where the national level of technical competence, objectivity and reliability is insufficient, the Member State is required to establish a certification and/or accreditation scheme combined with suitable training programmes for energy service providers, energy audits, energy managers and installers of energy-related building elements as defined in Article 2(9) of Directive 2010/31/EU. All information regarding the certification, accreditation, or qualification schemes should be made publicly available.

If the level of technical competence, objectivity and reliability of the respective entities can be considered adequate for achieving the objectives of Directive 2012/27/EU, it is advisable that appropriate schemes be put in place, in particular as regards qualifications, to expedite development in the field of energy efficiency and to improve the competences of entities active in

this area. Currently, Polish legislation provides for three basic types of documents intended to help entities interested in improving energy efficiency to assess the level of energy intensity of buildings, equipment and installations, and to identify sources of possible energy savings, as well as to estimate the costs associated with the introduction of solutions improving the efficiency.
The documents are:

- **Energy audit**

Pursuant to the Act of 21 November 2008 on supporting thermomodernisation and repairs (Journal of Laws of 2017, item 130), an energy audit means a study defining the scope and technical and economic parameters of a thermomodernisation project. It indicates a solution which is optimal in terms of the implementation costs and energy savings. An audit provides a basis for applying for co-funding of thermomodernisation works. The purpose of thermomodernisation is to decrease the consumption of energy needed to heat a building and prepare warm service water, and to reduce the costs of ensuring suitable comfort for building occupants. Energy audits include optimisation variants for: insulation of the building envelope, replacement of external windows and doors, replacement or refurbishment of the heating system, replacement or refurbishment of the system for warm service water preparation, refurbishment and improvement of the ventilation system, and use of renewable energy sources or high‑efficiency cogeneration. The scope of thermomodernisation work to be included in an energy audit should be as comprehensive as possible, covering both reduction of heat losses through the building envelope and use of efficient heating and transmission equipment, such as to guarantee maximum efficacy.

- **Energy efficiency audit**

Within the meaning of the Act of 20 May 2016 *on energy efficiency* (Journal of Laws, item 831), an energy efficiency audit is a study including an analysis of energy consumption and describing the technical condition of a building, equipment or installation, including a list of investments required to improve the energy efficiency of the building, equipment or installation, as well as an assessment of their economic viability and achievable energy savings. In most cases, an energy efficiency audit is prepared with the aim of obtaining support in the form of energy efficiency certificates (Article 20 of the Act). Such an audit is also required in connection with the obligation to implement an energy efficiency improvement project imposed on obliged entities (Article 10(1) point 1 of the Act), and for the purpose of confirming realised energy savings declared by end users (Article 15 of the Act).

- **Energy performance certificates of buildings**

Pursuant to the Act of 29 August 2014 *on energy performance of buildings* (Journal of Laws of 2017, item 1498), an energy performance certificate for a building or part of a building is issued

on the basis of the technical parameters of the building's structure and installations and the technical parameters of the heat source supplying the building or part of it, whereby in accordance with the Act, energy performance is to be understood as: a set of energy-related data and indicators of a building or its part which define the total energy demand necessary for using them for their intended purpose. The model energy performance certificates and the methodology for determining energy performance are laid down by Regulation of the Minister of Infrastructure and Development of 27 February 2015 *on the methodology for determining the energy performance of buildings or parts of buildings and on energy performance certificates* (Journal of Laws of 2015, item 376, as amended).

The above types of documents differ from each other in their scope, size, nature of actions they indicate, and the subject they analyse. However, they have certain common characteristics, namely they indicate existing energy consumption and measures which can be taken to improve their energy efficiency. Naturally, the fact that legislation specifies the three above types of documents does not mean that no other documents are acceptable. However, such alternative documents are not regulated by law.

Currently, it is a common practice for enterprises willing to reduce energy costs to have comprehensive energy audits carried out as part of their business operation. The scope of an energy audit determines the requirements to be met by the auditor, which means that all auditors must be accredited and certified so as to guarantee reliability and correctness of the audit. Additional requirements must only be met by persons who issue energy performance certificates of buildings. Such certificates may only be issued by persons who are entered in the Central Building Energy Performance Register (centralny rejestr charakterystyki energetycznej budynków).

Registration is available to a person:

1) who enjoys a full capacity to perform legal acts;
2) who has no previous convictions for an offence related to property, document fraud, economic or trade transactions, money and securities transactions, or tax offences;
3) has completed:
    a) higher education receiving the bachelor's degree of engineer, architect engineer, landscape architect engineer, fire safety engineer, master's degree of architect engineer, master's degree of landscape architect, master's degree of fire safety engineer, or master's degree of engineer, or
    b) higher studies other than those mentioned in point a) above and post-graduate studies whose curriculum covers subjects related to energy performance of

buildings, building energy audits, energy-efficient construction, and renewable energy sources, or

4) has a builder's licence, as referred to in Article 14(1) of the Construction Law of 7 July 1994 (Journal of Laws of 2017, item 1332, as amended).

The Ministry of Infrastructure and Construction keeps a register of the persons who hold the above qualifications.

The list is available via the website:https://rejestrcheb.mib.gov.pl, which is to facilitate access to updated details of experts who issue energy performance certificates. As of 30 March 2017, the register included 13 863 persons. Pursuant to the Act of 29 August 2014 *on energy performance of buildings*, a separate register of persons qualified to inspect heating and air-conditioning systems is also kept. The central register makes searching for qualified experts, verifying certificates and inspection reports easier, and is used for reporting on energy efficiency improvement in the public sector.

By contrast, no qualification-related requirements having a restrictive effect apply to carrying out energy audits for the needs of thermomodernisation or energy efficiency audits under the white certificate scheme. It has been decided that there is no need to restrict the possibility of completing energy efficiency audits in such a strict manner since this would limit their numbers. The focus should be on controlling the correctness of completed audits rather than on verifying the persons who are in charge of them. Energy efficiency audit can be carried out by entities not required to certify their qualifications through administrative procedures. This does not mean that such audits are carried out by incompetent persons. The preparation and completion of the refurbishment of specific categories of equipment, installations, or buildings requires independent certificates specified by legislation (e.g. the Construction Law or Energy Law). As a result, persons who conduct the most complicated categories of projects aimed at improving energy efficiency are already subject to accreditation and certification schemes. Duplicating certification schemes merely for the needs of energy-efficiency projects could only generate unnecessary additional costs and hinder the functioning of the market for energy audits.

In addition, the Act of 20 February 2015 *on renewable energy sources* (Journal of Laws of 2017, item 1148, as amended) introduced into the Polish legal system the concept of microinstallations and a separate support scheme for renewable energy micro-generation, which includes a scheme for the certification of installers of microinstallations, small installations, or renewable energy installations with a total installed thermal capacity of up to 600 kW. An installer's certificate confirms qualifications to install: biomass boilers and stoves, photovoltaic systems, solar thermal systems, heat pumps, or shallow geothermal systems. Certificates are issued by the President of

the Technical Supervision Office (Urząd Dozoru Technicznego) to persons who meet the requirements specified by the above Act. The Act also specifies how often examinations should take place and lays down the appeals procedure to be followed in cases when the issue of a certificate is refused. Provisions regarding the requirements for certifying installers are complemented by extensive regulations defining the thematic scope of training and examinations for installers, as well as the rules to be followed when conducting such examinations and on who can assess them. In addition, the Act regulates the conditions to be met by providers of training for installers, and specifies who and under what terms accredits such centres. Installer's certificates are issued for 5 years. Before the end of the period, installers may request that their certificate be extended. When having their certificates extended, in addition to taking part in mandatory refresher training, installers are required to present a list of at least 5 installations for the assembly of which they have been responsible, which is meant to verify the reliability of their work and confirm its continuity.

The following schemes for raising auditors' qualifications are available on the Polish market:

- **Postgraduate studies in the field of energy audits** are postgraduate studies the programme of which covers topics related to energy performance of buildings, energy audits of buildings, energy-efficient construction and renewable energy sources, as provided for by Article 17(3)(b) of the Act of 29 August 2014 *on energy performance of buildings*. Completing these studies, subject to the additional condition of having previously acquired education, qualifies a person to issue energy performance certificates for buildings.

- **Training for energy auditors:**
  - Fundacja Poszanowania Energii organises and conducts training[19] addressed to a broad range of professionals dealing with rational use of energy, as well as to people starting their professional career in this field. To date, more than 138 training courses have been organised on energy audits for thermomodernisation and repair projects implemented pursuant to the Act of 21 November 2008 *on supporting thermomodernisation and repairs* and Regulation of the Minister of Infrastructure of 17 March 2009 *on detailed scope and form of energy audits and parts of renovation audits, model audit sheets, and algorithm for evaluating the cost-effectiveness of thermomodernisation projects* (Journal of Laws, item 346, as amended).

[19] Training programme for energy auditors delivered by Fundacja Poszanowania Energii: http://www.fpe.org.pl/oferta-szkolen/szkolenia-audytorow-energetycznych/program-i-zgloszenia.aspx

- Towarzystwo Oświatowe PROFIL delivers training and courses[20] for a very broad-ranging group of participants. It offers training and courses in the technical fields which are currently the most sought-after on the labour market. Towarzystwo cooperates, inter alia, with the Gdańsk University of Technology, Szczecin University of Technology, University of Gdańsk, Warsaw University of Technology, Białystok University of Technology, University of Białystok, the WSB University in Szczecin, and the WSB University in Toruń.

According to a report prepared under the BuildUpSkills Poland project, the estimated demand for qualified energy efficiency professionals in 2017-2018 will amount to approximately 20 000 persons annually[21]. The number of school leavers (with qualifications of the highest relevance for energy-efficient construction and RES sector labour markets) has been estimated at approximately 16 000 annually.

3.1.6 Energy services market (Article 18 of Directive 2012/27/EU)

Poland has introduced legal acts and mechanisms which ensure the implementation of activities supporting the energy services market in accordance with Article 18 of Directive 2012/27/EU. With a view to stimulating the market for energy service companies, such as ESCOs, appropriate provisions have been introduced to existing Act of 20 May 2016 *on energy efficiency*.

The Act requires obliged entities to deliver projects intended to improve energy efficiency at final consumers, providing, at the same time, that such entities can comply with the above requirement through energy service companies. The Act also makes it possible for energy service companies to apply to the President of URE to obtain an energy efficiency certificate (white certificate) following the same procedure as for obliged entities. ESCOs may be beneficiaries of the white certificate scheme thanks to the fact that the Act provides for the possibility of aggregating energy savings and, based on them, bid for white certificates on behalf of other entities in which energy efficiency improvement projects generating cumulative energy savings of at least 10 toe will be delivered.

Poland also pursues various types of activities to promote energy performance contracting. As part of the promotion activities, the Ministry of Energy has developed and published on its website a guide to energy efficiency funding for the public sector. The guide provides guidance for the

[20] Courses in energy audits taught by Towarzystwo Oświatowe PROFIL: http://www.top.com.pl/kursy/31-kursy/25-audytor-efektywnosci-energetycznej-aee

[21] Authors: A. Więcka et al., Strategia podnoszenia kwalifikacji pracowników budowlanych w zakresie technologii OZE i działań zwiększających efektywność energetyczną budynków, Warsaw 2013.

public sector, and model core provisions of an energy performance contract (EPC)[22]. The website of the Ministry of Energy also includes a list of ESCOs active on the Polish market.

The figure below presents a division of ESCOs according to the services they provide. Advice and energy audits are the most popular and most frequently provided services. In most cases, they comprise the preparation of expert reports which define the potential areas for energy savings, and then recommendation of specific (technical, organisational) solutions, including an estimation of their cost-effectiveness.

The next step involves providing advice on potential investments likely to ensure more rational energy management. The next largest group are companies which deal with broad-ranging heating and cooling, energy efficiency in buildings, lighting, cogeneration and generation and distribution of electricity or heat.

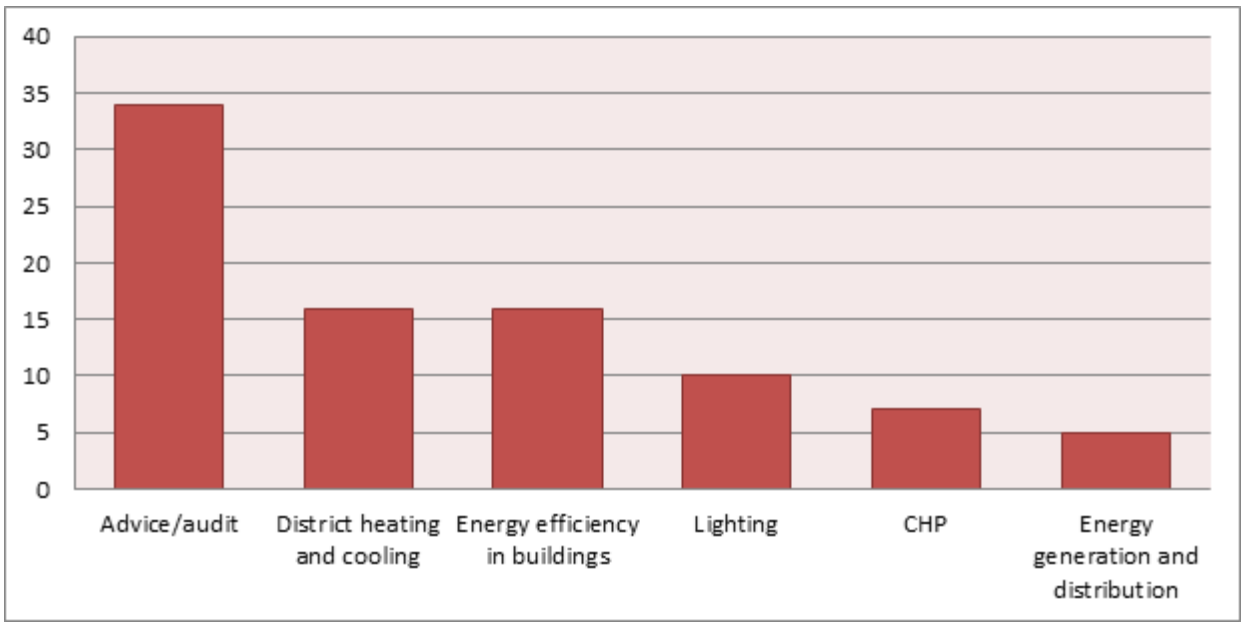


Figure. Scope of services provided by Polish ESCOs

Another piece of legislation relevant in the context of the implementation of Article 18 of Directive 2012/27/EU is the Act of 19 December 2008 *on public-private partnership* (Journal of Laws of 2017, item 1834). This follows from the fact that under the Act public bodies implement energy performance contracts through public-private partnerships they enter into. The Act sets out detailed rules for cooperation between public bodies and private partners (including ESCOs) on the delivery of joint projects. According to the Act, the minister responsible for regional development is required, in particular, to popularise and promote public-private partnership and analyse and assess their performance. For this purpose, a special online platform dedicated to

[22] Link to the guide on the website of the Ministry of Energy: http://www.me.gov.pl/files/upload/10722/Podrecznik-Sektor_publiczny_OSTATECZNY.pdf

public-private partnerships has been created: http://www.ppp.gov.pl. A central objective of the platform is to ensure effective completion of public-private partnership projects thanks to exchange of expertise, good practices and developing and disseminating model documents.

Currently, there is no system which could be used for continuous monitoring and obtaining accurate statistical data regarding the ESCO market in Poland. ESCOs operate in different sectors and for different clients. Their clients may include the public, commercial, and energy sectors, industry, small and medium-sized enterprises, and even households, which, taken together, represent a significant potential for reducing energy consumption. There are significant opportunities for the development of the ESCO model in the public administration sector. Even though, in recent years, the volume of projects for the public administration sector has declined, the sector remains one of the key segments of the ESCO market in Poland.

To date, expenditure on purchasing energy has taken precedence over outlays on improving energy efficiency. However, this trend is reversing. The competition on the market, both in the EU and worldwide, has forced companies to cut costs. One of the simplest and fastest ways to achieve this is by cooperating with an ESCO. A growing popularity and interest in this model of investing can be observed. It does not require financial contributions from enterprises, offers real savings, and introduces innovative solutions to enterprises.

The development of the energy services market will be determined by many factors. The drivers of the energy services market include dynamic development of energy technologies (including smart grids), the relation of the prices of construction services and materials to prices of energy carriers, the growing energy awareness of end users, and the involvement of non-energy companies, for example telecommunication operators, in the energy services market. It is expected that energy companies will keep adding new services to their offer, seemingly not related to their core operations.

According to the optimal scenario of the development of energy services, it is predicted that prosumers will appear on the market on a large scale and will be served by existing energy companies (offering all-comprising services). In addition, energy companies should offer their customers a comprehensive energy service, allowing them to use energy-saving equipment (e.g. LED lighting) without the need to bear the investment costs associated with their purchase.

The table below presents an example of good practices as regards energy services in Poland, namely the project of comprehensive thermomodernisation of school buildings in the municipality of Radzionków. The thermomodernisation investment in the municipality of Radzionków is a good example of a public-private partnership where the role of the private partner was to prepare, finance, and provide heat energy management services. The private partner also extended a full

guarantee on the anticipated economic benefits and savings. The agreement covers a period of 10 years: 2010-2020. The estimated amount of savings realised as a result of the refurbishment is approximately PLN 3.4 million[23].

Comprehensive thermomodernisation of school buildings in the municipality of Radzionków		
Main objectives	Scope of refurbishment	Results
- savings of heat and electricity costs - maintaining the buildings for a period of 10 years: 2010-2020 - reducing CO_2 emissions into the atmosphere; - improving the building use standard.	- thermomodernisation of central heating systems and heat sources; - retrofitting of the lighting system; - implementation of a heat and lighting management system.	- replacement of 762 windows; - retrofitting of 3 boiler rooms; - replacement of 1 179 light fittings - improving the appearance of the town; - reduction of CO_2 emissions by the end of 2020: 4 550 tonnes; - heat energy savings: 54%; - electricity savings: 40%.

3.2. Measures related to energy efficiency of buildings

3.2.1. Building renovation strategy (Article 4 of Directive 2012/27/EU)

The revised building renovation strategy entitled *Supporting Building Refurbishment Investments – An Update* (Wspieranie Inwestycji w Modernizację Budynków - Aktualizacja), prepared by the Ministry of Infrastructure and Construction in line with Article 4 of Directive 2012/27/EU, is presented in Annex No 3 to the National Action Plan.

3.2.2. Additional measures related to energy efficiency of buildings

Supporting investments which work towards improving energy efficiency of existing buildings is governed, *inter alia*, by the Act of 21 November 2008 *on supporting thermomodernisation and repairs*. The Thermomodernisation and Repairs Fund (Fundusz Termomodernizacji i Remontów), which is financed by the state budget, finances the Programme for supporting thermomodernisation projects and thermomodernisation-related repair projects in existing single-dwelling and multi-dwelling residential buildings. In its present form, the Programme has been implemented since 2009. Resources of the Thermomodernisation and Repairs Fund are allocated for refinancing a portion of the costs of thermomodernisation and repair projects with the aim of improving the technical condition of existing housing stock while reducing heat energy demand.

[23] http://www.ppportal.pl/artykuly-polskie/kompleksowa-termomodernizacja-budynkow-oswiatowych-gminy-radzionkow-studium-przypadku

In particular, the refinancing takes the form of the so-called "thermomodernisation bonuses" and "repair bonuses".

Measures taken to improve energy efficiency of buildings include, *inter alia*, the tightening of technical and building regulations which define the minimum requirements for energy savings and thermal insulation, including a path for achieving the level which, pursuant to Article 9 of Directive 2010/31/EU, is to be reached by 2021, when newly constructed buildings should be nearly zero-energy buildings – Regulation of the Minister of Infrastructure of 12 April 2002 *on the technical conditions to be met by buildings and their siting* (Journal of Laws of 2015, item 1422, as amended).

A description of the measures related to energy efficiency of buildings is presented in Annex No 3, in section 3.2. Sources of funding.

3.3 Energy efficiency measures implemented by public bodies

3.3.1 Buildings of central government (Article 5 of Directive2012/27/EU)

Pursuant to Article 5(1) of Directive 2012/27/EU, it is necessary to ensure that, as from 1 January 2014, 3% of the total floor area of heated and/or cooled buildings owned and occupied by central government is renovated each year to meet at least the minimum energy performance requirements set by the country concerned in application of Article 4 of Directive 2010/31/EU. Because Article 5(6) of Directive 2012/27/EU allows Member States to opt for an alternative approach to Article 5(1) to (5) of the Directive, the solution adopted by Poland is presented below.

1. Calculation of the target value of energy savings

The following assumptions were made in calculating the target value of energy savings:

- Based on the definition of the central government included in Directive 2012/27/EU and in the Guidance note[24], in order to identify the bodies subject to the requirements laid down by Article 5(1) of Directive 2012/27/EU, use was made of the list of central government bodies included in Annex IV of Directive 2004/18/EC of the European Parliament and of the Council of 31 March 2004 *on the coordination of procedures for the award of public works contracts, public supply contracts and public service contracts,* with the exception of the institutions which are not active across the entire territory of Poland.

[24] Commission Staff Working Document: Guidance note on Directive 2012/27/EU on energy efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC – Article 5: Exemplary role of public bodies' buildings

- Bodies obliged to meet the requirements of Article (5)(1) of Directive 2012/27/EU submitted information on the useful floor area of their buildings, the thermal transmittance coefficient values for their envelope, the non-renewable primary energy factor (PEF) based on the energy performance certificates, and the consumption of the energy carrier used to heat the building and prepare warm service water in cases where no energy performance certificate was available.
- Pursuant to Article 4 of Directive 2010/31/EU, minimum energy performance requirements were adopted both for newly constructed and existing buildings which are reconstructed. The requirements are laid down by Regulation amending Regulation of the Minister of Infrastructure of 12 April 2002 *on the technical conditions to be met by buildings and their siting*, which entered into force on 1 January 2014. The Regulation sets forth new requirements regarding the thermal protection and energy efficiency of buildings and technical installations consuming energy in buildings, and sets the "path" for achieving the nearly zero-energy requirements for buildings adopted for 2021. For newly constructed buildings, requirements were laid down regarding the maximum value of the non-renewable primary energy factor, the maximum thermal transmittance coefficient values, and the requirements for the heating, ventilation, warm service water, and cooling systems.

  For existing buildings which undergo reconstruction, i.e. construction works changing the functional or technical parameters of the building, with the exception of such characteristics as the cubic capacity, footprint area, height, length, width, or number of floors, requirements regarding the thermal insulation of the envelope (maximum thermal transmittance coefficient values) and for the heating, ventilation, warm service water, and cooling systems were determined.
- Pursuant to the Guidance note, the application of an alternative approach should include estimating potential energy savings, expressed in GWh/year, for buildings which fail to meet the requirements established by the above Regulation of the Minister of Infrastructure. These energy savings should be calculated as the difference between the non-renewable primary energy factor (PEF) for the respective building after the thermomodernisation and the non-renewable primary energy factor (PEF) for existing building, multiplied by the building's floor area. However, given that under the above Regulation, the requirements for existing buildings depend on the thermal transmittance coefficient value instead of the non-renewable primary energy factor (PEF), it was assumed for the needs of calculating the target values that after

completing the reconstruction of an existing building, the PEF value will be equal to the maximum PEF value for a newly constructed building as defined by the Regulation.

Table 13 presents a summary of data for buildings with a useful floor area of over 500 m^2 owned and occupied by central government which did not meet, as at 1 January 2015, the minimum energy performance requirements laid down by Regulation of the Minister for Infrastructure of 12 April 2002 *on the technical conditions to be met by buildings and their siting*, and for buildings with a useful floor area of over 250 m^2 owned and occupied by central government which did not meet, as at 9 July 2015, the minimum energy performance requirements laid down by the Regulation, in accordance with Article 4 of Directive 2010/31/EU.

Table 13. Data for buildings with a useful floor area of over 500 m^2 and buildings with a useful floor of over 250 m^2 which did not meet the maximum allowable thermal transmittance coefficient value*)

Intended use of buildings	Number of buildings	Cooled building YES/NO	Total useful floor area	Non-renewable primary energy demand factor (PEF)		Energy savings
				average	resulting from legislation for new buildings*) **)	
-	number		m^2	kWh/(m^2·year)	kWh/(m^2·year)	MWh/year
collective accommodation building	6	YES	16 080.20	431.95	220.00	3 408.20
	15	NO	38 494.31	304.78	195.00	4 225.91
multi-dwelling residential building	4	YES	3 271.15	155.41	115.00	132.19
	15	NO	16 628.56	160.98	105.00	930.87
	9	no data	2 577.36	no data	no data	no data
public building	98	YES	615 551.68	276.98	190.00	53 540.69
	68	NO	278 032.37	459.03	165.00	77 667.00
	38	no data	51 756.99	no data	no data	no data
warehouse, industrial and utility buildings	2	YES	1 932.50	371.68	235.00	264.13
	21	NO	73 644.50	272.89	210.00	4 631.50
	5	no data	3 880.35	no data	no data	no data
TOTAL	**281**	**-**	**1 087 964.1**	**-**	**-**	**144 800.49**

*) The maximum values of the thermal transmittance coefficient and the non-renewable primary energy demand factor are specified by Regulation of the Minister of Transport, Construction and the Maritime Economy amending Regulation on the technical conditions to be met by buildings and their siting. This requirement was established in accordance with Article 4 of Directive 2010/31/EU.

**) The requirements on the maximum non-renewable primary energy demand factor differ depending on the type of building, the time over which the lighting is on (except for residential buildings), and on whether the building is cooled.

Based on the calculations, it was estimated that the target value of annual energy savings from 2015 should be **3% x 144 800.49 = 4 344.01 MWh**.

2. Total floor area of rooms in buildings with a total useful floor area of over 250 m^2 owned and occupied by central government which did not meet, as at 1 January 2016, the building energy performance requirements referred to in Article 5(1) of Directive 2010/31/EU

Table 14 presents summary information about buildings with a useful floor area of over 250 m^2 owned and occupied by central government which did not meet, as at 1 January 2016, the energy performance requirements referred to in Article 5(1) of Directive 2010/31/EU. The buildings did not meet the requirements concerning the thermal transmittance coefficient U_c [W/(m^2K)].

Table 14. Buildings with a useful floor area of over 250 m^2 owned and occupied by central government which did not meet, as at 1 January 2016, the minimum energy performance requirements established in accordance with Article 4 of Directive 2010/31/EU (the buildings did not comply with the maximum allowable thermal transmittance coefficient value*))

Intended use of buildings	Number of buildings	Total useful floor area
-	number	m^2
collective accommodation building	21	54 574.51
multi-dwelling residential building	28	22 477.07
public building	204	93 1455.17
warehouse, industrial and utility buildings	28	79 457.35
TOTAL	**281**	**1 087 964.1**

*) The maximum thermal transmittance coefficient value is specified by an annex to Regulation of the Minister of Infrastructure of 12 April 2002 *on the technical conditions to be met by buildings and their siting*.This requirement was established in accordance with Article 4 of Directive 2010/31/EU.

Even though some buildings had undergone thermomodernisation in previous years, achieving the energy savings required for 2015, they are included in Table 14 because their thermomodernisation works had been planned several years in advance and the building permits had been obtained before the amendment of Regulation of the Minister of Infrastructure of 12 April 2002 *on the technical conditions to be met by buildings and their siting*, which entered into force on 1 January 2014.

3. Amount of energy savings resulting from actions taken in buildings owned and occupied by central government, realised through the alternative approach, as referred to in Article 5(6) of Directive 2012/27/EU

The alternative approach adopted to implement Article 5 of Directive 2012/27/EU was notified in December 2013, and its revision was notified in July 2014. It was decided that energy savings would be achieved through thermomodernisation of buildings and information campaigns promoting energy savings.
Table 15 presents a summary of actions taken in 2016 and the energy savings realised in buildings with a useful floor area of over 250 m^2 owned and occupied by central government.

Table 15. Actions taken in 2016 in respect of buildings with a useful floor area of over 250 m^2 owned and occupied by central government which did not meet, as at 9 July 2015, the minimum energy performance requirements laid down in accordance with Article 4 of Directive 2010/31/EU (the buildings did not comply with the maximum allowable thermal transmittance coefficient value)

No.	Type of building	Useful floor area m^2	Action	Energy savings MWh/year
	1	2	-	4
1	public building	4 813	Insulation of external walls. Replacement of lighting with energy efficient lighting.	230.9
2	public building	73 789.53	Insulation of external walls. Replacement of fan coil units. Replacement of lighting with energy efficient lighting. Temporary lighting switch-off. Training for employees in efficient energy management.	438.71
3	public building	16 960.2	Moving some tasks to a building with better energy performance. Training for employees in efficient energy management.	1 409.77
4	public building	2 731.5	Refurbishment of the heating system. Training for employees in efficient energy management.	91.42
5	public building	2 633	Deep thermomodernisation comprising insulation of external walls, insulation of the flat roof, replacement of windows and doors, refurbishment of the central heating system, and replacement of the heat exchanger.	659.55
6	public building	4 959.5	Regular training for employees in efficient energy management.	35.56
7	public building	24 899.25	Regular training for employees in efficient energy management.	6.64
8	public building	264	Regular training for employees in efficient energy management.	4.77
9	public building	1 110	Replacement of lighting with energy efficient lighting.	4.5

No.	Type of building	Useful floor area m^2	Action	Energy savings MWh/year
	1	2	-	4
10	public building	10 522.6	Replacement of lighting with energy efficient lighting. Regular training for employees in efficient energy management.	46.39
11	public building	3 778.38	Replacement of windows.	No data
12	public building	1 322	Replacement of windows and radiators.	No data
13	public building	1 596	Replacement of lighting with energy efficient lighting.	1.65
14	public building	1 814	Replacement of lighting with energy efficient lighting.	2.0
15	public building	902	Replacement of windows and radiators. Replacement of lighting with energy efficient lighting	0.8
16	public building	2 126	Replacement of radiators. Replacement of lighting with energy efficient lighting	1.1
17	public building	416	Replacement of radiators. Replacement of lighting with energy efficient lighting	4.2
18	Complex of public buildings	32 355.0	Deep thermomodernisation comprising: replacement of windows and doors, assembly of ventilation with heat recovery, replacement of the central heating system, replacement of lighting with energy-efficient lighting. Regular training for employees in efficient energy management.	592.03
19	public building	6 385.5	Regular training for employees in efficient energy management.	59.72
20	public building	318.5	Regular training for employees in efficient energy management.	2.7
21	public building	600	Regular training for employees in efficient energy management.	4.9
22	public building	737.62	Regular training for employees in efficient energy management.	6.11
23	public building	909.85	Regular training for employees in efficient energy management.	1.9
24	public building	953.9	Regular training for employees in efficient energy management.	2.9
25	Collective accommodation building	2 001	Regular training for employees in efficient energy management.	23.0
26	public building	7 401.03	Regular training for employees in efficient energy management.	7.23

No.	Type of building	Useful floor area m^2	Action	Energy savings MWh/year
	1	2	-	4
27	Residential building	2 339.5	Comprehensive thermomodernisation of the building comprising insulation of external walls and roofs, replacement of the roof decking, replacement of windows and doors.	228.0
28	public building	32 861.5	Full replacement of the central heating system. Regular training for employees in efficient energy management.	389.1
29	public building	7 401.03	Regular training for employees in efficient energy management.	7.2
30	public building	2000	Modernisation of the central heating system.	22.3
31	public building	12 424	Replacement of lighting with energy efficient lighting.	39.9
32	public building	6 459.99	Replacement of lighting with energy efficient lighting.	18.4
33	public building	10 263.6	Replacement of lighting with energy efficient lighting. Regular training for employees in efficient energy management.	677.4
34	public building	682.9	Replacement of lighting with energy efficient lighting. Regular training for employees in efficient energy management.	62.96
35	public building	552.2	Replacement of lighting with energy efficient lighting. Regular training for employees in efficient energy management.	109.13
36	public building	1 442.45	Replacement of lighting with energy efficient lighting. Regular training for employees in efficient energy management.	132.1
37	public building	1 098.8	Replacement of lighting with energy efficient lighting. Regular training for employees in efficient energy management.	91.9
38	public building	14 530.6	Replacement of lighting with energy efficient lighting. Regular training for employees in efficient energy management.	29.4
	TOTAL	**298 355.9**	**-**	**5 446.24**

The above table is compiled on the basis of data provided by central government bodies, as defined by Article 5(1) of Directive 2012/27/EU.

In light of the results obtained in 2016, it is estimated that the energy savings target of 4 344 MWh/year for central government buildings, pursued through the alternative approach will be attained.

3.3.2 Public bodies' buildings (Article 5(7) of Directive 2012/27/EU)

The requirement for public bodies to play an exemplary role is fulfilled on the basis of the Act of 20 May 2016 *on energy efficiency*, which defines, inter alia, the responsibilities of such bodies as regards the use of energy efficiency improvement measures. Pursuant to Article 6 of the Act, in carrying out its tasks, a public body is required to apply at least one out of the five energy efficiency improvement measures listed by the Act. The measures include thermomodernisation projects, as referred to in the Act of 21 November 2008 *on supporting thermomodernisation and repairs*. Delivering the thermomodernisation projects identified by an energy audit is recommended on the basis of their economic viability. Such projects can receive funding from NFOŚiGW.

Public bodies also play an exemplary role also by promoting low-energy buildings. Since 2016, co-funding from EU funds for public buildings, i.e. construction of schools, hospitals, etc., is granted exclusively for buildings with enhanced energy efficiency, primarily low-energy buildings. Promoting demonstration and pilot projects involving the construction of low-energy public buildings is also planned. Taking into account the pilot nature of such activities, the grant component should be higher than in the case of conventional activities connected with thermomodernisation of public buildings. A description of Submeasure 1.3.1 of the Operational Programme Infrastructure and Environment (OPI&E) 2014-2020, which is dedicated to the energy efficiency of public bodies' buildings, is presented in Annex No 3, in section 3.2. Sources of funding.

In 2015, NFOŚiGW, which is the main institution implementing EU cohesion funds in the field of environmental protection and energy efficiency, launched an initiative which worked towards the preparation of low-emission economy plans by all local governments willing to receive co-funding. Co-funding under OPI&E 2007-2013 (Measure 9.3 – Thermomodernisation of public buildings) was available for the preparation of documents to be included in municipal low-emission economy plans on the basis of information about the reduction of final energy consumption and carbon dioxide emissions required to achieve the 2020 climate and energy targets. The preparation of the plans by municipalities was a basis, *inter alia*, for receiving co-funding under OPI&E in the period 2014-2020 for purposes related to energy efficiency and improving air quality by reducing dust, sulphur dioxide and nitrogen oxide emissions within areas where specific pollution levels are exceeded. The above initiative is in line with Article 5(7) of Directive 2012/27/EU, and it was undertaken to coordinate and optimise activities at the local and

regional levels. According to guidelines on their preparation[25], the plans should identify the stakeholders and define specific investment activities in various areas (e.g. municipal and industrial buildings and installations, residential buildings, street lighting, industrial plants, and heat distribution plants). In addition to the above initiative, a number of cities have drawn up Action Plans for Sustainable Energy Consumption (Plany działań na rzecz zrównoważonego zużycia energii) in connection with their accession into the Covenant of Mayors. This has resulted in the creation of an extensive database containing local governments' plans regarding, inter alia, energy savings and associated activities for most of the territory of Poland.

Low-emission economy plans have been used to create a database on energy savings for individual sectors, comprising 256 cities/municipalities, including all province capitals, about 90% of regional cities, and 18.6% of local cities (in total, the database covers about 60% of the population).

Table 16. Description of energy efficiency measures in public bodies

Name of measure:	**Operational Programme PL04** – "**Saving energy and promoting renewable energy sources**" **under the EEA Financial Mechanism in 2009-2014 (Area No 5 – energy efficiency, and Area No 6 – renewable energy);**
Category	Funds
Programme objective	The objective of the programme is to reduce greenhouse gas emissions and air pollution, and to increase the share of renewable energy in the total balance of energy use.
Programme actions	Thermomodernisation of public buildings. Works necessary to reduce the consumption of electricity needed for the use of buildings. Refurbishment or replacement of existing energy sources (including replacement or reconstruction of obsolete local networks) supplying public buildings with modern, energy efficient and environmentally friendly heat or electricity sources with a total rated capacity of up to 5 MW, including: renewable energy sources or sources of heat and electricity produced through combined generation (cogeneration/trigeneration). Installation, retrofitting, or replacement of district heating substations supplying public buildings with a total rated capacity of up to 3 MW.
Status	Completed – calls for proposals have been closed, new competitive procedures are not planned; the launch of a new programme is being negotiated.
Timeframe	From 2013 to 2017
Type of beneficiaries	Public finance sector entities or non-public entities carrying out public tasks.
Implementing body	Ministry of the Environment in partnership with NFOŚiGW
Budget/	EUR 73 million – Area No 5, EUR 5.08 million – Area No 6;

[25] https://www.wfosigw.katowice.pl/files/kwiecien15/plany_gosp_niskoemisyjnej.pdf

Source of funding	EEA Financial Mechanism and Norway Grants in the years 2009-2014.

Table 17. Description of energy efficiency measures in public bodies

Name of measure:	**Green Investment Scheme – GIS. Part 5 – Energy management in buildings of selected public finance sector entities;**
Category	Funds
Programme objective	Reduction or avoidance of carbon dioxide emissions by co-funding projects improving the efficiency of energy use in buildings of selected public finance sector entities.
Programme actions	Thermomodernisation of buildings, including their refurbishment with equipment satisfying the highest, economically justifiable energy efficiency standards and linked directly with the thermomodernisation of the buildings, in particular: ▪ insulation of the building; ▪ replacement of windows; ▪ replacement of external doors; ▪ reconstruction of heating systems (including heat source replacement); ▪ replacement of ventilation and air conditioning systems; ▪ preparation of the technical documentation for the investment; ▪ use of energy management systems in buildings; ▪ use of RES technologies; ▪ replacement of indoor lighting with energy efficient lighting (as additional actions implemented in parallel to the thermomodernisation of a building).
Status	Completed – 2 competitive procedures were announced for which the calls for proposals have been closed, new competitive procedures are not planned.
Timeframe	From 2010 to 2016
Type of beneficiaries	Part A ▪ The Polish Academy of Sciences and scientific institutes set up by the Academy; ▪ State cultural institutions; ▪ local government's cultural institutions acting on the basis of the Act on the organisation and management of cultural activities; ▪ institutions of the state budget economy (instytucje gospodarki budżetowej); ▪ district and municipal units of the State Fire Service. Part B state budgetary entities (państwowe jednostki budżetowe).
Implementing body	NFOŚiGW
Budget /Source of funding	PLN 514 million (including PLN 128 million under part A and PLN 386 million under part B). Proceeds from the sale of allocated AAUs or from other NFOŚiGW funds:

Table 18. Description of energy efficiency measures in public bodies

Name of measure:	**Green Investment Scheme – GIS. Part 6 – SOWA project – Energy efficient street lighting**
Category	Funds
Programme objective	Reduction of carbon dioxide emissions by supporting projects improving the energy efficiency of street lighting systems.
Programme actions	Co-funding can be granted for the implementation of projects involving: ▪ modernisation of street lighting (including replacement of: light sources, fittings, igniters, feeder cables, poles, adding new lighting points to existing modernised street lamp lines if required to comply with all the parts of the series of standards PN-EN 13201 *Road lighting*); ▪ installation of smart lighting controls; ▪ installation of controllable power reduction and supply voltage stabilisation systems.
Status	Completed – 1 competitive procedure was announced for which the calls for proposals have been closed, new competitive procedures are not planned.
Timeframe	From 2013 to 2017
Type of beneficiaries	Local governments responsible for managing street lighting infrastructure insofar as the respective project is concerned.
Implementing body	NFOŚiGW
Budget/Source of funding	PLN 147 million, including: PLN 74 million – Non-reimbursable forms (grants), PLN 73 million – Reimbursable forms (loans)/ Proceeds from the sale of allocated AAUs or from other NFOŚiGW funds.

Table 19. Description of energy efficiency measures in public bodies

Name of measure:	**Operational Programme Infrastructure and Environment 2007‑2013 (Measure 9.3) Thermomodernisation of public buildings**
Category	Funds
Programme objective	Reduction of energy consumption in the public sector. In addition, the preparation of low-emission economy plans has supported the delivery of the 2020 targets related to reducing greenhouse gas emissions, increasing the share of RES energy, reducing the consumption of final energy by improving energy efficiency, and meeting the air quality standards established by Directive 2008/50/EC of the European Parliament and of the Council of 21 May 2008 on ambient air quality and cleaner air for Europe (CAFE).
Programme actions	The measure was dedicated to projects involving the thermomodernisation of public buildings, together with their refurnishing with energy efficient equipment, including: ▪ insulation of buildings; ▪ replacement of windows, external doors, and lighting with energy-efficient lighting; ▪ reconstruction of heating systems (including heat source replacement), as well as ventilation and air-conditioning systems. Co-funding was available for the preparation of documents to be included in municipalities' low-emission economy plans. Under the support of low-emission economy plans, municipalities

	obtained support for obligatory measures, i.e.: ▪ preparation or updating of the plan; ▪ the creation in the municipality of a database with selected and organised information to be used for assessing energy management in the municipality and across its sectors and buildings, and to take stock of greenhouse gas emissions; ▪ training for the staff of municipalities on issues related to the preparation of low-emission economy plans; ▪ information and publicity concerning the contribution of OPI&E co-funding to the creation of low-emission economy plans, and publicising information about the preparation of such plans. Additionally, support was available for optional activities, i.e.: ▪ preparation of elements to be used in newly prepared or updated plans (or in the assumption documents for such plans) for the supply of heat, electricity, or gas, and completing a strategic environmental assessment.
Status	Completed
Timeframe	From 2007 to 2015
Type of beneficiaries	Public finance sector entities, i.e.: - local governments and their unions and associations; - state budgetary entities; - entities other than entrepreneurs which provide public services to fulfil own tasks of local governments; - public authorities, including central government bodies, state inspection authorities, law enforcement authorities, courts and tribunals; - the Police, the Fire Service (including the Voluntary Fire Service), and the Municipal Police; - state higher education institutions; - autonomous public healthcare institutions. Non-governmental organisations, churches, church legal persons and their associations, and other religious associations.
Implementing body	NFOŚiGW
Budget/Source of funding	EUR 109.41 million – contributions from the Cohesion Fund EUR 19.31 million – national public contributions.

3.4. Energy efficiency measures in industry and SMEs:

Article 24(2) of Directive 2012/27/EU requires the provision of detailed information concerning all energy efficiency improvement measures which are helpful in implementing the main elements of the Directive. This section presents information on energy efficiency measures relevant for industry, including those which have been put in place to improve energy efficiency among small and medium-sized enterprises (SMEs), and large enterprises.

Activities which work towards improving energy efficiency in the sector of enterprises will be supported, inter alia, by the Cohesion Fund under the Operational Programme Infrastructure and Environment 2014-2020 (Measure 1.2 – Promoting energy efficiency and use of renewable energy sources in enterprises).

Table 20. Description of energy efficiency measures in industry and SMEs

Name of measure:	**1. Support for enterprises as regards low-emission and resource-efficient economy. Part 1 – Energy/electricity audit of an enterprise**
Category	Funds
Programme objective	The objective of the programme is to reduce negative impacts of enterprises on the environment by promoting energy efficiency.
Programme actions	Co-funding is available for energy audits of technological processes, electrical audits of buildings and in-plant electrical networks, energy audits of electricity, heat, and cold sources, energy audits of in-plant heating networks and buildings.
Status	Completed
Timeframe	From 2011 to 2014
Type of beneficiaries	Entrepreneurs within the meaning of the Act of 2 July 2004 on the freedom of economic activity (Journal of Laws of 2016, item 1829, as amended) which undertake energy savings projects and in which the minimum average energy consumption (sum of electricity and heat) was 20 GWh/year.
Implementing body	NFOŚiGW
Budget/Source of funding	PLN 32.2 million, NFOŚiGW funds: non-reimbursable forms (grants)

Table 21. Description of energy efficiency measures in industry and SMEs

Name of measure:	**2. Support for enterprises as regards low-emission and resource-efficient economy. Part 2 – Improving energy efficiency**
Category	Funds
Programme objective	The objective of the programme is to reduce the negative impact of enterprises on the environment.
Programme actions	Implementation of energy and quality management systems and systems for the management of electrical networks in buildings of enterprises. Electricity use rationalisation technologies, such as: ▪ energy-saving drive systems; ▪ drive control systems e.g. soft start installations;

	▪ energy efficient engines; ▪ pump and fan inverters; ▪ energy efficient compressors and their control systems; ▪ in-plant electricity transmission networks, including limitation of reactive power flows; ▪ energy efficient lighting systems; ▪ network drive rectifiers; ▪ higher efficiency transformers within local power systems and in-plant distribution networks. Heat use rationalisation technologies, including: ▪ insulation and dewatering of steam systems; ▪ renewable energy sources, including geothermal systems, solar collectors, and heat pumps; ▪ thermomodernisation of industrial and office buildings; ▪ heat recuperation and recovery from processes and equipment; ▪ refurbishment of internal heating networks; ▪ using energy from waste generated by industrial processes; ▪ construction/refurbishment of own (in-plant) energy sources, including cogeneration. Modernisation of industrial processes in terms of energy efficiency.
Status	Completed
Timeframe	From 2013 to 2017
Type of beneficiaries	Entrepreneurs within the meaning of the Act of 2 July 2004 on the freedom of economic activity (Journal of Laws of 2016, item 1829, as amended) which undertake energy savings projects and in which the minimum average energy consumption (sum of electricity and heat) was 20 GWh/year.
Implementing body	NFOŚiGW
Budget/Source of funding	PLN 724.5 million, NFOŚiGW funds: reimbursable forms (loans)

Table 22. Description of energy efficiency measures in industry and SMEs

Name of measure:	**3. Financial facility for SMEs (PolSEFF);**
Category	Funds
Programme objective	PolSEFF stands for the Polish Sustainable Energy Financing Facility, with a credit line of EUR 150 million. PolSEFF's offer is addressed to small and medium-sized enterprises (SMEs) willing to invest in new, sustainable energy technologies and equipment reducing energy consumption, or to produce renewable energy.
Programme actions	Loan- or leasing-based funding of up to EUR 1 million can be obtained from the financial institutions participating in the Programme (banks and leasing institutions). ▪ Investments leading to savings of consumed energy of at least 20%. ▪ Investments improving the efficiency of energy use in buildings which reduce energy consumption in commercial and administrative buildings of SMEs by 30%. ▪ Investments in renewable energy sources. ▪ Investments comprising selected technologies – investments in

	projects and equipment selected from a pre-specified list of technologies.
Status	Completed
Timeframe	From 2011 to 2014
Type of beneficiaries	Small and medium-sized enterprises (SMEs)
Implementing body	European Bank for Reconstruction and Development (EBRD)
Budget/Source of funding	EUR 180 million, EBRD funds

Table 23. Description of energy efficiency measures in industry and SMEs

Name of measure:	**4. Operational Programme Infrastructure and Environment 2007‑2013 (Measure 9.1) – High-efficiency energy generation**
Category	Funds
Programme objective	Improving the efficiency of electricity and heat generation. Supporting investment projects involving reconstruction and construction of units for combined heat and electricity generation meeting the requirements of high‑efficiency cogeneration. Promoting high-efficiency cogeneration based on the demand for useful heat is one of the EU priorities on account of the primary energy use efficiency, avoiding network losses, and reducing emissions of harmful substances it offers.
Programme actions	Construction or reconstruction of combined heat and electricity generation units so that they meet the high-efficiency cogeneration requirements defined by Directive 2004/8/EC. Construction or reconstruction of heat generation units by replacing them with cogeneration units meeting the high-efficiency cogeneration requirements defined by Directive 2004/8/EC.
Status	Completed
Timeframe	From 2007 to 2014
Type of beneficiaries	▪ Entrepreneurs. ▪ Local governments and their unions and associations; ▪ Entities which provide public services to fulfil own tasks of local governments.
Implementing body	NFOŚiGW
Budget/source of funding	EUR 46.66 million – contributions from the Cohesion Fund EUR 8.81 million – national public contributions

Table 24. Description of energy efficiency measures in industry and SMEs

Name of measure:	**5. Operational Programme Infrastructure and Environment 2007‑2013 (Measure 9.2) – Efficient energy distribution**
Category	Funds
Programme objective	Reducing energy losses in energy and heat distribution.

Programme actions	The measure included comprehensive projects involving the construction (in place of existing systems) or alteration of high, medium and low voltage power distribution networks with a view to reducing network losses (replacement of low energy-efficiency transformers, shortening power lines extending over very long distances, changing the cross-section of wires to adjust them to existing grid temperatures and other types of projects producing equivalent environmental effects). The measure also supported investment projects comprising alteration and construction (in place of existing systems) of heat distribution networks with the highest possible potential for reducing energy losses.
Status	Completed
Timeframe	From 2007 to 2015
Type of beneficiaries	▪ Entrepreneurs ▪ Local governments and their unions and associations; ▪ Entities which provide public services to fulfil own tasks of local governments.
Implementing body	NFOŚiGW
Budget/Source of funding	EUR 224.41 million – contributions from the Cohesion Fund EUR 6.24 million – national public contributions

Table 25. Description of energy efficiency measures in industry and SMEs

Name of measure:	**6. Improving energy efficiency, Part 3 – Energy efficient investments in small and medium-sized enterprises;**
Category	Funds
Programme objective	The objective of the programme is to reduce energy consumption as a result of energy efficiency and RES investments in the SME sector. The implementation of the programme will reduce CO_2 emissions.
Programme actions	Co-funding can be granted for the implementation of LEME projects, including investments related to: • improving energy efficiency and/or use of renewable energy sources; • thermomodernisation of buildings and/or use of renewable energy sources implemented through the purchase of materials/equipment/technologies included in LEME (List of Eligible Material and Equipment, published on the website of NFOŚiGW). Supported Investments – projects involving investments not eligible as LEME investments, related to: • improving energy efficiency and/or renewable energy sources leading to at least 20% energy savings; • thermomodernisation of buildings and/or renewable energy sources leading to at least 30% energy savings.
Status	Completed – the call for applications for partial repayment of the principal of bank loans carried out by banks has been closed.
Timeframe	From 2014 to 2016
Type of beneficiaries	Private legal entities (enterprises) established on the basis of Polish law and operating in Poland. Beneficiaries must meet the definition of micro-enterprises, and small and medium-sized

	enterprises as laid down by Commission Recommendation of 6 May 2003 on definition of micro-enterprises, and of small and medium-sized enterprises (OJ L 124, 20.5.2003, p. 36)
Implementing body	NFOŚiGW
Budget/Source of funding	NFOŚiGW funds: PLN 41 million – Non-reimbursable forms (grants).

Table 26. Description of energy efficiency measures in industry and SMEs

Name of measure:	**7. Operational Programme Infrastructure and Environment 2014-2020 (Measure 1.2) – Promoting energy efficiency and use of renewable energy sources in enterprises;**
Category	Funds
Programme objective	The effect will be the creation by enterprises of production systems based on the principles of sustainable use of resources, and improved energy efficiency will lead to establishing more efficient production systems in enterprises, thus improving the competitiveness of the economy.
Programme actions	Support is dedicated for large enterprises and it focuses on the application of solutions which optimise energy management and increase energy efficiency, including the use of renewable energy sources. The measure supports projects, as identified by energy audits of enterprises, aimed at improving energy efficiency, as well as the associated technological retrofits of existing constructions, installations, and technical equipment, including: ▪ reconstruction of existing production lines to make them more energy efficient; ▪ deep, comprehensive energy-related refurbishment of buildings in enterprises; ▪ use of energy efficient technologies in enterprises by reconstruction or replacement of equipment and process installations, lighting, as well as transport systems and production lines with energy-saving ones. ▪ construction or reconstruction of local heat sources (including source replacement with RES installations), ▪ putting in place an energy recovery technology together with a system for waste heat energy utilisation within the enterprise. Putting in place smart energy management systems in the enterprise should be an integral part of the project.
Status	Under implementation – in March 2017 a second call for proposals was announced.
Timeframe	From 1 January 2014 to 31 December 2023 (subject to state aid rules)
Type of beneficiaries	Large enterprises or energy service providers within the meaning of Directive 2012/27/EU acting for large enterprises (having one of the legal forms referred to in the Detailed Description of Priority Axes of OPI&E 2014-2020.
Implementing body	NFOŚiGW

Planned budget/Source of funding	EUR 150.32 million, EU allocation (the Cohesion Fund) in the form of reimbursable aid

Table 27. Description of energy efficiency measures in industry and SMEs

Name of measure:	**8. Supporting projects related to low-emission and resource-efficient economy. Part 4 – Energy efficiency in enterprises**
Category	Funds
Programme objective	The objective of the programme is to reduce the negative impacts of enterprises on the environment through investments.
Programme actions	Projects foreseen by the "Notice of the Minister of Energy of 23 November 2016 *establishing a detailed list of energy efficiency projects*" aimed at improving energy efficiency, as well as associated technological retrofits of existing buildings, installations, and technical equipment, including: 1) Electricity use rationalisation technologies, such as: a) energy-saving drive systems; b) drive control systems e.g. soft start installations; c) pump and fan inverters; d) energy efficient compressors and their control systems; e) in-plant electricity transmission networks, including limitation of reactive power flows; f) energy efficient lighting systems; g) network drive rectifiers; h) low-loss transformers within local power systems and in-plant distribution networks; i) renewable energy sources, including wind turbines, solar collectors, photovoltaic panels, and small hydropower power stations, j) construction/refurbishment of own (in-plant) energy sources, including cogeneration. 2) Heat use rationalisation technologies, including: a) insulation and dewatering of steam systems; b) renewable energy sources, including geothermal systems, solar collectors, and heat pumps; c) thermomodernisation of industrial and office buildings; d) heat recuperation and recovery from processes and equipment; e) alteration of in-plant heating networks; f) using energy from waste generated by industrial processes; g) construction/refurbishment of own (in-plant) energy sources, including cogeneration. 3) Refurbishment of industrial processes in terms of energy efficiency. 4) Implementation of energy and energy quality management systems and putting in place systems for the management of electrical networks in enterprises' facilities. In order to receive support for the above, applicants must jointly fulfil the following conditions: 1) The amount of average final energy consumption (sum of electrical and heat energy) of the entity applying for co-funding in the year preceding the application was at least 2 GWh/year; 2) Applying for support under the programme is conditional on

	carrying out a previous energy audit (performed in line with the Energy Audit Preparation Recommendations published on the NFOŚiGW website) in at least one of the following areas: a) energy audits of industrial buildings, b) energy audits of in-plant heating networks, c) energy audits of heat, electricity and cold sources, d) energy audits of technological processes, e) electrical audits – optimisation of the consumption of electricity by buildings, installations and in-plant transmission networks; 3) A co-financed investment must follow from the recommendations of an energy audit (as verified by NFOŚiGW during the evaluation of applications for co-funding, and the energy savings must not be lower than 5%); 4) In the case of heating network investments, once they are completed, the heating system is to meet the definition of "efficient district heating" following from Directive 2012/27/EU (this applies to loans granted on preferential terms).
Status	Under implementation
Timeframe	From 2017 to 2023
Type of beneficiaries	Entrepreneurs within the meaning of the Act of 2 July 2004 on the freedom of economic activity (Journal of Laws of 2016, item 1829, as amended) conducting business operations in the form of an enterprise within the meaning of Article 55 of the Civil Code of 23 April 1964.
Implementing body	NFOŚiGW
Budget/Source of funding	PLN 500 million, NFOŚiGW funds: reimbursable forms (loans)

Regional Operational Programmes for 2014-2020

Energy efficiency and use of renewable energy sources in enterprises will also be promoted at the level of Regional Operational Programmes financed by the European Regional Development Fund (ERDF) (most ROPs provide for supporting enterprises in the area of energy efficiency). When a particular ROP does not foresee measures in this respect dedicated for entrepreneurs, intervention will be possible through the nationwide programme. The allocation of interventions between the OPI&E and ROPs is defined by a set of criteria referred to as the Demarcation Line.

The intervention area covers broad-ranging activities increasing energy efficiency in small and medium-sized enterprises, and detailed information concerning, inter alia, the types of investments and potential beneficiaries are presented in implementing documents of ROPs.

3.5. Energy efficiency measures in transport

This section presents information on measures designed to improve energy efficiency in passenger and goods transport, and to support transportation towards more sustainable modes of transport.

Projects were delivered under OPI&E 2007-2013, Measure 7.3 – Urban transport in metropolitan areas, and Measure 8.3 – Development of intelligent transport systems. In addition, NFOŚiGW implemented a programme under the Green Investment Scheme (GIS), Part 7, GAZELA – Low-emission urban transport, which was dedicated to projects reducing the consumption of energy and fuels in urban transport. The programme comprised such activities as: purchase of new hybrid buses powered by CNG; training of public transport vehicle drivers in operating low-emission vehicles; infrastructure- and management-related activities consisting of the retrofitting or construction of refuelling points for public transport vehicles, such as to serve hybrid buses powered by CNG; upgrading or construction of bicycle routes; upgrading or construction of bus lanes; modernisation or construction of "Park& Ride" facilities; implementation of urban transport management systems; launching city bike systems.

Currently, supporting public transport is an element of the implementation of actions under Measure 6.1 of OPI&E 2014‑2020, which follow from local governments' low-emission economy plans, whose scope covers sustainable urban mobility. The investments are focused either on infrastructure or vehicles, or are comprehensive in nature, covering both types of projects. Preference is given to projects targeted at rail transport and bus fleets powered by fuels alternative to combustion engines. The projects also include other elements complementary to the essential linear infrastructure (investments), including Intelligent Transport Systems (ITSs), which improve the efficiency of the transport system as a whole. The projects will ensure infrastructural integration of existing modes of transport and will make the transport system capable of serving persons with limited mobility.

EU support for low-emission public transport in cities is also foreseen under the Operational Programme Eastern Poland 2014-2020 (which is the continuation of the Operational Programme Development of Eastern Poland 2007-2013) and under Regional Operational Programmes for 2014-2020.

Table 28. Description of energy efficiency measures in transport

Name of measure:	**1. Operational Programme Infrastructure and Environment 2007‑2013 (Measure 7.3) – Urban transport in metropolitan areas, and (Measure 8.3) - Development of intelligent transport systems**
Category	Funds
Programme objective	The programme is intended to improve traffic management by implementing Intelligent Transport Systems in road, maritime, inland water and urban transportation, as well as in intermodal transport, and to increase the share of environmentally friendly public transport serving residents of metropolitan areas, which will contribute to reducing energy consumption for transportation purposes.
Programme actions	1. Adaptation, construction, reconstruction, and development of railway systems (fast city train, tramway, and metro) and trolleybus networks: ▪ construction, reconstruction, and development of the track system along routes, at terminuses, sidings, and depots, including purchase of rolling stock and vehicles; ▪ adaptation of the railway network to the needs of urban public transport; ▪ construction, reconstruction, and development of metro lines, including purchase of rolling stock; ▪ construction, reconstruction, and extension of tramway and trolleybus overhead line networks and traction substations; ▪ providing roads, streets, and tracks with engineering structures and necessary road facilities to improve traffic safety of public transport vehicles; ▪ providing roads and streets with infrastructure serving public transport (e.g. lay-byes, ramps, exit roads) and passengers (e.g. stops, islands); ▪ modernisation of rolling stock and trolleybus fleet; ▪ purchase of rolling stock and trolleybus fleet, including necessary infrastructure for their maintenance; ▪ purchase of diesel multiple units (DMUs). 2. Construction, reconstruction, development of stops, stations and transport interchanges integrated with various types of transport systems, including: - "Park & Ride" and "Bike & Ride" facilities at terminal stops and transport interchanges for public transport needs, including associated infrastructure for serving passengers. 3. Telematics projects improving the functioning of public transport: - sound signalling systems; - systems of traffic lights activated by buses, trolleybuses, and trams (intelligent traffic lights); - tickets distribution and identification systems; - satellite navigation systems for improved traffic flow and increased safety of public transport; - traveller information systems – electronic display boards, including on-line systems; - security surveillance systems installed at stops, platforms, stations, transport interchanges, parking lots, and on board of vehicles. 4. Preparatory work for projects to be delivered under the measure.

	5. Road, maritime, inland waterway and intermodal transport projects related to: - traffic management; - passenger services; - fare collection; - crisis management in transport; - traffic safety; - traveller information; - data collection and processing. 6. City traffic management projects involving the purchase and installation of traffic management systems, including: - centralised signalling and traffic control systems; - traffic monitoring systems on key routes, in tunnels, critical points of the city, including real-time traffic information.
Status	Completed
Timeframe	From 2007 to 2014
Type of beneficiaries	▪ Municipalities and towns with district rights (miasta na prawach powiatu) in 9 metropolitan areas, or organisational entities acting on their behalf; ▪ Unions of local governments; ▪ Passenger transport operators acting on the basis of relevant agreements; ▪ Road managers; ▪ Transport infrastructure managers; ▪ Railway infrastructure managers; Provincial governments or organisational entities entrusted tasks falling within the competence of provincial governments.
Implementing body	The Centre for European Union Transport Projects (CUPT):
Budget/ Source of funding	EUR 2 905.70 million – contributions from the Cohesion Fund EUR 222.78 million – national public contributions

Table 29. Description of energy efficiency measures in transport

Name of measure:	**2. Green Investment Scheme – GIS. Part 7 – GAZELA – Low-emission urban transport**
Category	Funds
Programme objective	Reducing or avoiding carbon dioxide emissions by co-funding projects intended to reduce energy and fuel consumption by urban transport.
Programme actions	Co-funding is available for carrying out projects aimed at reducing the consumption of energy and fuel by urban transport. The programme covers the following measures: 1) related to the fleet: ▪ purchase of new hybrid buses powered by CNG; ▪ training of public transport vehicle drivers in operating low-emission vehicles; 2) related to infrastructure and management: ▪ refurbishment or construction of refuelling points for public transport vehicles, such as to serve hybrid buses powered by CNG; ▪ upgrading or construction of bicycle routes; ▪ upgrading or construction of bus lanes; ▪ modernisation or construction of “Park& Ride” facilities;

	▪ implementation of urban transport management systems; ▪ launching city bike systems.
Status	Completed – calls for proposals have been closed, new competitive procedures are not planned;
Timeframe	From 2013 to 2015
Type of beneficiaries	▪ urban municipalities; ▪ municipal companies carrying out tasks of urban municipalities related to local public transport; ▪ other entities providing local urban transport services on the basis of agreements concluded with urban municipalities.
Implementing body	NFOŚiGW
Budget/Source of funding	NFOŚiGW funds: PLN 80 million – Non-reimbursable forms (grants) Proceeds from the sale of allocated AAUs.

Table 30. Description of energy efficiency measures in transport

Name of measure:	**3. Operational Programme Infrastructure and Environment 2014-2020 Measure 6.1 – Developing public transport in cities**
Category	Funds
Programme objective	The purpose of interventions under the operational programme will be to develop and enhance the use of low-emission urban transport in serving residents of cities' functional areas.
Programme actions	1. Infrastructural investments: adaptation, construction, reconstruction, extension of urban transport networks, including: – construction, reconstruction, and development of the track system along routes, and at terminuses, sidings, and depots; – construction of a metro line, – construction, reconstruction, and extension of tramway and trolleybus overhead line networks and traction substations; – reconstruction and development of roads for the purpose of introducing privileged traffic or privileging existing traffic of public transport vehicles, – providing roads, streets, and tracks with engineering structures and necessary road facilities/ purchase of necessary equipment to ensure traffic safety of public transport vehicles; – providing roads and streets with infrastructure serving public transport (e.g. lay-byes, ramps, exit roads) and passengers (e.g. stops, islands); – construction, reconstruction and development of transport interchanges, including "Park & Ride" and "Bike & Ride" systems; – construction of Personal Rapid Transport (PRT) systems. 2. Rolling stock and fleet investments: purchase, upgrading of rolling stock (trams, metro) and trolleybus and bus fleets, including infrastructure necessary for their maintenance (e.g. technical facilities for rolling stock and fleet servicing and maintenance, including the necessary specialist equipment, and refuelling stations and equipment for alternative fuel). Possibility to implement projects combining the above types of projects. ITS investments improving the functioning of public transport (including, for example, ticketing systems) and investments involving the construction, reconstruction and expansion of transport

	interchanges can only be implemented as elements of a project, understood also as a broader investment project following from the ITI Strategy and intended to put in place the targeted transport solutions of province capitals and their functional areas.
Status	Under implementation – evaluation and signing of co-funding agreements for projects identified within the available allocation are under way, some investments are already in progress
Timeframe	From 2016 to the end of 2023
Type of beneficiaries	▪ local governments and their unions – province capital cities and their functional areas, as well as organisational entities and special purpose vehicles acting on their behalf; ▪ managers of infrastructure used by urban transport; ▪ public transport operators.
Implementing body	The Centre for European Union Transport Projects (CUPT):
Budget/Source of funding	EUR 2 299.18 million, contributions from UE funds (the Cohesion Fund)

Table 31. Description of energy efficiency measures in transport

Name of measure:	**4. Green Investment Scheme – GIS. Part 2 – GEPARD – Zero-emission public transport**
Category	Funds
Programme objective	Avoiding low-stack carbon dioxide emissions by co-funding projects intended to reduce energy and fuel consumption by urban transport.
Programme actions	Projects aimed at reducing the consumption of energy and fuels by urban transport: 1) related to the fleet: a) purchase of new electric buses, b) training of public transport vehicle drivers in operating zero-emission vehicles; 2) related to infrastructure and management, involving refurbishment or construction of charging stations for public transport vehicles insofar as serving electric buses is concerned.
Status	The first competitive procedure in the third quarter of 2017.
Timeframe	From 2017 to 2022
Type of beneficiaries	▪ urban municipalities and urban-rural municipalities, ▪ municipal companies carrying out tasks of urban municipalities related to local public transport; ▪ other entities providing local urban transport services on the basis of agreements concluded with municipalities.
Implementing body	NFOŚiGW
Budget/Source of funding	PLN 200 million, including: PLN 41 million – Non-reimbursable forms (grants)/ proceeds from the sale of allocated AAUs. PLN 159 million – Reimbursable forms (loans)/ NFOŚiGW own funds.

3.6. Efficiency of energy generation and supply (Article 14 of the Directive)

3.6.1 Comprehensive assessment of the potential

In connection with the implementation of Article 14(1) of Directive 2012/27/EU, the minister competent for energy is statutorily required to prepare a comprehensive assessment of the potential for the production of electricity through high‑efficiency cogeneration and energy-efficient district heating or cooling. The first such comprehensive assessment of the potential was prepared and transmitted to the European Commission in December 2015.

In accordance with the definition laid down by Article 2(41) of Directive 2012/27/EU, "efficient district heating and cooling" means a district heating or cooling system using at least 50% renewable energy, 50% waste heat, 75% cogenerated heat or 50% of a combination of such energy and heat.

Pursuant to the Act of 20 May 2016 *on energy efficiency*, the minister competent for energy is required to prepare a comprehensive assessment of the potential for the production of electricity through high-efficiency cogeneration and for energy-efficient district heating or cooling, and to submit it to the European Commission. In order to prepare such an assessment, the minister is required to carry out an analysis of introducing specific variants of the production of electricity through high-efficiency cogeneration and energy-efficient district heating or cooling in the territory of Poland, including the technical feasibility and economic viability of these variants.

Pursuant to the guidelines included in the last paragraph of Part 1 of Annex IX to Directive 2012/27/EU, it was also decided that competent local authorities, i.e. municipalities, should be assigned own tasks consisting of the preparation of economic and financial analyses to assess the potential within their territories. An assessment of the potential is also included as an obligatory element in draft assumption documents for heat, electricity and gas fuel supply plans prepared by municipalities.

Moreover, pursuant to the above Act, which implements Article 14 of Directive 2012/27/EU, a cost and benefit analysis covering the entire territory of Poland has been carried out for the needs of the comprehensive assessment. Energy companies generating, transmitting and distributing electricity or heat, and enterprises planning the construction or refurbishment of a generating unit are under an obligation to prepare a cost and benefit analysis regarding the construction or refurbishment of such a generating unit.

The purpose of the above analysis is to identify the most resource- and cost-efficient solutions which ensure that the applicable heating and cooling requirements are met. The analysis is prepared on the basis of a description of the planned construction or refurbishment of the generating unit, based on: the installed electricity or heat generation capacity, the type of fuel used

for generating electricity or heat, the anticipated useful life of the generating unit, the estimated number of hours of operation of the generating unit per year, the location of the generating unit, and the demand for electricity or heat.

3.6.2 Energy efficiency measures related to the generation and supply of energy

Article 24(2) of Directive 2012/27/EU and Part 2.2 of Annex XIV to the Directive require providing detailed information concerning all energy efficiency improvement measures which are helpful in implementing the main elements of the Directive. This subsection presents an overview of energy efficiency measures related to the electricity and heat supply sector.

In the years 2007-2012, a support scheme addressed to producers of electricity through high-efficiency cogeneration was in place in Poland (PES>10 %). In 2014, the scheme was renewed and will remain in effect until the end of 2018. Companies producing electricity through high‑efficiency cogeneration receive certificates of origin, and then they can dispose of the property rights derived from these certificates either at an exchange or through bilateral contracts. The Energy law of 10 April 1997 (Journal of Laws of 2017, item 220, as amended) identifies the entities which are obliged to redeem certificates of origin, and specifies the amounts under this obligation for each year.

In addition, there are other legal instruments for supporting companies producing electricity through high-efficiency cogeneration:

- within its respective scope of operation, a power system operator is required to ensure that all entities are given priority in transmitting and distributing the electricity they produce through high-efficiency cogeneration, while maintaining the reliability and security of the national power system;
- within its respective scope of operation, a power system operator is required to receive electricity produced through high-efficiency cogeneration by sources connected directly to the operator’s grid and located within the territory of the Republic of Poland;
- a requirement has been put in place whereby a new facility which is located within areas offering technical conditions for supplying heat from an energy efficient heating or cooling system and which is not connected to a district heating network or equipped with an individual heat source and in which the expected peak-load heat capacity of the installation and equipment for heating the facility is at least 50 kW, must either be connected to existing district heating network or equipped with an individual renewable heat source, a cogeneration heat source, or a waste heat source. The above requirement does not apply when the price of grid heat is equal to or higher than the average price of heat generated by the source other than the cogeneration unit, taking into account the same type of fuel.

In addition to legal instruments, there are schemes supporting investments in the construction of new high-efficiency cogeneration units and modernisation of power and heating networks which offer grants awarded on the basis of individual applications and subject to the requirements listed in the scheme description. Such schemes were implemented in Poland, *inter alia*, under the Operational Program Infrastructure and Environment (OPI&E) 2007-2013, and will be delivered under OPI&E 2014-2020.

In the period 2014-2020, the support for heating networks will be channelled to areas (mainly urban ones) which have already prepared their low-emission economy plans. Such plans may take the form of any local strategy which addresses issues related to local energy security and works towards achieving the EU's 2020 targets (3x20).[26]

With a view to increasing energy efficiency and reducing carbon dioxide emissions in urban areas, it is recommended that the efficiency of heat distribution be improved (in particular through the modernisation and extension of district heating networks), and that the efficiency of heat generation be increased by the replacement of heat sources with high‑efficiency cogeneration units.

Table 32. Efficiency of energy generation and supply

Name of measure:	**Operational Programme Infrastructure and Environment 2014‑2020 (Measure 1.5) – Efficient distribution of heating and cooling; (Measure 1.7.2 – Efficient distribution of heating and cooling in the Śląskie Province.**
Category	Funds
Programme objective	The aim of the intervention is to improve air quality by curtailing emissions of pollutants having a particularly harmful effect on people's wellbeing, i.e. reducing the so-called "low-stack emissions" in areas where the standards for PM10 concentrations are exceeded. Investments are to contribute to reducing the use of non-renewable primary energy, and curbing carbon dioxide and dust emissions to the atmosphere.
Programme actions	This measure supports improving the efficiency of heat transmission and distribution to existing consumers, in particular through modernisation and reconstruction of district heating networks and elimination of collective and individual sources of low-stack emissions, including from residential buildings, by connecting them to efficient district heating and cooling systems within the meaning of Directive 2012/27/EU, which meet, at the same time, applicable criteria for efficient heating and cooling. Co-funding under this measure will cover the following types of projects: • reconstruction of existing heating and cooling systems to reduce

[26] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Energy 2020 – A strategy for competitive, sustainable and secure energy, COM (2010) 639 final.

	transmission and distribution losses, • construction of connections for existing buildings and installation of individual substations with the aim of eliminating substations serving multiple buildings, • construction of new sections of district heating networks with connections and substations to eliminate existing local heat sources fired with solid fuels, • connecting buildings to the district heating network to eliminate individual and collective sources of low-stack emissions.
Status	Under implementation – under Measure 1.5, in 2016, two calls for proposals were completed (one on a non-competitive and one on a competitive basis), in 2017 two competitive procedures were conducted. Under Submeasure 1.7.2., in 2016, one non-competitive call for proposals was carried out, and in 2017 two competitive calls were completed.
Timeframe	From 2016 to 2023
Type of beneficiaries	▪ entrepreneurs; ▪ local governments and organisational entities acting on their behalf; ▪ housing cooperatives; ▪ entities other than entrepreneurs which provide public services to fulfil own tasks of local governments.
Implementing body	NFOŚiGW (Measure 1.5) WFOŚiGW (Measure 1.7.2)
Planned budget/Source of funding	EUR 473 million, EU contribution (the Cohesion Fund)

Table 33. Efficiency of energy generation and supply

Name of measure:	**Operational Programme Infrastructure and Environment 2014-2020 (Measure 1.6) – Promoting the use of high‑efficiency cogeneration based on the demand for useful heat.** **(Measure 1.7.3 – Promoting the use of high‑efficiency cogeneration in the Śląskie Province).**
Category	Funds
Programme objective	The measure will produce benefits connected with primary energy savings. The activities will lead to substantial reduction in emissions of carbon dioxide and other greenhouse gases, thus improving the quality of the environment at a local level by curtailing emissions of pollutants having a particularly harmful effect on human wellbeing. The programme foresees allocation for the construction of new high‑efficiency cogeneration units, or increasing the capacity of existing units producing electricity and heat through high‑efficiency cogeneration (as a result of their extension or reconstruction) for cogeneration units with a total rated electric capacity of more than 1 MW[27]. Preference will be given to projects which have the highest

[27] This applies to planned installed capacity delivered under the OPI&E. Support for projects of less than 1 MW will be available under regional operational programs.

	potential for reducing carbon dioxide emissions per unit of co-funding and generate the greatest reduction of particulate matter emissions to air.
Programme actions	Support focuses on the following areas: ▪ construction of economically viable new high-efficiency cogeneration units producing the lowest possible emissions of carbon dioxide and other pollutants to air (for RES fuels or fossil fuels), ▪ refurnishing existing plants with high-efficiency cogeneration units whereby carbon dioxide emissions are reduced by at least 30% compared to the heat flux in existing installation, ▪ construction of district heating or cooling networks (including the connections) capable of using thermal energy generated by high-efficiency cogeneration, ▪ use of waste heat produced by high-efficiency cogeneration systems as part of projects for the expansion or construction of district heating networks, ▪ construction of district heating or cooling networks capable of using heat generated by high-efficiency cogeneration (including possible use of waste heat or heat from RES installations) and increasing the utilisation of the heat produced by such installations, ▪ implementation of comprehensive projects involving the construction of new or reconstruction of existing high-efficiency cogeneration units together with district heating or cooling networks capable of utilising the heat/cold produced by the respective installation.
Status	Under implementation – under Measure 1.6, in 2016, three calls for proposals were carried out (one on a non-competitive and two on a competitive basis), in 2017, four competitive calls for proposals were organised. Under Submeasure 1.7.3., in 2016, one non-competitive call for proposals, and in 2017, two competitive calls were held.
Timeframe	From 2016 to 2023
Type of beneficiaries	▪ entrepreneurs; ▪ local governments and organisational entities acting on their behalf; ▪ entities other than entrepreneurs which provide public services to fulfil own tasks of local governments; ▪ housing cooperatives; ▪ entities which are energy service providers within the meaning of Directive 2012/27/EU and which act on behalf of local governments.
Implementing body	NFOŚiGW (Measure 1.6) WFOŚiGW (Measure 1.7.3)
Planned budget/ Source of funding	EUR 286.08 million, EU contribution (the Cohesion Fund)

Table 34. Efficiency of energy generation and supply

Name of measure:	**Supporting projects related to low-emission and resource-efficient economy. Part 3 – Efficient heating and cooling systems**
Category	Funds

Programme objective	Adaptation of existing district heating and cooling systems to the requirements following from the definition of energy efficient district heating or cooling.
Programme actions	This measure supports projects implemented in existing energy companies or industrial plants dedicated to the construction or reconstruction of generation units, including their connection to the distribution or transmission network, with the aim of bringing the district heating system of which they are part into line with the definition of *an energy-efficient district heating system*, namely such where heat or cold is generated using at least: 1) 50% renewable energy, or 2) 50% waste heat, or 3) 75% cogenerated heat, or 4) 50% of a combination of such energy and heat. The following are excluded from eligible projects: – investments involving the use of geothermal energy, – investments in heat/cold generation units which will ultimately use fuel with higher emission intensity than those used previously.
Status	Under implementation – the programme has been approved by the Supervisory Board of NFOŚiGW, the call for proposals is in progress
Timeframe	From 2016 to 2023
Type of beneficiaries	Entrepreneurs within the meaning of the Act of 2 July 2004 on the freedom of economic activity, conducting business operations in the form of an enterprise within the meaning of Article 55 of the Civil Code of 23 April 1964, if the main objects of such operations is the production of heat energy for municipal and domestic purposes (at least 30% of the heat flux generated).
Implementing body	NFOŚiGW
Planned budget/Source of funding	PLN 500 million – Reimbursable forms (loans)/ NFOŚiGW own funds

APPROVED

BY:

Prepared
by the Energy Department
of the Ministry of Energy

Annex No 1

Annual report on energy consumption in 2015 pursuant to Part 1 of Annex XIV to Directive 2012/27/EU

The table below shows data on energy consumption in 2015 pursuant to Part 1 of Annex XIV to Directive 2012/27/EU

Table. Data on energy consumption in 2015 pursuant to Part 1 of Annex XIV to Directive 2012/27/EU

Information	Unit	2015	Comments
(i) primary energy consumption	ktoe	90 318	as defined by the Directive
(ii) total final energy consumption	ktoe	67 759	includes consumption outside of the energy sector
(iii) final energy consumption by sector:			
– industry	ktoe	15 216	
– transport (passenger and freight transport)	ktoe	17 252	
– households	ktoe	18 857	
– services	ktoe	7 793	
(iv) gross value added by sector: – industry	PLN million, constant 2005 prices	488 069.2	total value added for industry and construction (sections B-F)
– services		772 916.0	total value added of sections G-T
(v) disposable income of households (net)	PLN million, current prices	1 029 206	net
(vi) gross domestic product (GDP)	PLN million, constant 2005 prices	1 450 045.2	
(vii) electricity generation from thermal power generation	GWh	4 348.718	
(viii) electricity generation from combined heat and power	GWh	147 245.526	
(ix) heat generation from thermal power generation	TJ	186 626.128	
(x) heat generation from combined heat and power plants, including industrial waste heat[28]			
(xi) fuel input for thermal power generation	ktoe	36 222	as defined by the Directive; includes also combined heat and power

[28] Presenting thermal power generation plants as a separate group in the statistics is inconsistent with the *Public Statistics Act* of 29 June 1995 (the group only includes two units). Data aggregated in the same way are sent to IEA – Eurostat, using the form: "Annual Questionnaire Electricity and Heat".

(xii) passenger kilometres (pkm)	Mpkm	52 584	excluding transport by passenger cars and by public transport
(xiii) tonne-km (tkm), if available	Mtkm	360 635	includes rail, road, pipeline, sea, inland waterway and air transport
(xv) population	’000	38 437	

Given that the indicators referred to in Part 1 of Annex XIV to Directive 2012/27/EU are not specified in an unambiguous way, the above figures are compiled on the basis of experience gained under ODYSSEE–MURE projects, which are dedicated to monitoring energy efficiency.

Annex No 2

I. Top-down calculations of final energy savings

The document entitled RECOMMENDATIONS ON MEASUREMENT AND VERIFICATION METHODS IN THE FRAMEWORK OF DIRECTIVE 2006/32/EC ON ENERGY END-USE EFFICIENCY AND ENERGY SERVICES recommends a methodology for calculating energy savings for the needs of Article 4 of Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 on energy end-use efficiency and energy services, and repealing Council Directive 93/76/EEC (OJ L 114, 27.04.2006, p. 64, as amended). The European Commission developed this methodology with the support and active participation of EU Member States. Methods recommended in the document represent harmonised principles for calculating final energy savings for the needs of the ESD. The procedures include: recommended formulae for top-down calculations of energy efficiency indicators and for bottom-up calculations of energy savings, as well as the recommended energy efficiency action timeframes to be used in the bottom-up calculations.

- The top-down model relies on aggregated data, as a result of which the method is also referred to as "energy efficiency indicators". It can be used to determine correct indicators of the development of the situation, which do not produce precise energy savings calculations. Usually, such calculations are used, for example, for modes of transport, industrial subsectors, etc. The calculated values of energy consumption or energy intensity are subject to adjustments based on such external factors as the number of degree days during the heating season, structural changes, production profiles, etc.
- The bottom-up method (from details to general concept) is a more precise way of calculating energy savings gained as a result of improved energy efficiency. First, the consumption of energy by an individual final consumer, e.g. a passenger car, over a specific time period prior to the implementation of the energy efficiency improvement measure is calculated, whereby "reference values" are obtained. Then, the thus determined consumption level is compared with the energy consumption measured over a period of the same duration, but after the implementation of the energy efficiency improvement measure. The difference between the two results measures the improvement in energy efficiency. If such calculations are made for all energy consumers, and the results are summed up, a reasonably precise

measure of energy efficiency improvement is obtained. It must be remembered that this method must be adjusted too, e.g. for climate conditions and other factors.

This Annex presents final energy savings using the top-down approach. In this respect, the European Commission's recommendations define two types of indicators to be used to calculate energy savings: preferred indicators (designated with letter P) and minimum indicators (designated with letter M).

The sections below present the final energy savings achieved in the years 2008-2014 by sectors of the Polish economy. The following are presented for each sector: the definition of the indicator, the energy savings calculation methodology, the necessary statistical data, and the results of the calculations.

Household sector

Indicator *P*1

The recommended energy efficiency indicators for calculating energy savings in the household sector are based on variations in the end use of energy for heating. The energy efficiency indicator adopted for the household sector is P1, which demonstrates savings achieved by final consumers. Indicator P1 defines specific energy consumption for space heating, as expressed in [toe/m^2] (tonnes of oil equivalent/m^2 of residential floor area), adjusted for climatic conditions. The formula for indicator P1 is as follows:

$$\mathrm{P1} = \frac{E^{H_{SH}}}{F} \cdot \frac{MDD_{25}^{heating}}{ADD^{heating}}.$$

The formula for calculating energy savings achieved in year *t* compared to the recommended base year 2007 is as follows:

$$\left[\left(\frac{E_{2007}^{H_{SH}}}{F_{2007}} \cdot \frac{MDD_{25}^{heating}}{ADD_{2007}^{heating}}\right) - \left(\frac{E_t^{H_{SH}}}{F_t} \cdot \frac{MDD_{25}^{heating}}{ADD_t^{heating}}\right)\right] \cdot F_t$$

where:

$E_{2007}^{H_{SH}}, E_t^{H_{SH}}$ - consumption of energy in the household sector for space heating in 2007 and in year *t* respectively;

$MDD_{25}^{heating}$ - average number of degree days over the last 25 years;

$ADD_{2007}^{heating}$, $ADD_t^{heating}$ - heating degree days in 2007; heating degree days in calculation year *t*;

F_{2007}, F_t - total area of dwellings [in m^2] in 2007 and in calculation year *t* respectively.

The following data are necessary for calculating indicator P1:

- number of permanently occupied dwellings;
- average dwelling size (m^2);
- energy consumption for space heating adjusted for climatic conditions.

To calculate energy consumption for space heating adjusted for climatic conditions, the following data is necessary:

- energy consumption for space heating;
- number of degree days;
- average number of degree days.

The climatic adjustment is based on the relationship between energy consumption and outside temperature. It is assumed that the consumption of energy for heating is in direct proportion to the number of degree days (S*d*).

The number of degree days is the product of the number of heating days and the difference between the average temperature of the heated space and the average outside temperature. According to the Eurostat methodology, the number of degree days S*d* in a year is calculated as follows:

$$Sd = \sum_{n=1}^{N} \begin{cases} 18^{o}\mathrm{C} - t_{śr}(n) & dla \quad t_{śr}(n) \le 15^{o}\mathrm{C} \\ 0 & dla \quad t_{śr}(n) > 15^{o}\mathrm{C} \end{cases}, \text{[day/year]}$$

where:

$t_{śr}(n) = \frac{t_{\min}(n) + t_{maks}(n)}{2}$ - average outside air temperature on the *n*-th day of the year [^{o}C];

$t_{\min}(n), t_{maks}(n)$ - minimum and maximum air temperature on day *n* of the year, [°C].

According to the formula, and following the assumption adopted by Eurostat, heating days are those days when the average daily outside temperature is below 15°C. For Poland, the average number of degree days in 1980-2004 is 3 615.77.

The tables below show statistical data used for calculating indicator P1 and the results of energy savings calculations.

Table 1. Data used for calculating energy efficiency and energy savings indicators in the household sector in 2008-2015

Value	Source	Unit	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number of dwellings	Central Statistical Office (GUS)	'000	12 994	13 150	13 302	13 470	13 587	13 723	13 853	13 983	14 119
Average floor area of dwellings	Central Statistical Office (GUS)	m^2	70	70	71	72	73	73	73	73	74
Number of degree days	Eurostat		3 222	3 164	3 439	3 881	3 317	3 552	3 505	3 095	3 113
Average number of degree days.	Eurostat		3 616	3 616	3 616	3 616	3 616	3 616	3 616	3 616	3 616
Energy consumption for heating	Central Statistical Office (GUS)	ktoe	15 235	15 718	14 672	14 374	15 332	14 835	14 730	15 305	14 406

Table 2. Indicator P1 for the household sector in 2008-2015

Energy efficiency indicator		Unit	2008	2009	2010	2011	2012	2013	2014	2015
P1	Energy consumption for heating 1 m^2 of useful floor area	$kgoe/m^2$	17.03	15.64	14.76	15.54	14.85	14.55	14.91	13.86

Final energy savings in the household sector calculated with preferred indicator P1 are presented below.

Table 3. Energy savings for the household sector in 2008-2015

Indicator used	Energy savings	Unit	2008	2009	2010	2011	2012	2013	2014	2015
P1	Space heating	ktoe	0	1 082	1 986	1 238	1 947	2 281	1 936	3 050

Energy savings in the household sector are subject to certain fluctuations, which is largely caused by the imperfect nature of the climate adjustment, as well as other factors, such as changes in residents' behaviour (e.g. related to climate). There is a general downward trend in specific energy consumption for space heating, resulting from the installation of more efficient equipment, with a major role played by thermomodernisation and the increasingly restrictive building thermal protection standards.

Service sector

Indicator M3

Indicator M3 defines specific non-electricity consumption, expressed in [toe/employee] (tonne of oil equivalent/full-time employee) adjusted for climatic conditions.

Indicator M3 is defined by the following formula:

$$\mathrm{M3} = \frac{E^{S_{NON-EL}}}{em^{S^{fte}}} \cdot \frac{MDD_{25}^{heating}}{ADD^{heating}}.$$

Energy savings achieved in year *t* relative to the recommended base year 2007 are calculated with the following formula:

$$\left[\left(\frac{E_{2007}^{S_{NON-EL}}}{em_{2007}^{S^{fte}}} \cdot \frac{MDD_{25}^{heating}}{ADD_{2007}^{heating}}\right) - \left(\frac{E_t^{S_{NON-EL}}}{em_t^{S^{fte}}} \cdot \frac{MDD_{25}^{heating}}{ADD_t^{heating}}\right)\right] \cdot em_t^{S^{fte}},$$

where:

$E_{2007}^{S_{NON-EL}}, E_t^{S_{NON-EL}}$ - non-electricity energy consumption in the service sector, in 2007 and in calculation year *t* respectively;

$em_{2007}^{S^{fte}}, em_t^{S^{fte}}$ - total number of employees (in full time equivalent) in 2007 and in calculation year *t* respectively.

MDD_{25} - average number of degree days over the last 25 years;

$ADD_{2007}^{heating}$, $ADD_t^{heating}$ - degree days in 2007; degree days in calculation year *t*.

Indicator M4

Indicator M4 defines specific consumption of electricity in the service sector, expressed in [kWh/employee] (kilowatt-hours/full-time employee).

Indicator M4 is calculated with the following formula:

$$\mathrm{M4} = \frac{E^{S_{EL}}}{em^{S^{fte}}},$$

Energy savings achieved in year *t* compared to the recommended base year 2007 are calculated as follows:

$$\left(\frac{E_{2007}^{S_{EL}}}{em_{2007}^{S^{fte}}} - \frac{E_t^{E_{EL}}}{em_t^{S^{fte}}}\right) \cdot em_t^{S^{fte}},$$

where:

$E_{2007}^{S_{EL}}, E_t^{E_{EL}}$ - total electricity consumption in the service sector in 2007 and in calculation year *t* respectively;

$em_{2007}^{S\ fte}$, $em_{t}^{S\ fte}$ - total number of employees (in full time equivalent) in 2007 and in calculation year *t* respectively.

The table below presents data used for calculating energy efficiency indicators M3 and M4.

Table 4. Data used for calculating indicators M3 and M4 in 2008-2015

Value	Source	Unit	2007	2008	2009	2010	2011	2012	2013	2014	2015
Number of degree days	Eurostat	degree days	3 222	3 164	3 439	3 881	3 317	3 552	3 505	3 095	3 113
Reference average number of degree days	Eurostat	degree days	3 616	3 616	3 616	3 616	3 616	3 616	3 616	3 616	3 616
Final energy consumption in the service sector	Central Statistical Office (GUS)	ktoe	7 170	7 979	8 017	8 834	8 387	8 264	8 030	7 771	7 800
Final electricity consumption	Central Statistical Office (GUS)	ktoe	3 197	3 532	3 487	3 755	3 800	3 816	3 708	3 884	3 908
Number of service sector employees	Central Statistical Office (GUS)	k*	7 698	7 952	7 883	7 956	8 031	8 059	8 183	8 413	8 601

*) k ≡ 1000

The tables below show calculations of energy savings in the service sector based on minimum indicators M3 and M4.

Table 5. Energy efficiency indicators for the service sector in 2008-2015

Indicator used	Energy efficiency indicator	Unit	2008	2009	2010	2011	2012	2013	2014	2015
M3	Specific non-electricity consumption per employee (adjusted for climatic conditions)	toe/ employee	0.64	0.60	0.59	0.62	0.56	0.54	0.54	0.53
M4	Total specific electricity consumption per employee	kWh/ employee	5 165	5 143	5 488	5 501	5 506	5 270	5 375	5 283

Table 6. Energy savings for the services sector in 2008-2015

Indicator	Energy savings	Unit	2008	2009	2010	2011	2012	2013	2014	2015
M3	Non-electricity energy savings	ktoe	-475	-198	-125	-348	140	281	326	461
M4	Electricity savings	ktoe	-230	-213	-451	-464	-469	-310	-394	-336
Total energy savings calculated on the basis of the minimum indicators		ktoe	0	0	0	0	140	281	326	461

Energy savings in the service sector are calculated on the basis of minimum indicators M3 and M4. Based on the methodology employed, no energy savings were observed in the service sector in 2008-2011. Indicator M3 shows that energy savings were generated in 2012-2015.

Transport sector

Energy savings for road transport can be calculated as the sum of energy savings for cars and trucks as well as light vehicles, calculated on the basis of preferred energy efficiency indicators P8 and P9.

Indicator P8

Indicator P8 indicator captures the consumption of energy by passenger cars per passenger (p) per kilometre (km), expressed in [goe/pkm], (grams of oil equivalent/passenger-km).

Indicator P8 is calculated with the following formula:

$$\mathrm{P8} = \frac{E^{CA}}{T^{CA}}.$$

Energy savings in year *t* compared to the recommended base year 2007 are calculated with the following formula:

$$\left(\frac{E_{2007}^{CA}}{T_{2007}^{CA}} - \frac{E_t^{CA}}{T_t^{CA}} \right) \cdot T_t^{CA}$$

where:

E_{2007}^{CA}, E_t^{CA} - energy consumption by passenger cars (car fuels) in 2007 and in calculation year *t* respectively;

T_{2007}^{CA}, T_t^{CA} - total traffic of cars in passenger-km, in 2007 and in calculation year *t* respectively.

Indicator P9

Indicator P9 defines the consumption of energy in freight transport by road, expressed in [goe/tkm] (grams of oil equivalent/tonne-km). Indicator P9 is calculated with the following formula:

$$\mathrm{P9} = \frac{E^{TLV}}{T^{TLV}}.$$

Energy savings in year *t* compared to the recommended base year 2007 are calculated with the following formula:

$$\left(\frac{E_{2007}^{TLV}}{T_{2007}^{TLV}} - \frac{E_t^{TLV}}{T_t^{TLV}} \right) \cdot T_t^{TLV}$$

where:

$E_{2007}^{TLV}, E_t^{TLV}$ - energy consumption by trucks and light vehicles in 2007 and in calculation year *t* respectively;

$T_{2007}^{TLV}, T_t^{TLV}$ - total traffic of road freight transport vehicles in tonne-km in 2007 and in calculation year *t* respectively.

The following table presents data used for calculating the energy efficiency indicators. The data are sourced from EUROSTAT and GUS.

Table 7. Data used for calculating energy efficiency indicators and energy savings in the transport sector in 2007-2015.

Values	Unit	2007	2008	2009	2010	2011	2012	2013	2014	2015
Energy consumption by passenger cars	ktoe	6 509	7 028	7 367	7 754	7 835	7 660	7 316	7 455	7 873
Energy consumption by road freight transport vehicles	ktoe	6 465	6 730	6 936	7 516	7 637	7 081	6 341	6 479	6 842
Car passenger traffic	Mpkm	162 280	172 620	182 758	188 810	197 835	208 501	213 120	218 900	223 587
Freight traffic by road	Mtkm	159 527	174 223	191 484	214 204	218 888	233 310	259 708	262 860	273 107

k ≡ 1000

Mpkm ≡ Millions of passenger-km

M ≡ 1 000 000

Energy efficiency indicators P8 and P9 for transport and energy savings calculated on the basis of these indicators are presented in the tables below.

Table 8. Energy efficiency indicators P8 and P9 in 2008-2015

Energy efficiency indicator		Unit	2008	2009	2010	2011	2012	2013	2014	2015
P8	Energy consumption by passenger cars per passenger	goe/pkm	41	40	41	40	37	34	34	35
P9	Energy consumption in freight transport by road	goe/tkm	39	36	35	35	30	24	25	25

Table 9. Energy savings for the transport sector in 2008-2015

Indicator	Energy savings	Unit	2008	2009	2010	2011	2012	2013	2014	2015
P8	Passenger cars (based on pkm)	ktoe	-104	-37	-181	100	703	1 233	1 325	1 095
P9	Trucks and light vehicles	ktoe	330	824	1 165	1 234	2 374	4 184	4 175	4 226
Sum of energy savings*):		**ktoe**	**330**	**824**	**1 165**	**1 334**	**3 077**	**5 416**	**5 500**	**5 321**

*) negative energy savings are not summed

In Poland, road transport accounts for nearly 95% of energy consumed by transportation, while rail transport represents over 2%. In addition, almost 3% of energy is consumed by air transport, and small quantities by inland waterway and near-coastal sea transport. With certain fluctuations in 2013-2015, a reduction in specific energy consumption in passenger transport has been observed.

Industry sector

Indicator P14

Indicator P14 is defined as specific energy consumption of an industrial subsector relative to its output. To calculate the indicator in accordance with the recommendations of the European Commission, information about the share of ETS in the consumption of energy by industrial subsectors is needed. The P14 indicators recommended by the Commission cover the following industrial subsectors (according to the Polish Classification of Activity [PKD] 2007):

- food (10-12);
- textiles (13-15);
- wood (16);
- paper (17-18);
- chemicals (20-21),
- minerals (23),
- metals (24),
- machinery (25-28);
- transport equipment (29-30);
- other (22, 31-32).

Indicator P14 is the ratio between energy consumption of an energy subsector and its production index. It is calculated on the basis of the following formula:

$$\mathrm{P14} = \frac{E^{I^X}}{IPI^{I^X}}.$$

Energy savings achieved in year *t* relative to the recommended base year 2007 are calculated with the following formula:

$$\left(\frac{E_{2007}^{I^X}}{IPI_{2007}^{I^X}} - \frac{E_t^{I^X}}{IPI_t^{I^X}} \right) \cdot IPI_t^{I^X} \cdot K_{2007}^{I^X},$$

where:

$E_{2007}^{I^X}, E_t^{I^X}$ - total energy consumption in the industrial subsector in 2007 and in calculation year *t* respectively;

$IPI_{2007}^{I^X}$, $IPI_t^{I^X}$ - industrial production index of the industry subsector concerned in 2007 and in calculation year *t* respectively;

$K_{2007}^{I^X}$ - share of energy consumption by the subsectors falling under the scope of Directive 2006/32/EC.

Indicator P14 describes energy consumption by individual industrial subsectors. Energy consumption per unit of output of an industrial subsector is defined as the ratio between the final energy consumption of that subsector and its production index.

Data necessary to calculate indicator P14 is as follows:

- final energy consumption by the subsector;
- production index of the industrial subsector;
- share of the consumption of energy by the industrial subsector falling under the scope of Directive 2006/32/EC.

The industrial production index for subsectors, which is measured in relation to a base year, is the most common indicator used to measure industrial output. The indices are specified by EUROSTAT and GUS.

The share of energy consumption by the industrial subsectors falling under the scope of Directive 2006/32/EC corresponds to the part of the consumption that is not covered by the Emissions Trading Scheme. The share may be based on data collected when preparing the National Allocation Plans and kept constant (over the period 2008-2016). Energy savings are calculated from the variation of energy consumption related to the production index. They may also include the effect of non-structural changes in the production mix, especially in the chemical industry – the effect of a shift from heavy chemicals to light chemicals (e.g. cosmetics, pharmaceuticals).

Energy savings in the industry sector are calculated on the basis of preferred indicators P14 for the following subsectors of manufacturing (PKD – SECTION C) and construction (PKD – SECTION F):

Manufacturing	**Subsector of PKD 2004**	**Subsector of PKD 2007**
Chemicals	24	20-21
Metals	27	24
Minerals	26	23
Wood	20	16
Paper	21-22	17-18

Food	15-16	10-12
Textiles	17-19	13-15
Machinery	28-32	25-28
Transport equipment	34-35	29-30
Other	25, 33, 36-37	22, 31-32

Table 10 presents data used for calculating the energy efficiency indicators. The data are sourced from EUROSTAT and GUS.

Table 10. Data used for calculating energy efficiency and energy savings indicators in the industry sector in 2008-2015

Data	Unit		2007	2008	2009	2010	2011	2012	2013	2014	2015
Energy consumption in the chemicals industry	ktoe		2 910	2 682	2 766	2 750	2 834	2 792	2 828	2 713	2 598
Energy consumption in the metals industry	ktoe		2 899	2 528	1 807	1 930	2 116	2 159	2 116	2 153	2 151
Energy consumption in the minerals industry	ktoe		2 980	2 763	2 645	2 787	3 090	2 768	2 620	2 708	2 638
Energy consumption in the wood industry	ktoe		635	715	691	765	774	773	859	815	884
Energy consumption in the paper industry	ktoe		1 195	1 167	1 201	1 271	1 232	1 284	1 571	1 551	1 573
Energy consumption in the food industry	ktoe		1 964	1 886	1 783	1 799	1 790	1 879	1 865	1 872	1 873
Energy consumption in the textiles industry	ktoe		206	171	132	131	108	105	117	123	117
Energy consumption in the machinery industry	ktoe		768	737	636	701	704	682	732	717	756
Energy consumption in the transport equipment industry	ktoe		441	452	337	357	355	353	408	389	383
Energy consumption in the other subsectors of the manufacturing industry	ktoe		582	557	456	508	585	541	669	717	711
Energy consumption in construction	ktoe		221	219	264	240	229	216	182	163	157
Production index for the chemicals industry	“2000=100”		169	166	167	196	190	199	196	197	203
Production index for the metals industry	“2000=100”		117	113	84	98	114	111	108	115	115
Production index for the minerals industry	“2000=100”		169	171	160	187	217	206	207	222	228
Production index for the wood industry	“2000=100”		148	143	141	155	160	167	178	192	199
Production index for the paper industry	“2000=100”		163	155	164	189	206	218	232	244	253
Production index for the food industry	“2000=100”		141	141	147	151	158	167	171	172	176
Production index for the textiles industry	“2000=100”		101	94	84	89	99	102	107	112	116
Production index for the machinery industry	“2000=100”		229	249	240	279	291	306	312	339	367
Production index for the	“2000=100”		196	210	186	206	241	234	251	256	288

transport equipment industry											
Production index for the other subsectors of manufacturing	"2000=100"		218	226	222	238	276	267	285	313	334
Production index for construction	"2000=100"		107	118	123	128	147	140	125	131	146

Table 11. Data used for calculations according to the National Centre for Emissions Management (KOBiZE)

Subsectors of manufacturing		$1-K_{2007}^{I^X}$
Chemicals (PKD 20-21)		0.39
Metals (PKD 24)		0.20
Minerals (PKD 23)		0.70
Wood (PKD 16)		0.47
Paper (PKD 17-18)		0.59
Food (PKD10-12)		0.39
Textiles (PKD 13-15)		0.11
Machinery (PKD 25-28)		0.11
Means of transport (PKD 29-30)		0.07
Other (PKD 22, 31-32)		0.22

The values of energy efficiency indicator P14 by industrial subsectors and the corresponding energy savings are presented in Tables 12 and 13.

Table 12. Values of energy efficiency indicator P14 for industrial subsectors in 2008-2015

Indicator	Industrial subsector	Unit	2008	2009	2010	2011	2012	2013	2014	2015
P14	Chemicals	Mtoe/index	1.62	1.65	1.40	1.49	1.40	1.44	1.38	1.27
P14	Metals	Mtoe/index	2.24	2.14	1.98	1.86	1.94	1.96	1.87	1.86
P14	Minerals	Mtoe/index	1.62	1.65	1.49	1.43	1.35	1.27	1.22	1.15
P14	Wood	Mtoe/index	0.50	0.49	0.49	0.48	0.46	0.48	0.42	0.44
P14	Paper	Mtoe/index	0.75	0.73	0.67	0.60	0.59	0.68	0.63	0.61
P14	Food	Mtoe/index	1.34	1.21	1.19	1.13	1.12	1.09	1.09	1.06
P14	Textiles	Mtoe/index	0.18	0.16	0.15	0.11	0.10	0.11	0.11	0.10
P14	Machinery	Mtoe/index	0.30	0.26	0.25	0.24	0.22	0.23	0.21	0.21
P14	Transport equipment	Mtoe/index	0.22	0.18	0.17	0.15	0.15	0.16	0.15	0.13
P14	Other	Mtoe/index	0.25	0.21	0.21	0.21	0.20	0.24	0.23	0.21
P14	Construction	Mtoe/index	0.19	0.21	0.19	0.16	0.15	0.15	0.12	0.12

Table 13. Energy savings in industry in 2008-2015

Indicator	Industry	Unit	2008	2009	2010	2011	2012	2013	2014	2015
P14	Chemicals	ktoe	107	75	384	274	387	339	417	571
P14	Metals	ktoe	214	234	404	586	498	467	576	590
P14	Minerals	ktoe	76	55	156	221	260	309	364	429
P14	Wood	ktoe	-55	-45	-53	-46	-31	-51	4	-14
P14	Paper	ktoe	-11	1	47	114	130	54	100	127
P14	Food	ktoe	53	165	193	259	278	316	321	364
P14	Textiles	ktoe	18	36	46	85	92	91	95	109
P14	Machinery	ktoe	87	150	209	241	305	277	371	423
P14	Transport equipment	ktoe	20	75	98	174	161	145	173	245
P14	Other	ktoe	35	107	97	117	132	70	89	142
P14	Construction	ktoe	24	-9	25	75	73	77	108	114
Sum of energy savings*):		**ktoe**	**634**	**898**	**1 660**	**2 146**	**2 317**	**2 145**	**2 618**	**3 114**

*) negative energy savings are not summed

For many years, industry has demonstrated a steady improvement in energy efficiency, with energy savings generated primarily in its most energy intensive subsectors. This trend is also observable in the period 2008-2015, for which the calculations are made.

Summary of realised energy savings

The energy savings are calculated according to the recommendations of the European Commission published in its *Recommendations on measurement and verification methods in the framework of Directive 2006/32/EC on energy end-use efficiency and energy service*s.

Table 14 presents a summary of the energy efficiency and energy savings indicators calculated for the individual years of the 2008-2015 period, and the sum of savings for four sectors.

Table 14. Energy savings by sectors of the economy in 2008-2015

Sector of the economy	Indicator	Unit	2008	2009	2010	2011	2012	2013	2014	2015
Households	P1	ktoe	0	1 082	1 986	1 238	1 947	2 281	1 936	3 050
Services	M3, M4	ktoe	0	0	0	0	140	281	326	461
Transport	P8, P9	ktoe	330	824	1 165	1 334	3 077	5 417	5 500	5 321
Industry	P14	ktoe	634	898	1 660	2 146	2 317	2 145	2 618	3 114
Energy savings calculated on the basis of indicators		**ktoe**	**964**	**2 804**	**4 811**	**4 718**	**7 481**	**10 124**	**10 380**	**11 946**

Energy savings have been growing steadily since 2008, which, in accordance with the European Commission's recommendations, is the first year from which savings are calculated (they amount to zero in 2007). The slight fluctuations in the values from one year to another result from the fact

that the proposed savings calculation methodology is based on indicators which reflect the prevailing economic processes, residents' behavioural patterns, and climate conditions in a simplified manner. The observable strong upward trend in energy savings indicates that the processes reducing the energy intensity of the economy are sustainable. The top-down method employed shows that the indicative target of Directive 2006/32/EC of the European Parliament and of the Council of 5 April 2006 *on energy end-use efficiency and energy services* was met as early as 2010.

Although the top-down model is based on estimates, it clearly demonstrates an improvement in the energy efficiency of the economy in the years under analysis. Calculations of energy savings based on the recommendations of the European Commission are a comparative tool, which can be used both in relation to a specific economy, or for comparisons between individual years spanned by the calculations and for comparing countries. It should also be stressed that the indicators are built on the basis of physical quantities, taking into account potential errors of the statistical methods. Noteworthy, Polish public statistics enable energy savings to be calculated by means of priority indicators (except for the service sector).

II. Bottom-up calculations of final energy savings

Table 15. Final energy savings calculation algorithms for different energy efficiency improvement measures

	Name of energy efficiency improvement measure	Energy savings calculation algorithm	Sources of information about input data	Energy savings lifetime adopted	Achieved and planned final energy savings (ktoe)
	Thermomodernisation and Repairs Fund	$O_{FTiR} = \sum_{i=1}^{n} o_i$ o_i – final energy savings realised/expected as a result of individual investments co-financed by the Thermomodernisation and Repairs Fund	Bank Gospodarstwa Krajowego (BGK)	30 years – as recommended by the European Commission	2016 – 590 2020 – 812
	Nationwide information and educational campaigns	$O_{kamp} = \frac{L_{odb} * Ods_{skł} * Ods_{dz} * Z_{energ-mieszkanie} * Ods_{zm-beh}}{L_{mieszk}}$ L_{odb} – audience of the most popular campaign in a given year $Ods_{skł}$ – percentage of people willing to save energy Ods_{dz} – percentage of persons whose declared willingness to save energy translates into concrete actions reducing energy consumption Z_{mieszk} – final energy consumption per 1 dwelling Ods_{zm-beh} – percentage of energy consumption by a dwelling which can be reduced through behavioural changes L_{mieszk} – average number of occupants of 1 dwelling in Poland	GUS, Ministry of Economy, Ministry of the Environment, Garrison Institute, RWE Polska, TVP SA	2 years – as recommended by the European Commission	2016 – 120 2020 – 260
	Green Investment Scheme – GIS. Part 1 – Energy management in public buildings;	$O_{GIS1} = \frac{B_{GIS1}}{B_{GIS1-zob}} * (O_{GIS1_1} + O_{GIS1_2-5}) =$ $= \frac{B_{GIS1}}{B_{GIS1-zob}} * \varphi * \left(\sum_{i=1}^{n} \frac{k_{i-GIS1-1}}{w_T} + \sum_{j=1}^{m} e_{j-GIS1_2-5} \frac{w_T}{w_{T-CO2}}\right)$ O_{GIS1_1} – final energy savings achieved/expected as a result of thermomodernisation measures implemented by public bodies under Competition 1 of GIS 1 O_{GIS1_2-5} – final energy savings achieved/expected as a result of thermomodernisation measures implemented by public bodies under Competitions 2-5 of GIS 1 $B_{B_{GIS1}}$ – GIS 1 budget $B_{GIS1-zob}$ – Commitments entered into under GIS 1 φ – primary/final energy conversion factor $k_{i-GIS1-1}$ – investment expenditure on projects implemented under Competition 1 of GIS 1	NFOŚiGW Report "Impact assessment of investments under measures 9.1, 9.2, and 9.3"	30 years – as recommended by the European Commission	2016 – 90 2020 – 160

		w_T – average investment expenditure on unitary primary energy savings under thermomodernisation projects e_{j-GIS1_2-5} – avoided CO_2 emissions achieved under GIS 1, Competitions 2-5, as declared by beneficiaries w_{T-CO2} – average investment expenditure per unit of CO_2 avoided under thermomodernisation projects			
	Green Investment Scheme – GIS. Part 5 – Energy management in buildings of selected public finance sector entities;	$O_{GIS5} = \varphi * \left(\sum_{i=1}^{n} \frac{k_{i-GIS5}}{w_T} \right)$ O_{GIS5} – final energy savings achieved/expected as a result of thermomodernisation measures implemented by public bodies under GIS 5 φ – primary/final energy conversion factor k_{i-GIS5} – investment expenditure on projects implemented under GIS 5 w_T – average investment expenditure on unitary primary energy savings under thermomodernisation projects	NFOŚiGW Report "Impact assessment of investments under measures 9.1, 9.2, and 9.3"	30 years – as recommended by the European Commission	2016 – 80 2020 – 80
	Operational Programme Infrastructure and Environment (OPI&E 2007-2013) – Measure 9.3 Thermomodernisation of public buildings	$O_{POIŚ9.3} = \varphi * \left(\sum_{i=1}^{n} \frac{k_{POIŚ9.3}}{w_T} \right)$ $O_{POIŚ\ 9.3}$ – final energy savings achieved/expected as a result of thermomodernisation measures implemented by public bodies under OPI&E 9.3 φ – primary/final energy conversion factor $k_{POIŚ9.3}$ – investment expenditure on projects implemented under OPI&E 9.3 w_T – average investment expenditure on unitary primary energy savings under thermomodernisation projects	NFOŚiGW Report "Impact assessment of investments under measures 9.1, 9.2, and 9.3"	30 years – as recommended by the European Commission	2016 – 5 2020 – 16
	Operational Programme PL04 "Saving energy and promoting renewable energy sources" (Programming Area No 5 – Energy Efficiency)	$O_{PL04} = \varphi * \left(\sum_{i=1}^{n} \frac{k_{PL04}}{w_T} \right)$ O_{PL04} – final energy savings expected as a result of thermomodernisation measures implemented by public bodies under PL04 φ – primary/final energy conversion factor k_{PL04} – investment expenditure on projects implemented under PL04 w_T – average investment expenditure on unitary primary energy savings under thermomodernisation projects	NFOŚiGW Report "Impact assessment of investments under measures 9.1, 9.2, and 9.3"	30 years – as recommended by the European Commission	2016 – 40 2020 – 55
	Improving energy efficiency. Part 2 – LEMUR – Energy Efficient	$O_{EWE4} = \varphi * \left(\sum_{i=1}^{n} e_{EWE4} \frac{w_T}{w_{T-CO2}} \right)$	NFOŚiGW Report "Impact assessment of	30 years – as recommended by the European	2016 – 6 2020 – 10

	Public Buildings	O_{EWE4} - final energy savings anticipated as a result of thermomodernisation measures implemented by public bodies under EWE4 w_T – average investment expenditure on unitary primary energy savings under thermomodernisation projects e_{EWE4} – avoided CO_2 emissions as declared by beneficiaries w_{T-CO2} – average investment expenditure per unit of CO_2 avoided under thermomodernisation projects	investments under measures 9.1, 9.2, and 9.3"	Commission	
	Green Investment Scheme – GIS. Part 6 – SOWA – Energy efficient street lighting;	$O_{GIS6} = \varepsilon * e_{GIS6}$ ε – Emission benchmarks for electricity production (average for years 2008-2010) e_{GIS6} – CO_2 emissions avoided under GIS 6, as declared by beneficiaries	NFOŚiGW KOBIZE	15 years – as recommended by the European Commission	2016 – 1 2020 – 4
	White certificates	$O_{cert} = \sum_{i=1}^{n} o_{i-cert}$ O_{cert} – final energy savings achieved/expected as a result of measures supported by the white certificate scheme o_{i-cert} – final energy savings achieved/expected under a project supported by the white certificate scheme	URE	15 years – as recommended by the European Commission	2016 – 1 550 2020 – 2 645
	Support for enterprises as regards low-emission and resource-efficient economy Part 2 – Improving energy efficiency	$O_{EWE2} = \varphi * \left(\sum_{i=1}^{n} \frac{k_{i-EWE2}}{w_{EWE2}} \right)$ O_{EWE2} – final energy savings achieved/expected as a result of measures implemented under the EWE2 programme φ – primary/final energy conversion factor k_{EWE2} – Amount of grants for projects implemented under EWE2 w_{EWE2} – Average amount of grant per unit of saved primary energy	NFOŚiGW	15 years – as recommended by the European Commission	2016 – 75 2020 – 90
	Financial facility for SMEs (PolSEFF);	$O_{PolSEFF} = \sum_{i=1}^{n} o_{PolSEFF} * m_i$ $O_{PolSEFF}$ – final energy savings achieved/expected as a result of measures implemented under PolSEFF $o_{PolSEFF}$ – Average final energy savings realised under PolSEFF m_i – Number of projects delivered in year *i*	EBRD	15 years – as recommended by the European Commission	2016 – 20 2020 – 20

	Priority Programme: Intelligent Energy Networks (IEN);	$O_{ISE} = \left(\sum_{i=1}^{n} e_{ISE} * \varepsilon\right)$ O_{ISE} - final energy savings expected as a resu of measures implemented under IEN e_{ISE} – Avoided CO_2 emissions expected to be achieved in year *i* ε – emission benchmark for electricity production	NFOŚiGW KOBIZE	15 years – as recommended by the European Commission	2016 – 0 2020 – 4
	Operational Programme Infrastructure and Environment – Measure 9.2 – Efficient energy distribution	$O_{POI\$9.2} = \varphi * \left(\sum_{i=1}^{n} \frac{k_{POI\$9.2}}{w_{9.2}}\right)$ $O_{POI\$ 9.2}$ – final energy savings achieved/expected as a result of measures implemented under OPI&E 9.2 φ – primary/final energy conversion factor $k_{POI\$9.2}$ – investment expenditure on projects implemented under OPI&E 9.2 $w_{9.2}$ – average investment expenditure per unitary primary energy savings under projects implemented through OPI&E 9.2	NFOŚiGW Report "Impact assessment of investments under measures 9.1, 9.2, and 9.3"	15 years – as recommended by the European Commission	2016 – 37 2020 – 37
	Operational Programme Infrastructure and Environment (OPI&E) – Measure 9.1 – High efficiency energy generation	$O_{POI\$9.1} = \varphi * \left(\sum_{i=1}^{n} \frac{k_{POI\$9.1}}{w_{9.1}}\right)$ $O_{POI\$ 9.1}$ – final energy savings achieved/expected as a result of measures implemented under OPI&E 9.1 φ – primary/final energy conversion factor $k_{POI\$9.1}$ – investment expenditure on projects implemented under OPI&E 9.1 $w_{9.1}$ – average investment expenditure per unitary primary energy savings under projects implemented through OPI&E 9.1	NFOŚiGW Report "Impact assessment of investments under measures 9.1, 9.2, and 9.3"	15 years – as recommended by the European Commission	2016 - 8 2020 – 8
	Operational Programme Infrastructure and Environment (OPI&E) – Measure 9.4 Production of energy from renewable sources [insofar as high-efficiency cogeneration is concerned].	$O_{POI\$9.4} = \varphi * \left(\sum_{i=1}^{n} \frac{k_{POI\$9.4}}{w_{9.4}}\right)$ $O_{POI\$ 9.4}$ – final energy savings achieved/expected as a result of measures implemented under OPI&E 9.4 φ – primary/final energy conversion factor $k_{POI\$9.4}$ – investment expenditure on projects implemented under OPI&E 9.4 $w_{9.4}$ – average investment expenditure per unitary primary energy savings under projects supported by OPI&E 9.4	"Assessment of the possibility of ensuring comparability of projects involving the use of different renewable energy sources as exemplified by Measure 9.4"	15 years – as recommended by the European Commission	2016 – 2 2020 – 2
	Operational Programme Infrastructure and Environment (OPI&E) –	$O_{ITS} = \sum_{i=1}^{m} (2 + \rho_i) \sum_{j=1}^{n} \varphi * w_{ITS} * k_{j\,ITS}$ φ – primary/final energy conversion factor	EUROSTAT, Evaluation of the TRAVOLUTION project under the	15 years – own assumption (no recommendations from	2016 – 44 2020 – 57

	Measure 8.3 Development of intelligent transport systems	w_{ITS} – unitary primary energy savings relative to investment expenditure $k_{j_{ITS}}$ – investment expenditure on projects related to traffic management systems and freight transport optimisation ρ_i – coefficient of change in allocation for programme for the years 2014-2020 relative to 2007-2013 programme	programme FuE "Information and communicatio ns technique" of the Free State of Bavaria. PKN Orlen Ministry of Regional Development, Partnership Agreement (draft, July 2013)	the EC regarding traffic optimisation systems are available)	
	Operational Programme Infrastructure and Environment (OPI&E) – Measure 7.3 Urban transport in metropolitan areas	$O_{FLOTA} = \sum_{i=1}^{m}(2+\rho_i)\sum_{j=1}^{n}\varphi * w_{FLOTA} * k_{FLOTA}$ φ – primary/final energy conversion factor w_{FLOTA} – unitary primary energy savings relative to investment expenditure k_{FLOTA} – investment expenditure on fleet replacement programmes undertaken by urban transport companies and on promoting eco-driving ρ_i – coefficient of change in allocation for programme for the years 2014-2020 relative to 2007-2013 programme	Data regarding urban transport systems in the cities of Lubin and Wałbrzych ; P. Rosik et al. "Dojazdy do pracy do Warszawy i Białegostoku, alternatywne podejścia metodolog. (Commuting to work to Warsaw and Białystok; alternative methodologica l approaches), 2010 Studia Regionalne i Lokalne, Uniwersytet Warszawski.	15 years – own assumption (no recommenda tions from the EC regarding traffic optimisation systems are available)	2016 -1080 2020 – 2016
	Low-Emission Economy Plans (PGN) in 2015-2020	Based on the PGN database, which covers 256 cities/municipalities, including all province capitals, 87/91% of regional and sub-regional cities, and 19% of local cities (60% of total population), a database was created on energy savings achieved in individual sectors. In order to ensure that the data gathered is representative for the whole country, the database was adjusted through increasing the savings by 30%.	Data on energy savings in sectors based on Atmoterm S.A. and KAPE S.A. databases	15/30 years – own assumption (no recommenda tions from the EC)	2016 – 630 2020 – 1230

Annex No 3

Supporting investments in the refurbishment of buildings

Supporting investments in the refurbishment of the national stock of residential and public buildings, privately owned or owned by the State Treasury and local governments, is consistent with the requirements of Article 4 of Directive 2012/27/EU. In accordance with the article, Member States are to establish "a long-term strategy for mobilising investment in the renovation of the national stock of residential and commercial buildings, both public and private", hereinafter referred to as "the long-term strategy", which includes:

1) an overview of the national building stock based, as appropriate, on statistical sampling;
2) identification of cost-effective approaches to renovations relevant to the building type and climatic zone;
3) policies and measures to stimulate cost-effective deep renovations of buildings, including staged deep renovations;
4) a forward-looking perspective to guide investment decisions of individuals, the construction industry and financial institutions;
5) an evidence-based estimate of expected energy savings and wider benefits.

EU Member States were required to publish the first version of the "strategy" by 30 April 2014 and update it every three years, as well as to submit each version of the strategy to the Commission as part of the National Action Plans. This annex to the National Action Plan is the first update of the 2014 strategy.

Given the scope of the long-term strategy, as well as the objectives of the directive and the terminology used in national provisions and in literature, it has been decided that the word "modernizacja" ("refurbishment") will be used. The term "renowacja" ("renovation") is understood as renewal, refreshment of something, or restoration, and usually refers to historic buildings, cultural properties, or works of art, although it can also refer to buildings. Meanwhile, the term "refurbishment" is understood as modernisation and improvement leading to an increase in the value in use, and embodies such concepts as: repair, reconstruction, and extension, as defined by the Building Law of 7 July 1994 (Journal of Laws 2016, item 290, as amended).

It must also be stressed that the thematic scope of this annex comprises activities related to the improvement of energy efficiency. This annex does not address other types of refurbishment, i.e. improvement of the building's structural elements, its telecommunications, electrical, and sewage installations, or other elements which have a limited relevance for improving energy efficiency.

The main aim of this annex is to indicate measures which can be implemented in already used buildings to improve their energy performance, and to present an overview of available financial

instruments which work towards reducing annual demand for final energy used for heating and ventilation, preparing hot water, cooling, and buildings' embedded lighting.

Appropriate shaping of the climate and energy policy, which ensures, inter alia, reduction of greenhouse gas emissions, supports the use of renewable energy and improvement of energy efficiency thanks to more energy efficient buildings, is one of the key challenges connected with a country's membership in the European Union, as well as a way for ensuring energy independence for the country and reducing carbon dioxide emissions. At the same time, work conducted under the policy should translate into improved innovation, implementation of new technologies in the construction sector and in the area of installation techniques, reduced energy intensity, and should create new jobs, thus improving the competitiveness of the economy and the prosperity of citizens. Currently, Directive 2010/31/EU is the key instrument of European law which regulates efficient energy use in buildings. The directive replaced *Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings* (OJ L 1, 4.1.2003, p. 65, as amended).

The abovementioned regulations are of a framework nature, which means that they do not set uniform levels of requirements applicable across EU countries, but instead oblige Member States to set specific requirements and put in place appropriate mechanisms related to the energy performance of buildings applicable in their respective territories. In the view of the European Parliament and the Council of the European Union, which have adopted these directives, elements such as tradeable energy certificates of buildings or parts of buildings, stricter requirements concerning thermal protection of buildings, and regular inspection of heating and air conditioning systems contribute to improving the performance of the whole sector of buildings in terms of reducing the consumption of non-renewable fuels, environmental protection, safety and ensuring thermal comfort for building users.

In addition, the directives stress the role of the public sector, as that which should fulfil an exemplary role as regards energy efficiency, in particular because of the fact that the floor area of buildings owned or occupied by public bodies represents about 12% of the total floor area of buildings in the EU. The above directives cover issues connected with reducing the energy demand in newly-erected buildings and buildings already in use by introducing a range of regulatory instruments, including:

- a requirement to set cost-optimal minimum requirements for energy performance for newly erected and existing buildings,
- a requirement to analyse the technical, environmental and economic feasibility of implementing highly effective alternative systems, if available,

– a requirement for Member States to specify requirements leading to near zero-energy consumption by newly erected buildings.

The directives also provide for information-based instruments, i.e.: energy performance certificates and reviews of heating and air-conditioning systems, information campaigns related to improving the energy performance of buildings.

In addition, reference should be made to two directives addressing energy intensity of buildings: Directive 2012/27/EU and Directive 2009/28/EC.

Directive 2012/27/EU requires establishing a long-term strategy for supporting investments in the renovation of the national stock of residential and public buildings. Each Member State should ensure that, as from 1 January 2014, 3% of the total floor area of heated and/or cooled buildings owned or occupied by its central government is renovated each year to meet at least the minimum energy performance requirements that it has set in application of Directive 2010/31/EU, or should ensure that an alternative equivalent approach is adopted. In the Commission's view, the key elements of a new 2030 climate and energy framework should comprise a greenhouse gas reduction target at EU level which is shared equitably among the Member States in the form of binding national targets. The key elements of the new framework include a reform of the Emissions Trading Scheme; an EU level target for the share of renewable energy and a new European governance process for energy and climate policies. The governance will be based on Member State plans for competitive, secure and sustainable energy. Energy efficiency will continue to play a significant role in delivering the EU's climate and energy objectives.[29]

When discussing legislation related to improving energy efficiency of buildings, account should be taken of the Act of 20 May 2016 *on energy efficiency* (Journal of Laws, item 831), which is the basis for drawing up this strategy. The act defines the key concept of "energy efficiency", which, pursuant to Article 2(3) of the Act, is the ratio between the usability effect achieved by a given building, item of technical equipment or installation under typical conditions in which they are used or operated and the amount of energy consumed by the building, item of technical equipment or installation, or as a result of the required service provided to produce this effect. In addition, it specifies the responsibilities of public bodies as regards improving energy efficiency and the principles underlying the fulfilment of the obligation to produce energy savings.

Until 9 March 2015, the requirements regarding energy efficiency of buildings and improvement of the energy standard of buildings in the context of Directive 2002/91/EC were governed by the

[29] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions, Energy 2020, A policy framework for climate and energy in the period from 2020 to 2030, COM(2014)015 final

provisions of the Construction Law of 7 July 1994– and its implementing provisions. Since 9 March 2015, a revised system for assessing and improving the energy efficiency of buildings, taking into account the provision of Directive 2010/31/EU, has been in effect, based on the Act of 29 August 2014 *on energy performance of buildings* and the associated implementing legislation. Most of the provisions on energy performance of buildings laid down by the Construction Law of 7 July 1994 were repealed and recast by the Act of 29 August 2014 *on energy performance of buildings*. The purpose of the Act of 29 August 2014 *on energy performance of buildings* is to promote improvement of the energy performance of buildings, and to put in place an improved system for assessing the energy performance of buildings, taking into account previously gained experience. The Act lays down rules on:

- the energy rating system for buildings;
- the requirements to be met by persons qualified to issue energy performance certificates;
- the requirements for persons qualified to inspect heating systems or air-conditioning systems;
- the obligation to inspect heating systems or air-conditioning systems;
- the verification of energy performance certificates and heating system and air-conditioning system inspection reports by the minister responsible for construction, planning and spatial development and housing;
- the authorisation for the minister responsible for construction, spatial development and planning and housing to prepare a national plan aimed at increasing the number of low-energy buildings;
- the obligation to prepare energy performance certificates for the buildings in which judicial authorities, the Public Prosecutor's Office, and public administration bodies occupy a floor area of more than 250 m^2 and in which services are provided to the public, and to display them in a visible place;
- the obligation to provide information about the energy efficiency of buildings or their parts in advertising materials concerning their rental or sale in cases when a certificate has already been issued for a building or its part.

In addition, as a result of the entry into force of the above act, a central building energy performance register has been established, which includes the following lists:

- list of persons qualified to prepare energy performance certificates;
- list of persons qualified to inspect heating systems and air-conditioning systems;
- list of energy performance certificates;
- list of heating system and air-conditioning system inspection reports;

– list of buildings whose useful floor area occupied by judicial authorities, the Public Prosecutor's Office and public administration bodies exceeds 250 m^2 and in which services are provided to the public.

The lists in points 1, 2 and 5 are available via the website https://rejestrcheb.mib.gov.pl, which is to facilitate easy access to updated details of experts qualified to prepare energy performance certificates and inspect heating and air-conditioning systems.

Below, this document describes amendments to technical and building regulations related to energy savings and thermal insulation of buildings and amendments to provisions related to the technical description included in a construction design which introduce a requirement to prepare, for all buildings, an analysis of the feasibility of rational use of high-efficiency alternative systems based on RES, and discusses a methodology for determining energy performance of buildings which comprises solutions promoting the use of renewable energy.

Issues related to the technical equipment, energy savings and thermal insulation of buildings with respect to newly designed, constructed, and reconstructed buildings, or buildings undergoing a change in their intended use, are governed by Regulation of the Minister of Infrastructure of 12 April 2002 *on the technical conditions to be met by buildings and their siting* (Journal of Laws of 2015, item 1422).

As a result of an amendment to the above regulation, since 1 January 2014, revised requirements regarding the technical equipment of buildings, parameters affecting its energy efficiency, and the quality of its thermal protection have applied.

According to the revised legislation, a building and its heating, ventilation, air-conditioning, and warm service water installations, and for public, collective accommodation, production, utility and storage buildings – also their embedded lighting, should be designed and made so as to meet the applicable minimum requirements:

The minimum requirements for a newly designed building are understood as:

– ensuring a PEF value [kWh/(m^2·year], which measures the annual calculated demand for non-renewable primary energy to be used for heating, ventilation, cooling, warm service water preparation, and, in the case of public, collective accommodation, production, utility and storage buildings, also for embedded lighting, as calculated according to the provisions establishing the methodology for calculating the energy performance of buildings, which is lower than the acceptable limit value referred to in Regulation *on the technical conditions to be met by buildings and their siting*,

– complying with the requirements on the thermal insulation of space dividing elements (e.g. external walls, internal walls, windows, doors, roofs) and technical equipment of buildings,

as specified in Annex 2 to Regulation *on the technical conditions to be met by buildings and their siting*.

For a building under reconstruction, the minimum requirements are considered to be complied with if the space dividing elements and technical equipment undergoing the reconstruction meet at least the thermal insulation requirements established by Annex 2 to the above regulation. Notably, the level of requirements for energy savings and thermal insulation will be gradually increased until 2021 (the last change took place on 1 January 2017). Such staged changes will, *inter alia*, allow all participants of the construction market to adapt in a smooth way to applicable legal requirements.

EPH+W [kWh/(m2· rok)]	PEFh+w [kWh/(m2· rok)]
Zmiany wartości wskaźnika EP	Changes in PEF
Budynek mieszkalny - jednorodzinny	Single-dwelling residential building
Budynek mieszkalny wielorodzinny	Multi-dwelling residential building
Budynek zamieszkania zbiorowego	Collective accommodation building
Budynki użyteczności publicznej - opieki zdrowotnej	Public buildings - healthcare
Pozostałe budynki publiczne	Other public buildings
Od 1 stycznia 2014/2017/2021 r.	From 1 January 2014/2017/2021.
Od 1 stycznia 2019 r. - w przypadku budynków zajmowanych przez władze publiczne	From 1 January 2019 – for buildings occupied by public authorities

Figure 1. Minimum requirements for the annual non-renewable primary energy demand factor

The provisions regarding the construction design have also been amended – since 3 October 2013, Regulation of the Minister of Transport, Construction and the Maritime Economy of 25 April 2012 *on the detailed scope and form of the construction design* (Journal of Laws, item 462, as amended) has been in effect in its new wording. The revision included modifications of the provisions regarding the technical description included in a construction design, which extended the obligation to analyse the feasibility of rational use of high-efficiency alternative systems by comprising all buildings (previously the obligation had applied to buildings with a useful floor area of more than 1 000 m^2), and a change in the scope of the analysis. In accordance with the new wording of § 11(2) point 12 of the above regulation, the technical description included in an architectural and construction design should include an analysis of the feasibility of rational use of high-efficiency alternative energy and heat supply systems. Such systems include decentralised energy supply systems based on renewable energy, cogeneration, local or block heating or cooling, in particular when it is based, fully or partially, on energy from renewable sources, and heat pumps. The use of such systems should be considered at the stage of the preparation of construction designs to be approved through construction permit decisions or construction design approval decisions, or to be submitted to the competent office when a construction project is notified. In addition, regulation defines the scope of such an analysis. The analysis can be carried out for a group of buildings located within the same area which have the same intended use and similar technical and use parameters. The above regulations seek to promote alternative solutions wherever they are economically, technically and environmentally viable.

On 18 April 2015, Regulation of the Minister of Infrastructure and Development of 27 February 2015 *on the methodology for determining the energy performance of buildings or parts of buildings and on energy performance certificates* (Journal of Laws, item 376), issued on the basis of Article 15 of the Act of 29 August 2014 *on energy performance of buildings*, entered into force. The regulation adjusts the methodology for determining the energy performance of buildings or parts of buildings and the model energy performance certificates to the provisions of the above act. The regulation provides for the method for determining energy performance, *inter alia* on the basis of actual energy consumption, for calculating CO_2 emissions and share of renewable energy sources in the annual energy demand, and sets forth the model energy performance certificate. In addition, it provides that an energy performance certificate must include recommendations for cost-effective and technically feasible energy performance improvement measures. When formulating such recommendations, the person who prepares the certificate is obliged to share his/her expertise likely to increase significantly the awareness of both the owner and user of the building regarding possible improvements and related savings.

Another legislative act which addresses the energy efficiency of buildings is the Act of 21 November 2008 *on supporting thermomodernisation and repairs* (Journal of Laws of 2017, item 130), which governs the thermomodernisation and repair support scheme operated by the central government. The purpose of the scheme is to improve the technical condition of existing residential buildings, collective accommodation buildings, and buildings owned by local governments used for the fulfilment of their public mission. The scheme contributes to reducing annual energy demand, annual energy losses, and annual costs of heat or switching to a renewable source, as well as to promoting high-efficiency cogeneration. Beneficiaries of the scheme include owners of housing stock (municipalities, housing cooperatives, owners of company flats and private owners), owners of collective accommodation buildings, and local governments. The scheme comprises two main modules of support for thermomodernisation projects and support for repair projects. It provides for additional support for owners of residential buildings which have been previously subject to a regulated rent regime. The support takes the form of the so-called "bonus", i.e. repayment of a portion of liabilities contracted for the project delivery. The repayment is made out of the resource of the Thermomodernisation and Repairs Fund, which is managed by Bank Gospodarstwa Krajowego and funded by the State budget. From the beginning of its existence to 31 December 2016, the fund received PLN 2.055 billion.

The following implementing acts have been issued on the basis of the Act of 21 November 2008 *on supporting thermomodernisation and repairs*:

- Regulation of the Minister of Infrastructure of 17 March 2009 *on the detailed method for verifying energy audits and parts of renovation audits and detailed conditions to be met by entities which Bank Gospodarstwa Krajowego may request to verify such audits* (Journal of Laws, item 347, as amended),
- Regulation of the Minister of Infrastructure of 17 March 2009 *on detailed scope and form of energy audits and parts of renovation audits, model audit sheets, and algorithm for evaluating the cost-effectiveness of thermomodernisation projects* (Journal of Laws, item 346, as amended).

The above regulations govern the procedures for completing audits for the purposes of the bonus and the method for verifying such audits.

1. Overview of the national building stock

Pursuant to Article 4(a) of Directive 2012/27/EU, one of the elements of the "strategy" should include "an overview of the national building stock based, as appropriate, on statistical sampling".

This overview only comprises buildings within the meaning of the Construction Law of 7 July 1994[30)]. It does not include information concerning other constructions.

In preparing an overview of the building stock, it is necessary to establish criteria for the classification of buildings useful in the context of this annex. The classifications included in the Construction Law, technical and building regulations, the Polish Classification of Types of Construction[31)], and the Classification of Fixed Assets[32)] can be helpful here.

The overview was carried out taking into account the following criteria: function of the building (intended use), age structure, and the form of ownership.

The energy efficiency of buildings is primarily influenced by their thermal insulation, technical equipment, and the heat source. Therefore the thermal properties of the building envelope and the heat supply method are also used as additional indicators in the overview.

The energy intensity of buildings also depends on their shape and the climatic zone where they are located so these parameters taken into account, too.

1.1. Age structure of buildings and their energy efficiency

The age structure of buildings is assessed on the basis of data from the publication *Zamieszkane budynki* (Occupied Buildings), which presents the results of the National General Population and Housing Census carried out in 2011[33], and the publication *Opracowanie optymalnych energetycznie typowych rozwiązań strukturalno-materiałowych i instalacyjnych budynków*[34], as well as based on own research.

According to the 2011 National General Population and Housing Census, Poland had approximately 6 million buildings with at least 1 dwelling.

[30)] In accordance with Article 3(2) of the Construction Law of 7 July 1994, a building means a construction which is permanently connected to the ground, separated from the space by envelope elements, and has foundations and a roof.

[31)] The Polish Classification of Types of Construction (Polska Klasyfikacja Obiektów Budowlanych, PKOB) is established by Regulation of the Council of Ministers of 30 December 1999 *on the Polish Classification of Types of Construction* (Journal of Laws, item 1316, as amended), and constitutes a systematised list of constructions, understood as the final product of construction activities. It was prepared on the basis of the European Classification of Types of Construction.

[32)] Classification of Fixed Assets (Klasyfikacja Środków Trwałych, KŚT) is established by Regulation of the Council of Ministers of 10 December 2010 on the Classification of Fixed Assets (Journal of Laws, item 1622).The Classification of Fixed Assets is a systematic list of fixed asset items which is used, *inter alia*, for reporting purposes, determining depreciation rates, and for statistical research.

[33] *Zamieszkane Budynki*. *Narodowy Spis Powszechny Ludności i Mieszkań 2011*, GUS, Warsaw 2013

[34] Collective study, edited by Stanisław Mańkowski and Edward Szczechowiak, entitled *Opracowanie optymalnych energetycznie typowych rozwiązań strukturalno-materiałowych i instalacyjnych budynków* (Developing optimum energy solutions for the structure, materials, and installations of buildings). Volume I, Part A. Conditions underlying the transformations in the construction sector. Study Task No 2, carried out under the Strategic Research Project entitled "Integrated system for reducing the use-related energy intensity of buildings", commissioned by the National Research and Development Centre.

Table 1 presents the age structure of the Polish housing stock, together with estimates regarding the unitary demand for primary energy (PE) and for final energy (FE) of the stock.PEF (Polish symbol: EP) is an indicator describing the annual demand for non-renewable primary energy per unit of floor area of spaces with regulated air temperature, expressed in [kWh/(m^2·year)], while FEF (Polish symbol: EF) is an indicator describing the annual demand for final energy per unit of floor area of spaces with regulated air temperature expressed in [kWh/(m^2·year)].

Table1. Age structure of the Polish housing stock, and its unitary annual energy demand factors

No.	Period when building was constructed	Buildings		Dwellings		PEF	EK
	years	’000	%	million	%	kWh/(m^{2}year)	kWh/(m^{2}year)
1	pre-1918	404.7	7.3	1.18	9.1	> 350	> 300
2	1918 – 1944	803.9	14.5	1.45	11.2	300 – 350	260 – 300
3	1945 – 1970	1363.9	24.6	3.11	24.0	250 – 300	220 – 260
4	1971 – 1978	659.8	11.9	2.07	16.0	210 – 250	190 – 220
5	1979 – 1988	754.0	13.6	2.15	16.6	160 – 210	140 – 190
6	1989 – 2002	670.9	12.1	1.52	11.7	140 – 180	125 – 160
7	2003 -2007	321.6	5.8	0.60	4.6	100 – 150	90 – 120
8	2008-2011	205.1	3.7	0.41	3.2	-----	-----
9	under construction	27.7	0.5	0.04	0.3	-----	-----
10	unknown	332.7	6.0	0.43	3.3	-----	-----
	total	5 544.3	100.0	12.96	100.0	-----	-----

Source: Zamieszkane Budynki. Narodowy Spis Powszechny Ludności i Mieszkań 2011, GUS 2013, Collective study edited by Stanisław Mańkowski and Edward Szczechowiak „Opracowanie optymalnych energetycznie typowych rozwiązań strukturalno-materiałowych i instalacyjnych budynków” [37].

Table 2. Number of buildings commissioned for use in recent years

Years	2015	2014	2013
Total	10 0492	96 345	99 606
Residential buildings	76 663	73 072	77 575
Including single-dwelling residential buildings	71 558	68 880	73 663
Non-residential buildings	23 829	23 273	22 031

Source: Own study on the basis of GUS data

The requirements regarding energy efficiency of buildings between the mid-20th century and 1998 were being determined by specifying the acceptable thermal insulation of the building envelope, which involved limiting the value of the thermal transmittance coefficient of building envelope elements according to the following formula:

$k \leq k_{\max}$,

where:

k – thermal transmittance coefficient of the envelope element [W/(m^2·K)],

k_{max} – maximum allowable value of the thermal transmittance coefficient for envelope element concerned [W/(m^2·K)].

In 1998, the legislator replaced symbols k and k_{max} with the symbols U and U_{max}, which are used in international standards, and started to use a new method for formulating energy requirements, applicable exclusively to the categories of multi-dwelling residential buildings and collective accommodation buildings, which involved the limitation of the E factor, representing the calculated demand for final energy needed to heat a building during the heating season per 1 m^3 of the building's heated space:

$E \leq E_0$,

where:

E – seasonal heat demand factor [kWh/(m^3·year)],

E_0 – maximum allowable value of seasonal heat demand factor [kWh/(m^3·year)]

Values of the E_0 factor were determined on the basis of the building shape coefficient A/V, where A represented the external surface area of the envelope of the heated part of the building, and V represented its air space.

The technical and building regulations applicable at the time allowed the requirements to be complied with by alternative means, namely, for single-dwelling residential buildings energy requirements were considered to be met if the thermal insulation of the building's envelope elements met the requirement resulting from the dependence $U \leq U_{max}$ or the value of the E factor was consistent with the requirement $E \leq E_0$. In 2002, new technical and building regulations entered into force, revising significantly the energy requirements for buildings compared to earlier regulations.The amendments required that multi-dwelling residential buildings and collective accommodation buildings meet the requirements expressed by the U factor and the E factor at the same time.

The technical and building regulations regarding thermal protection and energy use rationalisation which applied in Poland from the early 2009 to the end of 2013 put in place the requirements to reduce energy consumption of buildings foreseen by Directive 2002/91/EC *on the energy performance of buildings*.

The legislation introduced a new energy evaluation method for all categories of new and existing buildings, based on PEF, which measures the annual demand for non-renewable primary energy per 1 m^2 of the floor area of a building with controlled indoor temperature. However, they also provided for an alternative evaluation method, which worked towards ensuring the required thermal insulation of individual building envelope elements, as expressed by the thermal transmittance coefficient U_{max}, and ensuring the required thermal insulation of the installation

techniques. Requirements regarding energy savings were considered to be complied with if the thermal insulation of the building's envelope elements was consistent with the requirement defined by $U \leq U_{max}$ or if the PEF value met the requirement $EP \leq EP_{max}$.

Applying the general requirements expressed by PEF requires calculating the energy performance of a building according to the procedure laid down by Regulation of the Minister of Infrastructure of 27 February 2015 *on the methodology for determining the energy performance of buildings or parts of buildings and on energy performance certificates.*

Since 1 January 2014, new requirements concerning energy efficiency of buildings have applied. For newly erected buildings, all the following minimum requirements must be met:

1) the PEF value, which measures the annual calculated demand for non-renewable primary energy to be used for heating, ventilation, cooling, warm service water preparation, and in the case of public, collective accommodation, production, utility and storage buildings, also for embedded lighting, as calculated according to the provisions establishing the methodology for calculating the energy performance of buildings, is lower than the allowable limit value established on the basis of the partial maximum values of the factor ($EP \leq EP_{max}$),
2) the building's envelope elements and technical equipment comply at least with the applicable thermal insulation requirements, and the window surface area is in compliance with the requirements specified by Annex 2 to Regulation of Minister of Infrastructure 12 April 2002 *on the technical conditions to be met by buildings and their siting* ($U \leq U_{max}$).

For a building undergoing reconstruction, the minimum requirements are considered to be complied with if the envelope elements and technical equipment subject to the reconstruction and the surface area of the windows meet at least the thermal insulation requirements established by Annex 2 to the above mentioned regulation.

The requirements will be gradually tightened in accordance with the schedule of changes specified by Regulation of the Minister of Infrastructure of 12 April 2002 *on the technical conditions to be met by buildings and their siting*, with a view to achieving the 2021 objective, according to which all new buildings should be nearly zero-energy buildings.

Table 3 presents a summary of the requirements concerning maximum thermal insulation (maximum values of the thermal transmittance coefficient of the envelope elements of heated building spaces), which illustrate the evolution of the standards for thermal insulation of buildings over the years.

Table 3. Requirements on the maximum values of the thermal transmittance coefficient for envelope elements of heated building spaces

Standard/provision	Thermal transmittance coefficient U_{max} [W/(m^2·K)]				
	External wall	Flat roof	Floor over unheated basement	Ceiling under an attic	Balcony windows and doors
PN-B-02405:1957P [a)]	1.16 ÷1.42	0.87	1.16	1.04 ÷ 1.163	-
PN-B-03404:1964P [a)]	1.16	0.87	1.16	1.04 ÷ 1.163	-
PN-B-03404:1974P [b)]	1.16	0.70	1.16	0.93	-
PN-B-02020:1982P [b)]	0.75	0.45	1.16	0.40	2.0 ÷ 2.6
PN-B-02020:1991P [b)]	0.55 ÷ 0.70 [d)]	0.30	0.60	0.30	2.0 ÷ 2.6
Technical and building regulations (1997)[b)]	0.30 ÷ 0.65 [c)]	0.30	0.60	0.30	2.0 ÷ 2.6
Technical and building regulations (2002)[b)]	0.30 ÷ 0.65 [d)]	0.30	0.60	0.30	2.0 ÷ 2.6
Technical and building regulations (2009)[b)]	0.30	0.25	0.45	0.25	1.7 ÷1.8
Technical and building regulations (2014)[b)]	0.25	0.20	0.25	0.20	1.3 ÷1.5
Technical and building regulations (2017)[b)]	0.23	0.18	0.25	0.18	1.1 ÷1.3
Technical and building regulations (2021)[b)]	0.20	0.15	0.25	0.15	0.9 ÷1.1

Source: Pogorzelski J. A., Kasperkiewicz K., Geryło R.: Budynki wielkopłytowe – wymagania podstawowe. Zeszyt 11 – Oszczędność energii i izolacyjność cieplna przegród. Stan istniejący budynków wielkopłytowych (Large panel buildings – essential requirements. Booklet 11 – Energy savings and thermal insulation of envelope elements. Existing condition of large panel buildings). ITB. Warsaw 2003, own study of the Ministry of Infrastructure and Development.

Explanation: [a)] θi = 18 °C, [b)] θi = 20°C, [c)] depending on the wall type (with or without openings), [d)] depending on the wall type and design

Most Polish buildings, in particular multi-dwelling residential buildings, were put into use several dozen years ago, that is in a period when the prices of energy were low and did not reflect its economic value. The technical solutions used at the time did not take due account of the thermal insulation of buildings, and proper indoor temperature was ensured by extensive heating systems which consumed relatively high amounts of energy. Existing buildings which were constructed before 1998 are characterised by a much higher demand for non-renewable primary energy than buildings erected at present.

The energy standard of existing buildings depends on their age and the requirements which were in place when they were constructed. Account must also be taken of the reduction in energy efficiency of buildings through their use, and, on the other hand, its improvement as a result of construction, installation and assembly works completed.

The structure of Polish buildings in terms of the technology used to build them is diversified. Pre-war urban building stock is dominated by what is referred to as *kamienice* (town houses) – masonry buildings, mostly made of bricks, usually several floors high. Many buildings of this type are still in a poor technical condition and require deep renovation. The heating and warm service water preparation methods vary. Coal boilers are still widely used as the main source of heat. Electric instantaneous water heaters are also popular. Some dwellings are equipped with single-floor central heating systems with a gas boiler or a solid fuel fired boiler.

The years 1946-1990 saw an intensification of the construction of buildings (see Table 1), and the mid-1960s observed rapid development of large panel technologies. Most of the latter type are high-rise or four-floor buildings, which are in need of refurbishment, with a focus on improving the thermal insulation of the envelope and replacing the central heating system. Most of such buildings are supplied with heat by district heating networks.

High demand for energy in buildings is chiefly linked to historical energy efficiency requirements. According to the study *Efektywność Energetyczna w Polsce Przegląd 2013* (Energy Efficiency in Poland – Overview 2013), Kraków 2014, Stowarzyszenie Instytut Ekonomii Środowiska, this mainly applies to single-dwelling buildings located in rural areas. In addition, the GUS publication entitled *Zużycie energii w gospodarstwach domowych w 2015 r.* (Energy consumption of households in 2015) shows that a proportion single- and multi-dwelling buildings do not have thermal insulation at all or are insulated only partially.

According to the study, some Poles live in insufficiently insulated buildings.As it suggests, the problem my concern up to 70% of single-dwelling residential buildings in Poland (around 3.6 million).

Data of the Central Statistical Office demonstrates that approximately 50% of residential buildings in Poland have been thermally insulated, but at a suboptimal level. Given that insulating already insulated buildings is expensive, efforts should focus in the first place on the thermomodernisation of previously uninsulated buildings.

1.2 Intended use of buildings

An overview of buildings according to their intended use has been prepared on the basis of a series of GUS studies entitled *Informacja o sytuacji społeczno-gospodarczej kraju* (Information on the socio-economic situation of the country) for individual years. The results are presented in Table 4.

Table 4. Structure (in current prices) of construction and assembly production by types of constructions

Types of constructions	Structure (%)									
Years	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
TOTAL	100	100	100	100	100	100	100	100	100	100
Total buildings	45.2	46.4	45.3	47.8	48.7	41.7	40.6	39.9	44.7	48
Residential buildings	14	13.9	13.4	16.1	17.4	14.4	12.7	12.4	14	13.1
including:										
single-dwelling buildings	1.7	1.7	1.4	1.5	1.8	1.7	1.5	1.3	1.6	1.4
two- and multi-dwelling buildings	10.9	11.1	10.7	13.4	13.9	11.1	10	9.7	10.7	10.2
Non-residential buildings	31.2	32.5	31.9	31.7	31.3	27.3	27.9	27.5	30.7	34.9
including:										
office buildings	3.9	4	3.6	3.5	3.7	3.2	3.2	3.1	3.8	4
commercial/service buildings	5	6	6.2	6.6	7	6.3	6.2	6.5	6.4	7.4
industrial/warehouse buildings	11.6	12.7	12.2	13.3	11.4	9.4	7.9	8.3	9.7	12.1
buildings with educational and cultural functions, hospitals and healthcare institutions, buildings used for sports activities, and other	7.7	6.8	6.4	5.3	5.4	7.5	7.7	6.6	7.3	7.9
Civil engineering structures	54.8	53.6	54.7	52.2	51.3	58.3	59.4	60.1	55.3	52

Source: *Informacja o sytuacji społeczno-gospodarczej kraju* (Information on the socio-economic situation of the country), 2004-2013, GUS.

As is shown by table 4, the structure (in current prices) of construction and assembly production, by types of constructions, has remained largely unchanged over the last 10 years. Out of the general number of constructions (excluding townscape structures), buildings represented from 39.9% to 48.7%, and the other structures from 51.3% to 60.1%. Within the category of buildings, the breakdown of construction and assembly production was as follows: the value of residential buildings constituted from 12.4% to 16.1% of the entire production, while the value of non-residential buildings ranged from 27.5% to 34.9% of the total production.

The tables and graphs below present the median of PEF values for different categories of buildings, as determined on the basis of energy performance certificates based on the Central

Building Energy Performance Register (centralny rejestr charakterystyki energetycznej budynków).

Table 5. Values of the annual primary energy demand factor for residential buildings depending on the intended use of the building and commissioning year

Type of building	Intended use	Commissioning year	Median of PEF values [kWh/(m^2 year)]
Residential building	single-dwelling	<1994	265.84
	multi-dwelling	<1994	145.03
	single-dwelling	1994-1998	202.72
	multi-dwelling	1994-1998	146.7
	single-dwelling	1999-2008	130.64
	multi-dwelling	1999-2008	105.51
	single-dwelling	2009-2013	114.1
	multi-dwelling	2009-2013	101.09
	single-dwelling	2014-2016	108.82
	multi-dwelling	2014-2016	97.00

Source: Own study based on data from the Central Building Energy Performance Register

Mediana wartości EP [kWh/(m2· rok)]	Median of PEF values [kWh/(m2· year)]
Jednorodzinny	Single-dwelling
Wielorodzinny	Multi-dwelling
Lata	Years

Figure 2. PEF relative to commissioning year

Table 6. Values of the annual primary energy demand factor for public buildings depending on the intended use of the building and commissioning year

Type of building	Intended use	Commissioning year	Median of PEF values [kWh/(m^2· year)]
Public building	office building	<1994	249.05
		1994-1998	211.92
		1999-2008	195.51
		2009-2013	188.92
		2014-2016	157.69
	building for the needs of public administration	<1994	231.34
		1994-1998	233.35
		1999-2008	214.72
		2009-2013	187.85
		2014-2016	179.46
	building for the needs of education and schools	<1994	247.46
		1994-1998	233.22
		1999-2008	168.31
		2009-2013	158.58
		2014-2016	133.75
	building for the needs of trade and services	<1994	309.20
		1994-1998	305.4
		1999-2008	300.46
		2009-2013	194.57
		2014-2016	168.65
	building for sports needs	<1994	244.47
		1994-1998	264.38
		1999-2008	257.79
		2009-2013	165.90
		2014-2016	172.31
	building for the needs of the administration of justice	<1994	250.78
		1994-1998	252.9
		1999-2008	217.26
		2009-2013	209.68
		2014-2016	163.61
	building used for healthcare purposes	<1994	438.78
		1994-1998	494.04
		1999-2008	315.94
		2009-2013	388.72
		2014-2016	369.93

Source: Own study based on data from the Central Building Energy Performance Register

Wartości wskaźnika EP ze względu na przeznaczenie budynku	PEF values by building's intended use
Mediana wartości EP [kWh/(m2· rok)]	Median of PEF values [kWh/(m2· year)]
Biurowy	Office building
Budynek na potrzeby administracji publicznej	Building for the needs of public administration
Budynek na potrzeby oświaty i szkolnictwa	Building for the needs of education and schools
Budynek na potrzeby handlu i usług	Building for the needs of trade and services
Budynek na potrzeby sportu	Building for sports needs
Budynek na potrzeby wymiaru sprawiedliwości	Building for the needs of the administration of justice
Budynek na potrzeby opieki zdrowotnej	Building used for healthcare purposes
Lata	Years

Figure 3. PEF relative to the intended use of public buildings

Table 7. Values of the annual primary energy demand factor for collective accommodation buildings depending on the intended use of the building and commissioning year

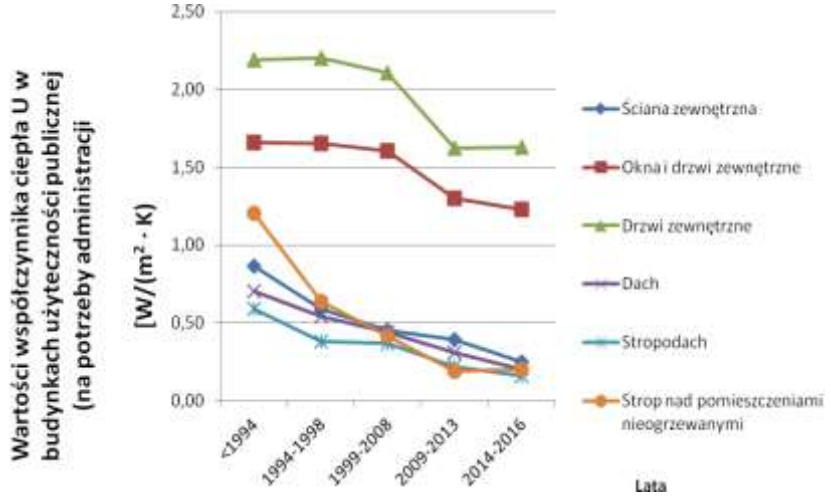
Type of building	Intended use	Commissioning year	Median of PEF values [kWh/(m^2· year)]
Collective accommodation building	pensions, rest homes	<1994	312.21
		1994-1998	211.92
		1999-2008	195.51
		2009-2013	-
		2014-2016	157.69
	boarding houses	<1994	293.51
		1994-1998	307.78
		1999-2008	170.94
		2009-2013	-
		2014-2016	183.99

	hotels	<1994	429.52
		1994-1998	351.91
		1999-2008	167.9
		2009-2013	-
		2014-2016	190.51

Source: Own study based on data from the Central Building Energy Performance Register

Wartości wskaźnika EP ze względu na przeznaczenie budynków	PEF values by buildings' intended use
Mediana wartości EP [kWh/(m2· rok)]	Median of PEF values [kWh/(m2· year)]
Pensjonaty, domy wypoczynkowe	Pensions, rest homes
Internaty	Boarding houses
Hotele	Hotels
Lata	Years

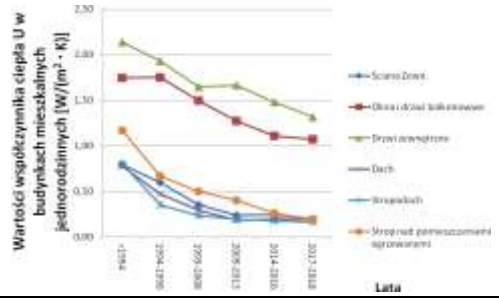
Figure 4. Comparison of PEF values for collective accommodation buildings



Wartości współczynnika ciepła U w budynkach użyteczności publicznej (na potrzeby administracji [W/(m2 - K)	Values of the U-factor in public buildings (used for the needs of the administration [W/(m2 - K)

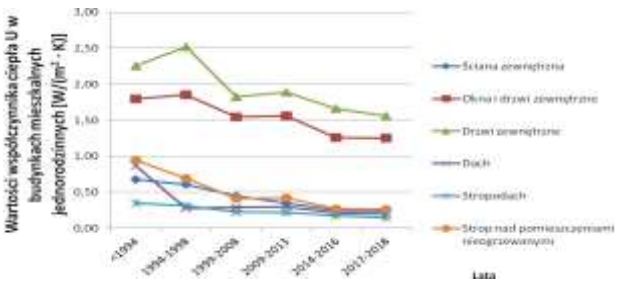
Ściana zewnętrzna	External wall
Okna i drzwi zewnętrzne	External windows and doors
Drzwi wewnętrzne	Interior doors
Dach	Roof
Stropodach	Flat roof
Strop nad pomieszczeniami nieogrzewanymi	Ceiling over unheated rooms
Lata	Years

Figure 4a. U factor values over time for public buildings



Wartości współczynnika ciepła U w budynkach mieszkalnych jednorodzinnych [W/(m2 - K)	Values of the U-factor in public buildings (used for the needs of the administration [W/(m2 - K)
Ściana Zewn.	External wall
Okna i drzwi balkonowe	Balcony windows and doors
Drzwi zewnętrzne	External doors
Dach	Roof
Stropodach	Flat roof
Strop nad pomieszczeniami ogrzewanymi	Ceiling over heated rooms
Lata	Years

Figure 4b. U factor values over time for multi-dwelling residential buildings



Wartości współczynnika ciepła U w budynkach	Values of the U-factor in public buildings (used

mieszkalnych jednorodzinnych [W/(m2 - K)	for the needs of the administration [W/(m2 - K)
Ściana zewnętrzna	External wall
Okna i drzwi zewnętrzne	External windows and doors
Drzwi wewnętrzne	Interior doors
Dach	Roof
Stropodach	Flat roof
Strop nad pomieszczeniami nieogrzewanymi	Ceiling over unheated rooms
Lata	Years

Figure 4c. U factor values over time for single-dwelling residential buildings

The tables below present other data concerning the domestic building stock, which come from the latest GUS studies (Energy consumption of households in 2015).

Table 8. Breakdown of dwellings in Poland by types of buildings

Dwellings by type/intended use of the building				
	Multi-dwelling building	Single-dwelling house		Other type of building
		terraced	detached	
Share of dwellings [%]	55.51	5.99	38.32	0.18

Table 8 presents a simplified breakdown of dwellings by types/intended use of existing residential buildings (data for 2015). A majority of residential buildings are multi-dwelling buildings. As regards single-dwelling houses, detached houses predominate.

Table 9. Breakdown of buildings in Poland by insulation status of the building

Dwellings by insulation status of the building				
	Insulated building	Non-insulated building	Partially insulated building	No information
Share of dwellings [%]	58.83	29.46	10.19	1.53

Table 9 presents a breakdown of residential buildings by insulation status. Buildings classified as "insulated" account for slightly more than half of the survey sample. Non-insulated buildings account for about 30% of all the buildings under study.

Table 10. Breakdown of dwellings in Poland by type of windows used

Dwellings by window type		
	Multiple-glazed windows	Casement window

Share of dwellings [%]	88.49	11.51

Table 11. Breakdown of dwellings in Poland by the number of window panes

Dwellings by the number of window panes			
	One pane	Two panes	Three panes
Share of dwellings [%]	5.82	91.53	2.66

Tables 10 and 11 show the breakdown of dwellings by window type. It should be emphasised that, on average, both multiple-glazed windows and windows with two or three panes are characterised by better insulating properties in the context of thermal transmittance. Thus, in view of the results of the survey presented in the tables, it can be concluded that in terms of the key design parameters windows in dwellings potentially demonstrate good insulating characteristics.

Table 12. Breakdown of dwellings in Poland by thermal comfort (as assessed by respondents)

Dwellings by thermal comfort		
	Sufficiently warm in winter	Insufficiently warm in winter
Share of dwellings [%]	89.78	10.22

Table 12 presents the results of research based on respondents' subjective assessment of thermal comfort. The concept of thermal comfort is very complex due to the lack of a stable reference point, but it is associated to a very large extent with energy efficiency of buildings. Buildings with good energy parameters ensure sufficient thermal comfort for users. It can therefore be concluded that a majority of the dwellings under study, and thus also the buildings in which they are located, demonstrate parameters which allow maintaining sufficient thermal comfort in winter.

Table 13. Breakdown of dwellings in Poland by availability of running water

Dwellings by availability of running water						
	Cold water			Warm water		
	from the water supply network	from own water intake	not available	from the district heating network	heated locally	not available
Share of dwellings [%]	94.44	6.74	0.62	29.91	66.88	3.21

Table 13 presents a breakdown of dwellings by connection to water supply and district heating networks. As regards connection to a water supply network, it can be observed that a vast majority of dwellings have such a connection. The second division presented in the table reveals a relatively low percentage of dwellings connected to a district heating network. It must be emphasised that district heating is the most efficient system in terms of the preparation and supply of warm service water to buildings.

1.3 Ownership of residential buildings

The structure of inhabited residential buildings by form of ownership is based on data from the publication *Zamieszkane budynki* (Inhabited Buildings), which presents the results of the 2011 National General Population and Housing Census.

As a result of the introduction of new legal regulations regarding ownership of premises and the activities of housing cooperatives, the period between the National General Population and Housing Census in 2002 and that in 2011 observed changes in the structure of ownership of residential buildings and dwellings in such buildings. Compared with the 2002 Census, the number of inhabited jointly-owned residential buildings with individually-owned dwellings increased considerably[35]. The number of residential buildings owned by natural persons and Social Building Societies increased, too. By contrast, the share of other forms of ownership in the structure of residential buildings declined.

Table 14 presents the ownership structure of the inhabited housing stock in Poland for 2011.

Table 14 Inhabited residential buildings and dwellings in inhabited residential buildings in 2002 and 2011.

Form of ownership		Buildings (’000)		Dwellings (’000)	
		2011	2002	2011	2002
ownership of	natural persons	4616.1	4204.8	5 408.8	4 819.0
	housing cooperatives	20.4	82.3	239.3	3 031.5
	municipalities	56.8	95	282.6	595.5
	of the State Treasury	19.6	27.1	62	146.4
	employers	28.3	39.4	84.7	192.6
	Social Building Societies	3.1	2	43.1	33.2
	other entities	12	12.8	22.9	33
joint ownership	with individually-owned dwellings	505.1	268.3	6 505.0	2 935.3
	with no individually-owned dwellings	36.7	42	50.6	79.1
Total		5 298.1	4 773.6	12 960.5	11 865.8

Source: *Zamieszkane Budynki*. National General Population and Housing Census 2011, GUS 2013

In 2011, most buildings were owned by natural persons (83.3 % of the total number of inhabited residential buildings). The persons owned more than 4.6 million residential buildings with approximately 5.4 million dwellings. Compared to 2002, the number of residential buildings

[35]) Jointly-owned buildings with individually-owned dwellings – buildings which are a joint property in which all or only some dwellings are owned individually by natural and/or legal persons (e.g. joint ownership by natural persons, joint ownership by natural persons and the municipality, joint ownership by natural persons and an employer). All individual owners of dwellings in a building form the so-called “housing association” (after the entry into force of the Act of 15 December 2000 *on housing cooperatives*, individual ownership titles were established for some dwellings and acquired by natural persons).

owned by natural persons increased by 9.8 %. Jointly-owned buildings with individually-owned dwellings ranked second in terms of the share in the stock of residential buildings (9.1%). In 2011, the number of residential buildings with such ownership was 500 000, with more than 6.5 million dwellings.

Compared to the previous Census, the number of jointly-owned residential buildings with individually-owned dwellings increased by 88%, and the number of dwellings in such buildings more than doubled. The upward movement in the number of buildings representing such property was associated with the completion of new buildings with joint ownership, as well as with the establishment of individual ownership titles to dwellings in buildings previously owned by a single entity. In the years 2002-2011, approximately 172 000 residential buildings changed their ownership status to joint ownership with individually-owned dwellings.

1.4 Use of buildings and method for supplying space heat to residential buildings

According to GUS data, in 2014 households had a considerable, 20% share in the nationwide energy consumption in Poland. Poland was among the EU countries where the share of households was relatively high (a 20% or greater share in nationwide consumption was recorded by 6 countries, with an average of 16%). On average, Polish households consumed approximately 21 GJ of energy per capita, which ranked Poland below the European average of 22 GJ/per capita, with less energy per capita mainly consumed by households in countries of southern Europe.

The largest share in the structure of energy consumption by Polish households is that of solid fuels, mainly hard coal (which is an exception in the European Union) and firewood. They were the energy carriers most commonly used for heating purposes. Solid fuels were used for space heating by nearly half of the households surveyed. A lower percentage of households used these fuels additionally for water heating, and a much lower percentage – for cooking meals.

District heating was a very important source of energy, supplying about 41.5% of all dwellings, primarily in big cities, where it was the dominant energy carrier. About 30% of households, i.e. 72% of the consumers of district heat, used it also for water heating.

Natural gas was used by 55.1% of households, but half of its consumers used it exclusively for cooking meals, and only 10% for heating their dwellings. This is attributable to the long-standing practice of installing gas systems in multi-dwelling buildings solely for the purpose of cooking meals. In areas of the country where a natural gas network was not available, stationary use of liquefied gas was common, with the gas used almost entirely for cooking purposes.

Approximately 42% of households used firewood. It was the only renewable energy carrier used massively by households. In general, it was burnt in the same boilers and furnaces as hard coal, together with coal or interchangeably. In addition to firewood, households also used other types of

biomass, but they were far less popular than wood. Solar collectors were used by one household in 56, and heat pumps only by one household in 1 250.

Electricity was commonly consumed by households, with a vast majority of them using it for lighting and powering household appliances and electronics. The use of electricity for heating purposes was insignificant due to high prices and availability of cheaper substitutes. Electricity was rather used for cooking meals and space heating as an additional carrier, and it was utilised for water heating mainly in cases where no district heating or gas network were available.

A vast majority of households had essential electrical appliances, i.e. combined refrigerator-freezers, automatic washing machines, vacuum cleaners, and TV sets. As regards light bulbs, traditional light bulbs predominated because the process of withdrawing them from the market began only in 2009.

Most households were well furnished with the key energy consuming equipment, both that which satisfied their basic heating needs and that improving the living comfort of occupants. However, in Poland, similarly to other European countries, there are households which are poorly equipped in this respect. The survey shows that 3.2% of dwellings did not have warm running water, 10.2% were considered by respondents as insufficiently warm in winter, and 3.1% were equipped with solid fuel stoves or solid fuel cookers as the only heat sources.

The years 2002-2015 saw progress in the use of more modern and more energy-efficient technologies. Most dwellings equipped with their own central heating boilers (fired with solid fuels or natural gas) had dual-purpose boilers, which were also used for the preparation of hot water. Single-purpose boilers were less popular, and fireplaces were even less common. In some old buildings, solid fuel stoves or solid fuel kitchens were the only heating equipment.

There were slight but positive changes in the structure and level of the average annual consumption of different energy carriers by households. Given that households use more electrical equipment, an increase in the average electricity consumption was recorded in 2015 compared to 2002. Notwithstanding this, in terms of the consumption of electricity by households relative to the number of population, Poland ranked last but one among the European Union countries. For the other energy carriers, the average consumption per household decreased, with the drop in consumption ranging from 4% to 14%.

As a result of wide-ranging activities including: thermomodernisation, tightening of the building standards, and improving the energy efficiency of heating equipment, the share of energy consumed for space and water heating in the overall consumption shrank. An important criterion when performing an overview of buildings is the method used to supply them with heat. In

residential buildings, heating needs account for approximately 65% of the final energy consumed by households[36].

According to the GUS study *Zużycie energii w gospodarstwach domowych w 2015* (Energy consumption of households in 2015)[37], solid fuels and district heating clearly predominate in space heating. Almost half of households (49%) used heating equipment fired with solid fuels, mostly dual-purpose central heating boilers, which were used both for heat generation and water heating. Such boilers were used by 47.7% of the households which heated their homes with solid fuels. Single-purpose boilers were utilised by 29.3% of such households. 15.3% of households used the most conventional heating equipment, namely stoves in rooms, chiefly tiled ones, with 83.3% of households using them as their basic equipment and the other utilising them only occasionally. 7.8% of the households which relied on solid fuels used fireplaces, mainly with a closed insert, with only 19.7% of such households using them as their basis equipment for space heating.

41.7% of all households relied on district heating. District heating was mostly consumed by residents of multi-dwelling blocks, with single-dwelling houses accounting for a small share.

Out of district heating consumers, 72% used it also for water heating. This relatively low share of households using district heating for this purpose had two reasons:

- supplying district heat to older buildings which had a central heating system, but had no internal warm service water installation;
- operation of small, local central heating systems whose use in the summer season was not economically viable.

In many households, both these factors occurred simultaneously. When feasible in terms of the technical potential of the district heating system, buildings can be additionally furnished with a warm water installation, but such building repair-stage retrofits are costly and cumbersome.

Also central heating boilers fired with natural gas were used for space heating, which was the case for 9.9% of households, with 7.8% of such boilers being dual-purpose units, and 2.1% single-purpose units.

Electric heating equipment was utilised by 4.3% of households, but chiefly as an extra source of heating, and not the essential one. Permanently installed electric heaters were used by 1.8% and underfloor heating installations by 0.3% of households. Portable electric heaters were found in 2.5% of households, and were chiefly used as an additional heat source, in emergency situations, or on a temporary basis.

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[36] *Energy efficiency in 2005-2015* (Efektywność wykorzystania energii w latach 2005-2015), GUS, Warsaw 2017.
[37] Energy consumption of households in 2015, GUS, Warsaw 2017.

The smallest number of households heated their dwellings with liquid fuel boilers – 0.4% of households used fuel oil boilers, and 0.14% liquid gas boilers. Also here, dual-purpose boilers (83.7%) predominated over single-purpose ones (16.3%).

On occasion, solar units and heat pumps were used for space heating. The survey identified 0.15% of households heated by solar energy and 0.08% of households using heat pumps.

Some households, i.e. more than 9%, used two different techniques for heating purposes, one as the basic one and the other as a supplementary one, or used two techniques with equal or similar shares in supplying heat to their dwellings.

Subject to the reservation that the division of dwellings according to heating techniques is not disjoint, it can be estimated on the basis of GUS data that the share of individual techniques in households was approximately as shown in Figure 5.

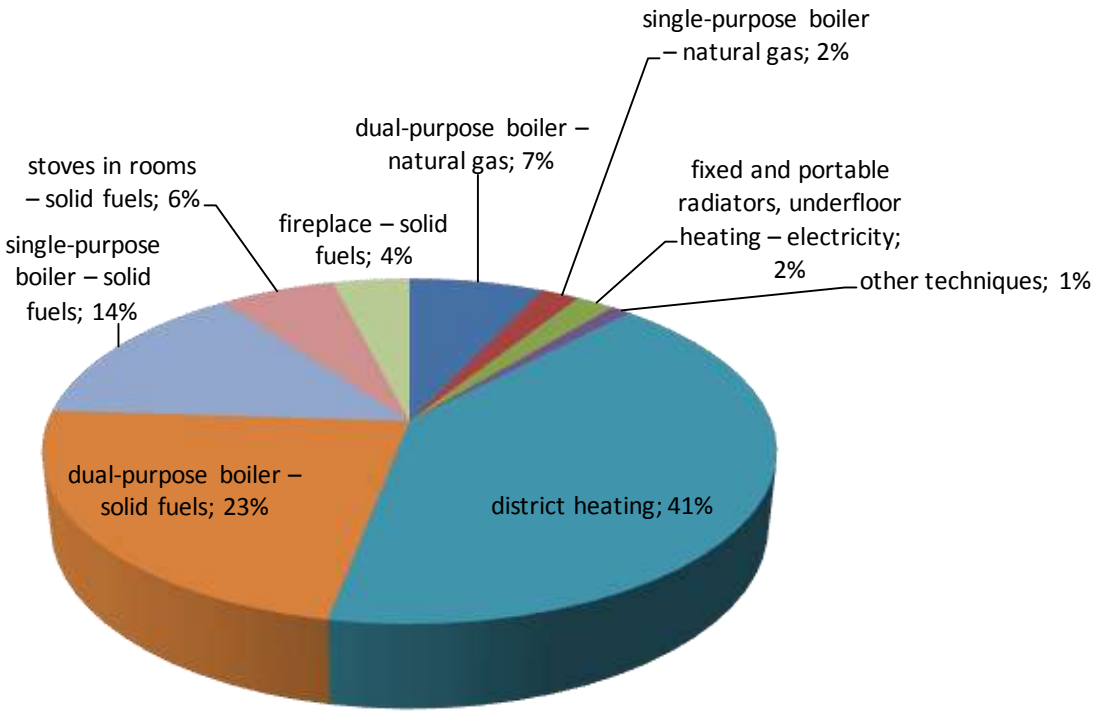


Figure 5. Space heating according to heating techniques

Similarly to space heating, the methods households use for domestic water heating are also diversified. Subject to the reservation that the classes are not disjoint, which means that many households use two or more different types of water heating equipment (this applies to about 11% of households), based on GUS data, the shares of individual techniques can be presented as in Figure 6.

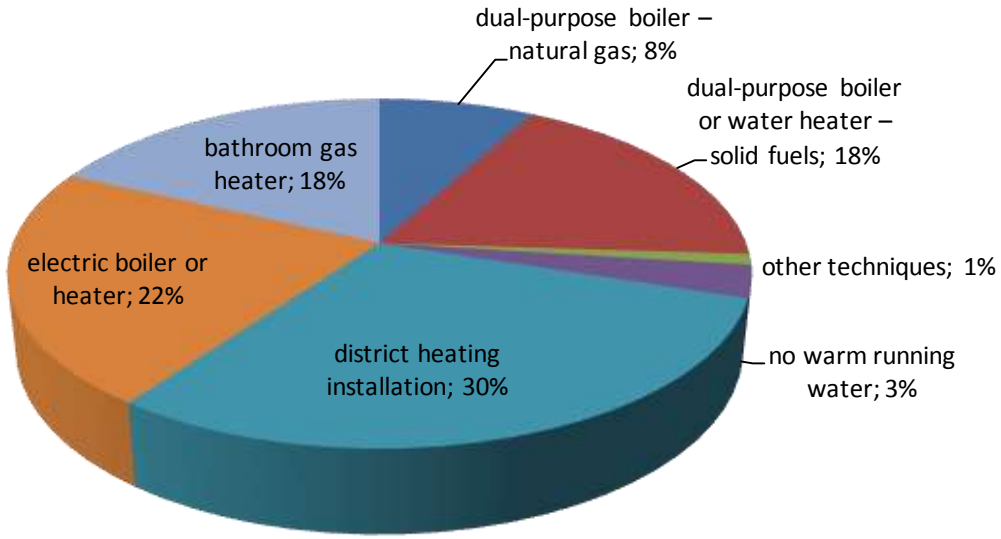


Figure 6. Preparation of warm service water by heating techniques

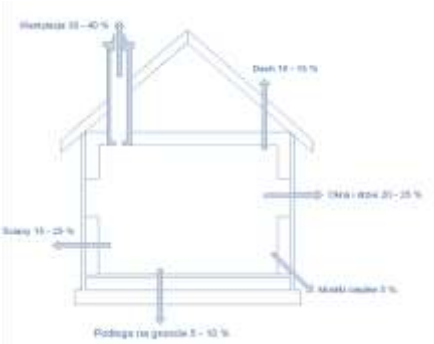
2. Determining cost-effective building renovation methods

One of the tools which can be used to determine cost-effective methods for renovating a particular building is energy audit, as provided for by Regulation of the Minister of Infrastructure of 17 March 2009 *on detailed scope and form of energy audits and parts of repair audits, model audit sheets, and algorithm for evaluating the cost-effectiveness of thermomodernisation projects*. Following this, based on calculations made as a result of the audit, the actions can be selected which provide the highest energy savings, with a short payback period.

When planning refurbishment, the following actions should be taken into consideration:

- increasing the thermal insulation of the building envelope;
- improving energy efficiency of: the heating, warm service water, ventilation, cooling and lighting systems;
- replacement or refurbishment of the heat source.

It is estimated that space heating and cooling is responsible for nearly 70% of the total energy consumption in European buildings. Therefore, actions aimed at reducing energy losses and increasing energy gains will significantly improve the energy performance of buildings.



Ściany 15 - 25%	Walls 15-25%
Wentylacja 30 - 40%	Ventilation 30-40%
Dach 10- 15%	Roof 10-15%
Okna i drzwi 20 - 25%	Windows and doors 20-25%
Mostki cieplne 5%	Thermal bridges 5%
Podłoga na gruncie 5 - 10%	Ground floor 5-10%

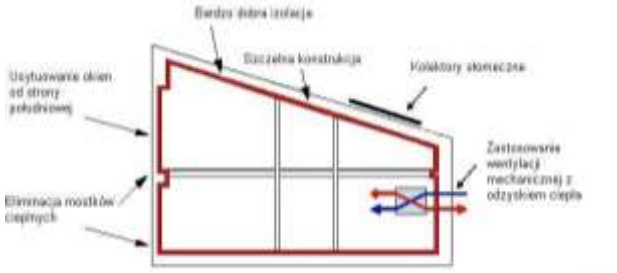
Figure 7. Distribution of heat losses in the building's energy balance caused by heat transfer through envelope elements and ventilation

It can be observed that the greatest heat losses in a building result from the penetration of heat through envelope elements (the greatest losses are generated by glazed elements, such as windows and doors), with a share of 60-70% of the balance.

By contrast, ventilation causes losses of 30-40%. This requires minimising heat losses, while maximising energy gains.

Heat losses can be reduced using improvements in the following:

- ventilation – using mechanical ventilation with heat recovery from exhaust air and ensuring high airtightness of buildings;
- windows and doors – using energy-efficient units;
- external walls – appropriate insulation of walls;
- the roof – proper roof insulation;
- ground floors – proper insulation;
- thermal bridges – using solutions which minimise the presence of thermal bridges.



Eliminacja mostków cieplnych	Elimination of thermal bridges
Usytuowanie okien od strony południowej	Placement of windows from the south
Bardzo dobra izolacja	Very good insulation
Szczelna konstrukcja	Airtight structure
Kolektory słoneczne	Solar collectors
Zastosowanie wentylacji mechanicznej z odzyskiem ciepła	Use of mechanical ventilation with heat recovery

Figure 8. Example of heat loss minimisation in a building

2.1. Measures

The shape, orientation and surroundings of the building

In order to improve the energy performance of a building, the greatest possible energy gains and the lowest possible losses must be ensured. This can be obtained not only by ensuring the right orientation of the building's body relative to the directions of the world, but also by the right management of the building's surroundings.

In winter, the surroundings should provide as much light from the south as possible, and protect the building against excessive overheating in summer. In addition, from the north, where no gains

resulting from solar radiation are available, the building should have a buffer zone protecting it from heat losses.

The above can be ensured, for example, by planting a group of deciduous trees from the southern side of the building, which will create shade in summer, and after the threes lose their leaves, will allow sunlight into the building in winter. By contrast, from the northern size, planting coniferous trees is recommendable to create a buffer zone protecting the building against wind throughout the year, and thus minimise heat losses. The geometry of the building, the layout of its interiors and special equipment and structural elements, such as roller shutters, eaves or winter gardens, are also crucial for satisfying the above requirements.

Heat losses depend not only on the parameters of the thermal insulation used, but also the geometry of the building. In order to obtain optimum energy characteristics, the ratio of the area of the building envelope to the building's heated space should as small as possible. The smaller the area through which the building loses heat, the better. Therefore, the optimal solution is to ensure that the body of the building is as compact as possible. Care should also be taken to avoid such additional external (technical and decorative) elements in buildings as bay or dormer windows, which increase the area over which heat is lost through the envelope and make the occurrence of thermal bridges more likely. If such elements cannot be avoided, efforts must be taken to ensure that their thermal insulation is very carefully made.

The standard PN-EN ISO 10211 *Thermal bridges in building construction – Heat flows and surface temperatures – Detailed calculations*, a thermal bridge is defined as part of the building envelope in which uniform thermal resistance is significantly changed by:

- full or partial penetration of the building's envelope by materials with a different thermal conductivity or
- change in the thickness of the layers of materials, or
- difference between the internal and external surface areas of envelope elements, as in the case of wall-to-floor-ceiling junctions.

The spots within buildings structures where thermal bridges are most common include balcony-to-ceiling junctions, tie beams, lintels, edges of window openings and of balcony doors.

Additionally, the energy performance of a building can be improved by the creation of a thermal buffer zone on its southern side, for example in the form of a winter garden. Such a zone should be characterised by large glass surfaces. A winter garden does not generate heat losses because it does not require heating, but at the same time is a source of energy gains from solar energy.

When planning the room layout, attention must also be paid to recommendations regarding building ventilation. This will be discussed in detail below.

Designing the shape of the building and its surroundings properly translates into reduced demand for conventional air-conditioning or heating. Thermal comfort in a thus designed building can be ensured by very good insulation, energy produced by sunlight, and energy recovered from air blown out of the building's interiors.

Although the above information mainly concerns newly designed buildings, it can also prove helpful in understanding the influence of the orientation and shape of a building and the management of its surroundings on its energy performance and the possibility of using energy effectively.

Non-transparent elements of the envelope

As was explained above, even as much as 70% of heat can escape through the envelope of buildings constructed with conventional technologies. In order to improve the energy performance of a building, in line with the low-energy building concept, all building elements, including walls, windows, roofs and ground floors, should be subject to the heat loss minimisation/heat gain maximisation principle.

The thermal insulation of envelope elements is measured by the thermal transmittance coefficient also known as the U-factor. The thermal transmittance coefficient of an envelope element depends on the thermal transmittance coefficient of the materials used for the individual layers of the wall (the structural, insulating and finishing layers) λ and their thickness, and thus it depends on the element's total thermal resistance R. The lower the thermal conductivity of the material, the greater its thermal insulation power. In practice, this means that in order to achieve the desired thermal transmittance coefficient for an external wall, use can be made of thinner layers of structural and insulation materials with low thermal conductivity λ or of thicker layers of such materials, but with poorer thermal properties.

In addition, the thermal insulation of a building's envelope elements depends on:

- whether the thermal insulation has been applied properly – mainly whether it is airtight and has no gaps so as to prevent thermal bridges;
- the number of window and door openings and how they are designed in the context of thermal insulation (the effect of windows and doors on the thermal insulation will be discussed below).

The role of thermal insulation in a building is to:

- reduce heat losses from the building to the surroundings;

– maintain appropriate temperatures of internal envelope surfaces so as to prevent condensation of water vapour and dampness within the envelope, and consequently to prevent the growth of mould.

Thermal insulation is one of the key factors determining the level of heat needed to keep a building warm, and consequently the cost of using the building. Well insulated elements of the building envelope translate into reduced U-values of these elements, thus contributing to lower energy losses and heating costs. A one-off investment in good thermal insulation and its proper installation generate savings during each subsequent heating season throughout the life of a building.

Various types of construction materials for thermal insulation are available on the market, including mineral wool, glass wool, and foamed polystyrene. The minimum thickness of thermal insulation depends on the maximum allowable value of the thermal transmittance coefficient, which is determined by technical and building regulations. Insulation should have no gaps, be of uniform thickness and should be adjusted to the type of envelope element. In addition, the surface should be properly prepared (cleaned), and the thermal insulation panels installed should overlap in the successive layers of thermal insulation. In addition, junctions between different types of envelope surfaces and spots were insulation is punctured by mechanical joints are particularly susceptible to the occurrence of thermal bridges. As is commonly known, thermal bridges are among the least desirable phenomena in a building. Therefore, connections of thermal insulation of the envelope (e.g. in the corners of a building or at the wall-to-balcony or wall-to-roof junctions) should be designed in a well-thought-out manner and made with great attention to detail.

For example, when insulating an inclined roof, two layers of thermal insulation are used: one layer of insulation, usually made of mineral wool, is laid between the rafters, and the other is applied on the first one from the loft side. Furthermore, in order to avoid thermal bridges, it is essential that insulation be applied properly around window and door openings. In this case, connecting neighbouring panels in the corners of an opening is not acceptable. Insulation panels should be cut so that the corner of a window or door opening is surrounded by a single insulation panel.

As regards balcony slabs, thermal insulation must be placed along the entire length of the slab – both on top of it and underneath. Appropriate insulation of the junction between the external wall and the balcony slab significantly reduces heat losses. Another option is to use thermally insulated balcony connectors, which are designed to limit the thermal bridge while maintaining the continuity of reinforcement between the floor slab and the balcony slab (however, given the technology of the solution, it can only be used in newly erected buildings).

In order to limit heat losses and maximise solar radiation gains, consideration should also be given to applying the so-called “transparent insulation”, i.e. a system for heating external walls by means of light transmitting capillary panels made of polycarbonate, covered with transparent glass plaster. Such panels transmit heat from solar radiation to the absorbent mass (black-coloured adhesive mass), which is closest to the insulated wall.

Transparent insulation can be used to provide additional light for interiors or in combination with a solid wall, which accumulates heat and can emit it back for 6 to 8 hours after solar radiation stops. On account of its design, such insulation is most efficient in winter, and does not lead to overheating the building’s interior in the summer. This is because capillary materials let the greatest amounts of sunlight in when the angle of incidence of the sun rays relative to the surface is small (i.e. in winter). However, when the sun ray incidence angle increases, ever more rays are reflected and do not reach the absorption mass.

Insulation of the envelope from the outside is the most common and recommendable solution from the point of view of a structure’s physics. However, there are also cases when, for example on account of the historic character of a building, installing thermal insulation on the façade is undesirable. In such cases, in order to improve the thermal parameters of external walls, insulation can be applied from the inside. The advantages of such a solution include the possibility to preserve the original appearance of the façade and improve the energy performance of a single room or dwelling in a building where no comprehensive thermomodernisation is planned. However, poorly made insulation from the inside may lead to wall dampness and contribute to indoor mould development. In addition, an external wall, which in the case of conventional solutions receives heat from the heated space and can ensure that heat is accumulated in the room and its temperature stabilised, when insulated from the inside, is exposed to freezing and associated degradation resulting from the impact of precipitation and low temperatures.

With insulation from the inside, the most important parameter of products used for thermal insulation is their diffusion resistance, i.e. their ability to pass water vapour.

Basically, there are two types of solutions used for insulating walls from the inside:

- insulation with a tight vapour barrier installed from the inside (using products with high diffusion resistance),
- insulation with vapour-permeable products (with low diffusion resistance).

With the former type of solutions, a thermal insulation layer, usually made of mineral wool or polyurethane foam panels, is laid on the wall on a wooden or metal frame, and then covered with vapour barrier foil to create a tight layer which prevents moisture accumulating in the interior from penetrating the insulation layer and its later condensation at the interface with the cold wall.

The next layer is made of plaster or gypsum board and the finishing. It must be remembered that when using this solution, attention must be paid to efficient ventilation, preferably by mechanical means, such as to ensure that water vapour is removed and proper level of humidity in the room is maintained.

The latter method relies on the use of materials allowing free flux of water vapour, such as calcium silicate boards or cellular concrete panels. These materials have a porous structure and are capable of absorbing water vapour from the interior and distributing it evenly over their entire surface, and then release the accumulated water vapour when humidity in the interior decreases. Importantly, such products are characterised by non-flammability and anti-fungal properties, which is associated with their high pH (approximately 10).

When employing insulation from the inside, the interior must always be analysed in terms of its humidity and the amount of possible condensation inside the wall, as well as the possibility of removing the accumulated water vapour, so as to adjust the technology to the needs of the users and the conditions in which the building is used.

Transparent envelope elements

Transparent envelope elements, such as: windows, balcony doors, glazed curtain walls or skylights are the elements of a building which generate the greatest loss of heat. They are characterised by a far lower thermal insulation power than external walls, thus leading to higher heat losses caused by heat transfer. The very method for embedding window frames in walls or roofs can also cause losses associated with the formation of thermal bridges. However, when arranged skilfully and designed properly, these elements can generate higher energy gains than the losses they are likely to cause. For this reason, it is advisable that most windows should be placed in the southern side of the building.

Transparent space dividing elements consist of two basic parts: the translucent part, that is a set of panes, and the non-translucent part, namely window and door frames or mullion and transom structures of light curtain walls. The key parameter which determines heat losses produced by such types of envelope elements is the thermal transmittance coefficient: U_w for windows, U_D for doors, U_{cw} for curtain walls. The lower the thermal transmittance coefficient, the higher the thermal insulation of the envelope component. The value of thermal transmittance coefficient depends on the following constituents: the glazing – U_g, the window and door frames – U_f, and the mullion and transom structure – $U_{m/t}$, as well as the linear thermal transmittance coefficients describing the thermal insulation of connections.

From the point of view of energy savings, the window and door installation method is also relevant. The lowest heat losses through thermal bridges occur when windows and doors are

embedded in a layer of thermal insulation or installed at the interface between the wall and insulation. It must be borne in mind that windows intended for low-energy buildings and characterised by the best heat transfer parameters do not support ventilation, as it is expected in conventional construction. Such windows do not have trickle ventilation features and their seals are appropriately designed and made of good quality materials. Therefore, if a building relies on non-mechanical ventilation, when replacing doors and windows, new windows must be equipped with such ventilation features as to ensure sufficient inflow of air into the building and allow proper operation of the building's ventilation system.

Window frames

Given their thermal transmittance coefficient, window frames are the most crucial element of a window's design. In order to ensure the lowest value of the thermal transmittance coefficient for window frames – U_f, the following must be considered:

- the thickness of window sections;
- the system of hollows, so-called chambers, in the sections;
- the filling of the hollows with thermal insulation;
- appropriate location (depth) of the glazing;
- improving the thermal insulation in the area of the glass edges using additional insulators made of foam composites.

The thicker the frame section, the greater the number of hollows in the profile, which allows the latter to be appropriately distributed with a view to ensuring better thermal insulation power of the frame, i.e. lower U_f value. In addition, modern windows are fitted with additional insulation of the window frame (thermal insert). Aluminum and PVC, wooden and wood-aluminum profiles are available on the market.

Glazing

Typically, glazing represents 70% of the window surface or more for light curtain walls based on a mullion and transom structure, and thus it is highly relevant for the heat parameters of transparent envelope elements.

Currently, 3 types of glass units are available on the market:

- double glazed units with thermal transmittance coefficient U_g of 1.0 W/(m_2K);
- triple glazed units with thermal transmittance coefficient U_g ranging from approximately 0.3 to 0.7 W/(m^2K);
- quadruple glazed units with thermal transmittance coefficient U_g ranging from approximately 0.3 to 0.7 W/(m_2K).

The thermal insulation is provided by the gas filling the cavity between the panes. Argon is the gas most commonly used at present, with krypton or xenon being less common. The use of different types of gas is associated with the fact that the greater the atomic mass of gas, the better its insulating properties.

In addition to different types of gas in the cavity, the market offers panes with various light and solar energy transmittance or reflection properties, which can highly improve the balance of heat gains and losses, and thus help use energy in an efficient way.

Given their low radiation transmittance, low-emission panes are capable of reflecting most of the thermal radiation emitted by internal partitions and equipment installed inside the rooms. In practice, this means that low-emission glass reflects heat radiation back into the interior of the building, thanks to which heat losses are much lower than in the case of ordinary glass.

It is worth mentioning that different types of low-emission glass allow various amounts of solar heat to be gained, thus helping to reduce the heating needs, especially in colder months of the year. A low-emission layer lets thermal radiation into the room, and at the same time blocks the transfer of heat outside. In order to achieve the greatest possible energy effect, the properties of glazing used should depend on where windows are located. From the northern side of the building, thermal insulation should be given the greatest attention, while from the south, the controllability of the amount of day light and solar heat getting into the interior should be prioritised.

Similarly to absorption panes, reflective window panes are an example of sun protection glass. Their coatings reflect solar radiation, or they only pass some of radiation of the visible spectrum and reduce the transmission of infrared (heat) and ultraviolet (UV) radiation. Reflective glass is characterised by light transmittance of 40÷70%, and reflexivity of 15÷45%. The properties of windows associated with the use of the solar radiation factor are strongly connected with the type of panes used for glazing. Total energy transmittance (TET) also known as the g value is the ratio of the total energy transmittance of a window pane to the solar energy falling onto it. The value indicates what portion of solar radiation energy falling onto the glass is let into the interior.

The glazing parameters are also determined by the materials and design of the glass unit. Among other things, the glass spacer used is important. Spacers used in multiple-glazed windows are to ensure the intended distance between the panes and provide space for moisture absorbing material, which dehumidifies the gas filling the space between the two sheets of glass. Standard frames are made of aluminium or stainless steel and are perforated inside the cavity to allow the moisture absorber placed inside the frame to act. However, the metal spacer constitutes a thermal bridge, leading to deterioration of the thermal insulation of the window. For this reason, use is also made of the so-called “warm spacers”, which are made of plastic or stainless steel and are characterised

by lower thermal transmissivity coefficients than aluminium. The use of warm spacers increases the temperature at the edges of the glass sheets, which reduces the risk of water vapour condensation. Thank to using warm spacers, the allowable relative air humidity at which water vapour condenses on the glass surface in specific conditions may be approximately 10-15% higher. It should be noted that the actual effect of a thermal bridge at the edge of a pane installed in a multiple-glazed window depends on the spacer type, the gas filling the cavity, the depth of the pane inside the section, and the U_f value of the window frame section. As the depth of the window pane increases, the share of the window's heat losses through the pane edges decreases, minimising the likelihood of water vapour condensation. Warm spacers reduce the average heat factor of a window by approximately 0.1÷0.2 W/(m^2·K) compared to windows with glazing with aluminium spacers.

Sun protection systems

It must be remembered that thermal comfort involves not only ensuring a sufficiently high temperature in winter, but also protection against overheating in summer, when high temperatures and sun exposure occur. Considering this, use should be made of sun protection systems, which are designed to:

- provide protection against excessively high insolation (sun exposure) in summer;
- provide insolation in wintertime and during transitional periods;
- increase the living comfort for building occupants;

Sun protection systems used in buildings are divided into immovable and movable ones.

Permanent systems:

- protruding cornices;
- wide or long balconies;
- eaves;
- canopies;
- permanent sun shading panels mounted on the facade (brise soleil or "sun breakers").

Movable systems (with electric drive or manually adjustable):

- awnings;
- sliding panels;
- external blinds;
- external roller blinds;
- shutters;

Airtightness

Adequate building airtightness is also important from the point of view of energy savings. Airtightness is expressed by the n_{50} value, which indicates the amount of air exchange in a building with a pressure difference between the outside and inside of 50 Pa.

The airtightness of a building is closely linked to its thermal insulation, but there is no strict correspondence between the two properties. A well-insulated building may not be sufficiently airtight, and a sufficiently airtight building may not have adequate thermal insulation of its envelope.

The airtightness of a building is influenced by:

- the method by which gaps in the building's envelope created by the passage of installations are protected;
- the coping of the gable walls where the structural elements of the roof slopes are connected to the walls (rafters, wall plates, etc.);
- the method for the installation of roof elements (roof tiles, roofing panels);
- the way in which openings for the passage of sanitary installations in the basement or in the attic are made;
- the door installation method;
- the window installation method;
- the way in which electrical installations inside the roof and close to surfaces of external walls are placed.

Polish technical and building regulations include the following recommendations on airtightness of buildings:

- building with gravitation or hybrid ventilation $n_{50} \leq 3.0\ h^{-1}$;
- building with mechanical ventilation or air-conditioned $n_{50} \leq 1.5$ h-1 .

Materials recommended to ensure airtightness and details of the solutions include:

- expanding tapes for circumferential sealing when assembling windows and doors, which, once they expand, fill the gap between the wall and the frame, eliminating non-tightness;
- polyurethane foam, which expands and fills in gaps or openings, intended for sealing window or door joints, as well as openings around wiring or other non-tight spaces created during assembly work;
- wind-protection insulation to be applied inside ventilated frame walls on the thermal insulation from the cavity side. Such insulation eliminates heat losses connected with aeration of the insulation as a result of air movement inside the cavity.

It is recommended that the airtightness of the entire building should be checked by means of the "Blower Door" method, which measures the air permeability of buildings with the non-invasive fan pressurisation method. The test procedures and the preparation of the results must be consistent with the guidelines of the Polish Standard PN-EN 13829 *Thermal performance of buildings. Determining the air permeability of buildings. Fan pressurisation method* or other methods producing comparable results.

Diffusion tightness

Another issue to be taken into account in order to improve the energy performance of a building is diffusion tightness, i.e. the capacity to limit (control) the diffusion of water vapour through envelope elements. The question is of paramount importance, especially in the context of the design and assembly of the thermal insulation "from the inside".

Diffusion tightness is closely linked to the moisture-related condition of envelope elements, in particular to ensuring (securing) such moisture levels of the envelope as can be considered appropriate, i.e. not causing negative impacts in thermal and building use terms. A diffusion-tight envelope element is one which is resistant to the diffusion of water vapour, and in which the type and configuration of its layers ensure that it is not exposed to indoor condensation (of water vapour at low temperatures), especially condensation which builds up over years and is likely to increase the moisture of some layers and lead to the growth of fungi.

Slight condensation of water vapour in an envelope element is acceptable on condition that such moisture evaporates completely in spring and does not cause damage to the layers of the envelope element. In some cases, cutting off water vapour flow in an envelope element completely is unadvisable, and may even be harmful, for example when it hinders the removal of initial moisture, especially from timber elements. Therefore, various foil-based solutions have been developed to ensure specific water vapour flow levels (the value is given in product description or manufacturer's declaration of performance characteristics).

Using appropriate insulation foil sheets is not enough to ensure that an envelope element is vapour tight. Vapour-tight insulation can be installed erroneously or negligently, as a result of which water vapour can penetrate through layers designed as vapour-tight.

The recommended rules to be followed to ensure vapour tightness of an envelope element are as follows:

- vapour-tight insulation should be laid with adequate overlays at the foil joints, and not on an edge-to-edge basis;

- each ductwork opening in vapour insulation must be sealed with vapour-tight self-adhesive tapes or tapes attached with glues for joining vapour barriers. In such places, vapour insulation should be folded down and any non-tight opening should be sealed with vapour-tight self-adhesive tape.

Heating, mechanical ventilation and warm service water installations

For most buildings, their dual-purpose heat source requires looking at the central heating and warm service water installations in a comprehensive way, and choosing the best solution depending on the prevailing conditions.

The choice of a central heating and warm service water system, which includes choosing the heat source, depends on a number of factors, such as:

- the architectural layout and structure of the building, as well as the way in which it is used;
- the requirements regarding the comfort of use (as defined, for example, by standard PN-EN 15251:2012 *Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics*),
- the local conditions of the heat supply;
- the relationships between the prices of energy carriers and of the components of installations and heat sources, as well as trends in these prices;
- the environmental requirements;
- the requirements and financial possibilities of the investor;
- the requirements of technical and building regulations and available schemes supporting energy efficient solutions.

Central heating and warm service water installations should be designed in such a way as to provide adequate and the highest possible overall efficiency of both systems. High efficiency of such installations can be obtained by using high-efficiency heat sources and reducing heat losses in the transmission, accumulation, control and use of heat.

The maximum possible efficiency can be ensured, *inter alia*, by:

- using condensing boilers and heat pumps with a high coefficient of performance (COP);
- appropriate installation of pipes distributing the heating medium (compact installation) and their proper thermal insulation;
- adequate insulation of accumulation and buffer tanks and choosing their charging and discharging controls in correspondence to the specificities of their operation and use;
- low-temperature panel, radiator or mixed heating systems;

- choosing such adjustment and control technique as to ensure the most efficient control for respective installation design and use;
- choosing such warm service water preparation method as to ensure high efficiency for the respective mode of use;
- using high-efficiency auxiliary pumps characterised by low power consumption and leading to low consumption of auxiliary energy;
- elimination or minimisation of the use of low-efficiency circulation systems;
- adequate insulation of warm service water storage tanks and choosing their charging and discharging controls in correspondence to the specificities of their operation and use;

In order to reduce distribution heat losses, the installation should be compact, which means that water distribution points should be as close to each other as possible. It is recommended that kitchens and sanitary rooms (bathrooms, toilets), as well as other damp rooms, should be adjacent to each other and be aligned heightwise (vertically). This allows the water supply and sewerage systems (cold water, warm water, and sewerage) and possibly the mechanical extract ventilation system in the building to be designed in a compact way, thus reducing the investment and operating costs for these installations (lower heat and pressure losses translate into lower costs).

Warm service water piping and equipment, for example storage tanks, should be placed within the building's heated envelope. This reduces heat losses of such piping and storage tanks and allows them to be used for the building's heating purposes. In summer, this reduces indoor heat gains, and therefore reduces the risk of overheating inside the building. In small installations, circulation pipes should be eliminated. Circulation has the negative effect of considerable heat losses. The losses can be reduced by providing proper thermal insulation of warm service water and circulation pipes. The best solution is to place these two types of pipes side by side and insulate them together.

Warm service water installations should be capable of energy efficient operation, for example by being fitted with high-quality water-saving fittings (taps, showers, etc.) and by ensuring individual user billing.

As regards choosing the structure of heat sources, in addition to selecting high-efficiency equipment, the use of renewable energy sources should be considered.

The choice of the system for supplying warm service water depends not only on the building's energy standard, but also on the share of energy consumed for warm service water purposes in the total energy consumption by the building. When the share is low, warm service water installations can be supplied by direct heaters or flow heat exchangers. If the share is significant, warm service

water installations should be supplied by an independent heat source. In such cases, using solar energy is advisable.

Each time, the choice of the warm service water system and diversification of the heat sources depend on the intended and planned use of the building. Notably, warm service water systems can be designed as independent installations with the heat source relying chiefly on solar energy, which is ensured by the use of solar collectors with a storage tank acting as long-term energy storage.

Another installation which needs to be supplied with energy is mechanical ventilation. Although many investors still use conventional gravity ventilation systems, the solution recommended in the context of improving the energy performance of buildings is a supply-exhaust installation furnished with high-efficiency heat recovery of ≥ 75% and load-based adjustment. Use can also be made of an intermediate solution, i.e. hybrid ventilation, in which natural and mechanical ventilation support each other or operate alternately, depending on the prevailing needs and conditions. Most hybrid ventilation systems are based on humidity controlled ventilators (which supply more fresh air when the humidity in the room increases) and load-controlled mechanical extraction.

It should also be mentioned here that some systems used in low-energy buildings are based on solutions other than conventional ventilation and heating installations. The thermal comfort in such buildings is ensured by very good insulation, the use of solar energy and energy recovered from exhaust air. Space is heated exclusively by warm air distributed by mechanical ventilation systems. Consequently, ventilation in such a building fulfils several functions: it ensures adequate ventilation of all rooms, taking into account their type and demand for fresh air, distributes heat across the building space, and minimises energy losses while maximising heat recovery from exhaust air.

A model ventilation system for such a building consists of a recuperator, supply air distribution ducts, and exhaust air ducts. Additionally, use can be made of a ground heat exchanger, which preheats the air which is drawn from the outside and injected into the ventilation system. The heat for heating outside air comes from the ground, which has, at depths of more than 1.5 m, constant temperatures ranging from 3-6°C. The simplest design of a ground heat exchanger consists of a polyethylene pipe with an appropriately selected diameter (110 or 200 mm) and a length of 30-50 m, which is buried 1.5-2.5 m underground. The pipe must be tightly sealed to prevent undesirable substances in the ground (e.g. pollutants, microorganisms, and insects) from getting into the air. In addition, the pipe should have a gradient of approximately 1% to allow the water which condenses when the air is cooled during warmer spells to be drained. There are also other types of ground

heat exchangers which have slightly more complex designs, for example gravel, flat-panel or glycol fluid-based exchangers. The air intake through which outside air is sucked in should have an integrated filter to remove preliminarily any impurities and other particulates which may be present in the air. Well designed and installed ground heat exchangers can warm air to temperatures above 0°C in winter, even when outside temperature is minus 20°C. At the same time, such heat exchangers pre-cool air in summer. Using such systems translates into lower consumption of energy needed to heat or cool the outside air blown into the building through the mechanical ventilation system than in situations when no exchanger-based preheating/precooling is in available.

Preheated air enters the next element of the ventilation system, namely the recuperator. A recuperator is a device used for recovering heat from exhaust air and using this energy to heat inbound air. Usually, a recuperator consists of two intersecting air flow ducts and is equipped with a supply and exhaust fan. The ducts are sealed and fully separated. This means that fresh air supplied into the building cannot mix with exhaust air. The air ducts are designed to exchange heat in the most efficacious way. The supply air duct has an additional air heating circuit at the outlet. It is used in winter at particularly low outside temperatures, when the air temperature leaving the recuperator is too low to ensure thermal comfort.

The recuperator should have an efficiency of 75% or more. The market offers recuperators with an efficiency of 95%, but naturally the price of such units is correspondingly higher than that of recuperators with poorer performance.

Air heated by a recuperator is distributed throughout the building. In order for the entire ventilation system to function properly, the air must be distributed among the rooms in the right order. First, air is supplied to residential spaces (bedrooms, living rooms, day rooms, offices, etc.). Such rooms require clean and fresh air. In addition, after passing through such spaces the air is not polluted in any way and is suitable for heating and ventilating the next zone of interiors, which is referred to as the “intermediate” one.

It consists of such rooms as entrance halls and corridors. Through these, air passes on to the last exhaust zone, which is formed by sanitary rooms, such as bathrooms, shower rooms, and toilets. Such rooms require good ventilation, inter alia for the purpose of quick removal of water vapour produced there, e.g. in connection with drying. The exhaust zone also includes kitchens. Air from sanitary rooms and kitchens can no longer be used in other spaces and is transported out through special ducts passing through the recuperator.

The entire ventilation system is designed to provide optimum temperatures for each room, irrespective of outside temperatures. The controlled air flow and direction in the ventilation

system improve the comfort and hygiene conditions in the building. The air is cleaner because each ventilation system is equipped with a set of filters which ensure both efficient operation of the installation equipment and clean air for occupants. The direction of the air flow ensures that the main rooms of the building always have access to fresh air, devoid of any unwanted odours. Additionally, when a ground heat exchanger is employed, air is heated in winter and cooled in summer, which acts as a simple air-conditioning system.

In low-energy buildings, the ventilation system can be integrated with the warm service water installation. This allows water to be additionally heated with exhaust air and air to be heated with water, depending on the prevailing thermal conditions and the season. What is more, an integrated system takes less space that two independent systems. A heat pump is the main heat source which supplies such integrated systems. Alternatively, natural gas, biomass or fuel oil boilers can be used interchangeably. When employing an integrated system, supporting it with solar energy by means of solar collectors is advisable.

A heat pump is a device used to force the transport of heat from a source having a low temperature to a space with a higher temperature. Energy is drawn from what is referred to as the "bottom source", for example air, ground or a water reservoir. The flow of heat against the natural direction is possible when additional energy is supplied. Thanks to gaining the energy used for preheating (precooling) water or air, such a system can reduce the demand for energy needed to produce the desired temperatures.

In some cases, putting in place the above solutions is not sufficient for creating the desired thermal comfort. This happens in areas with harsher climatic conditions. Then, in colder periods of the year, recuperation can be supported by additional underfloor heating.

The sections below discuss the recommended components of heating, ventilation and warm service water installations depending on the type of building.

Air conditioning systems

In order to ensure thermal comfort in summer months, use is made of air conditioning systems, which can prove non-efficient in energy terms when parameters of the building as regards its shape and materials are unfavourable. It is recommended that the use of air conditioning systems relying on refrigerating units should be eliminated or limited as far as possible by:

- reducing heat gains (reduction of solar gains by using sun protection and limitation of internal heat gains);
- adjusting the air stream to actual load;

– employing alternative cooling methods (night-time cooling, use of ground energy, free cooling, and passive cooling).

For small buildings, direct evaporation systems based on individual air conditioners of the SPLIT or MULTISPLIT type are recommended.

For larger buildings, with a large number of rooms, using systems based on 15/18^{o}C or 18/21^{o}C cooling water circuits integrated with cooling beams or thermally active ceiling systems and other cooling surfaces with the possibility of using free cooling is recommendable.

For buildings with many occupants per floor area, it is advisable that use be made of air cooling through an air conditioning station, which supplies, at the same time, the necessary stream of fresh air. The flow of air and technical parameters are adjusted against the current load with heat and pollutants (CO_2).

Lighting systems

The primary purpose of lighting is to provide visual comfort. This can be achieved with natural or artificial lighting, preferably a combination of the two. Properly designed lighting allows visual comfort to be maintained, and at the same time, energy to be saved. How much energy is needed to ensure proper interior lighting is not only determined by the lamps used, but also by the way they are used.

In the case of artificial lighting, illumination of rooms while no persons are present in them should be avoided. This can be ensured by the installation of infra-red or microwave presence sensors, light sensors, etc.

The installation of LED (Light Emitting Diode) lighting provides new opportunities for controlling both the intensity and colour of light. Dynamic lighting systems are another modern solution, which – as manufacturers assure – is not only capable of responding to users' needs, but also of stimulating human activity by modelling the level of light intensity and the color temperature during the day. LED lighting has one more important property: it is powered by DC, and thus it can be supplied by PV panels, fuel cells, etc. New technologies can be used to reduce significantly installed capacity and decrease in a noticeable way annual energy consumption, as well as the amounts of primary energy needed to lit building interiors.

Building automation systems

In order to manage building systems in an optimal way, so that they ensure comfort for residents and users and that, at the same time, the energy needed to provide the comfort is used efficiently, building automation can be used for installations. Buildings in which such systems are installed are referred to as intelligent buildings or houses.

Building automation systems consist of sensors and detectors, as well as a single centralised management system for controlling all installations in the building. Thanks to information received from the detectors, which supply data about the conditions inside and outside the building, individual systems can respond to changing needs, thus maximising the functionality, comfort and safety, while minimising the cost of building use.

Automation systems implemented in a building are always integrated with the technical equipment installed in the building. Thus, the configuration of an automation system will largely depend on the technical advancement of the equipment in a concrete building. As a result, proposing an automation system in isolation from the building's technical equipment is impossible.

Heat accumulators

When plans to improve the energy performance of a building are made, it must be remembered that solar systems based on heat accumulators are an important element of low-energy buildings. Their purpose is to accumulate solar energy during the day and release it at night, when no additional solar energy is available. Solar heating systems are divided into passive and active ones. Passive systems are those which do not require additional energy to operate, while active systems need energy from outside of the system. Passive systems can capture energy directly or indirectly.

With direct passive design, all heated surfaces, including surfaces covered with accumulation elements, for example solid walls, are exposed to direct sunlight. Energy accumulated in these elements and objects placed on their surfaces is to heat interiors during the night. One disadvantage of this solution is the need to use thermal accumulators characterised by high conductivity and thermal capacity (i.e. need to cover walls with ceramic bricks, rather than cellular concrete blocks, which, despite offering better thermal conductivity parameters, have poorer heat retention capacity). Otherwise, thermal comfort will significantly deteriorate as a result of heat fluctuations once solar radiation stops completely. A direct passive system can be created, for example, by placing a large glazed surface in the southern wall of a room and building a ceramic or stone wall opposite it for such wall to accumulate heat during the day.

The principle underlying indirect systems is completely different than that of direct systems. It involves exposing accumulation surfaces to direct solar radiation for them to collect energy all day to gradually release it at night. By selecting the thermal inertia of the accumulator appropriately the time when heat is released can be delayed until the moment it is most needed. One disadvantage of passive systems is their inability to control the released heat and their complete dependence on external factors. One example of an indirect passive system is the Trombe wall, where solar radiation passes through a glass layer to be accumulated in a solid accumulation component.

The above problems do not occur in active systems, which accumulate energy and can radiate it back to heat various rooms or service water "at request". However, they require additional energy, which must be taken into account in the thermal balance of newly designed buildings.

A solar collector is an example of an active system. Currently, the most commonly used collectors in Poland are liquid collectors: flat-plate and vacuum tube collectors.

The principle of a flat-plate collector is simple: the liquid flowing through its tubes (low-freezing fluid, usually a glycol solution) is heated from the sun-heated surface of the absorber. Then the heat produced in this way is transported for further use in the solar system, where water is heated.

A solar collector consists of the following three key elements:

- solar glass (which transmits solar rays inside the collector and, at the same time, keeps the thermal radiation of the collector's absorber and heat losses at the lowest possible level),
- collector housing with thermal insulation (ensures that the collector is insulated inside to minimise heat losses),
- absorber (absorbs sun rays and transfers energy to tubes with liquid; it is usually made of copper or aluminum).

Vacuum flat plate collectors are a variety of collectors, where vacuum is used as the thermal insulation. By contrast, vacuum tube collectors are collectors in which the absorber is placed inside high-vacuum glass tubes closed on bother sides. The vacuum inside the tubes is intended to prevent air flow and exchange of heat between the glass and the absorber. In addition to liquid collectors, also air collectors are in use. They are collectors where the absorption tubes contain air instead of liquid. They are usually used for space heating by means of an air system.

Other improvement measures

The consumption of energy in a building can also be reduced as a result of change in the behaviour of building users. To this end, conducting information and incentive campaigns is advisable. Notably, local authorities and building administrators should give good example in this respect. A good way to incentivise people into action is by dividing the savings gained among building users.

2.2 Actions for single-dwelling residential buildings (non-air conditioned)

The following best currently available key components of the heating, ventilation, and warm service water systems can be recommended for single-dwelling non-air conditioned residential buildings:

1) low-temperature water heating:
   a) underfloor heating or underfloor convection heaters;

b) installation parameters: 55/45°C or 40/30°C;
c) heater controls with adjustment accuracy of 1K;
d) heat source:
   – gas condensing boiler;
   – heat pump $HP_{COP\ 6.0}$;
   – low-temperature boiler;

2) use of solar energy – solar thermal collectors;
3) warm service water installation supplied by a bivalent storage tank (water tank equipped with two heating coils, which forms, together with collectors, the core element of most solar installations), system with no circulation;
4) mechanical load-controlled supply-exhaust ventilation with high-efficiency heat recovery.

2.3 Actions for multi-dwelling residential buildings (non-air conditioned)

The following best available key components of the heating, ventilation, and warm service water systems can be recommended for non-air conditioned multi-dwelling residential buildings:

1) low-temperature water heating:
   a) convection heaters or underfloor convection heaters;
   b) installation parameters: 55/45°C, 45/35°C, or 40/30°C;
   c) heater controls with adjustment accuracy of 1K;
   d) heat source:
      – gas condensing boiler;
      – district heating substation with housing;
      – mini-CHP (cogeneration – combined heat and electric power generation);
      – heat pump $HP_{COP\ 4.2}$;
      – low-temperature boiler;
2) use of solar energy – solutions combining solar thermal collectors with a storage tank;
3) warm service water installation with energy supplied by a bivalent storage tank, system with circulation or warm service water installation supplied by dwelling-based mini stations (dwelling-based installation with no circulation);
4) ventilation – mechanical supply-exhaust ventilation with high-efficiency heat recovery of at least 75%, load-controlled.

2.4 Actions for public buildings (non-air conditioned)

The following best available key components of the heating, ventilation, and warm service water systems can be presented for non-air conditioned public buildings:

1) low-temperature water heating:
   a) convection heaters or surface heating;
   b) installation parameters: 55/45°C, 45/40°C, or 40/30°C,
   c) heater controls with adjustment accuracy of 1K;
   d) heat source:
      – gas condensing boiler;
      – district heating substation;
      – heat pump $HP_{COP\ 4.5}$;
      – low-temperature boiler;
2) use of solar energy – solutions combining solar thermal collectors with a storage tank;
3) warm service water installation supplied by a bivalent storage tank or intermediate storage tank, installation with circulation, or warm service water installation with energy supplied from a mini-station or directly (installations without circulation);
4) mechanical supply-exhaust ventilation with high-efficiency heat recovery (at least 70%) or decentralised ventilation with heat recovery with demand-based variable air flow.

2.5. Estimated benefits of individual building refurbishment activities

Based on data from the *Savings Calculator*, a tool prepared for the needs of the Ministry of Infrastructure and Construction, the sections below present examples of estimated savings associated with building refurbishment activities.

Table 15: Results of calculations made with the *Savings Calculator* for insulation of external walls with top-quality foamed polystyrene for a surface of envelope elements of 300 m^2

CALCULATION OF SAVINGS ASSOCIATED WITH INSULATION OF EXISTING ENVELOPE ELEMENT:			
1.	Location:		Poland
2.	The nearest meteorological station:		Warsaw
3.	Outside temperature:	°C	-20
4.	Indoor temperature:	°C	22
5.	Standard of the building:		pre-1990, not refurbished
6.	Type of insulated envelope element:		external wall
7.	Surface area of insulated envelope element:	m^2	300
8.	Type of insulation layer material:		foamed polystyrene
9.	Insulation layer thickness:	cm	15
10.	Heat source used for building heating:		light heating oil boiler
11.	Calorific value:	MJ/l	36.12

12.	Price of fuel:	PLN/l	PLN 3.20
13.	Cost of 1 GJ:	PLN/GJ	PLN 88.59
14.	Reduction of energy losses resulting from heat transfer:	GJ/year	88.228
15.	Annual cost savings:	PLN/year	7 816.41

Table 16. Results of calculations made with the *Savings Calculator* for insulation of flat roof with mineral wool for a roof surface of 150 m^2

CALCULATION OF SAVINGS ASSOCIATED WITH INSULATION OF EXISTING ENVELOPE ELEMENT:			
1.	Location:		Poland
2.	The nearest meteorological station:		Warsaw
3.	Outside temperature:	°C	-20
4.	Indoor temperature:	°C	22
5.	Standard of the building:		pre-1990, not refurbished
6.	Type of insulated envelope element:		roof/ flat roof
7.	Surface area of insulated envelope element:	m^2	150
8.	Type of insulation layer material:		mineral wool
9.	Insulation layer thickness:	cm	15
10.	Heat source used for building heating:		light heating oil boiler
11.	Calorific value:	MJ/l	36.12
12.	Price of fuel:	PLN/l	PLN 3.20
13.	Cost of 1 GJ:	PLN/GJ	PLN 88.59
14.	Reduction of energy losses resulting from heat transfer:	GJ/year	28.508
15.	Annual cost savings:	PLN/year	2 525.61

Table 17. Results of calculations made with the *Savings Calculator* for insulation of external walls with mineral wool

CALCULATION OF SAVINGS ASSOCIATED WITH INSULATION OF EXISTING ENVELOPE ELEMENT:			
1.	Location:		Poland
2.	The nearest meteorological station:		Warsaw
3.	Outside temperature:	°C	-20
4.	Indoor temperature:	°C	23
5.	Standard of the building:		built in 1990-2000, not refurbished
6.	Type of insulated envelope element:		external wall
7.	Surface area of insulated envelope element:	m^2	1 000
8.	Type of insulation layer material:		mineral wool

9.	Insulation layer thickness:	cm	15
10.	Heat source used for building heating:		light heating oil boiler
11.	Calorific value:	MJ/l	36.12
12.	Price of fuel:	PLN/l	PLN 3.20
13.	Cost of 1 GJ:	PLN/GJ	PLN 88.59
14.	Reduction of energy losses resulting from heat transfer:	GJ/year	147.719
15.	Annual cost savings:	PLN/year	13 086.98

Table 18. Results of calculations made with the *Savings Calculator* for insulation of flat roof with mineral wool for a roof surface of 400 m^2

CALCULATION OF SAVINGS ASSOCIATED WITH INSULATION OF EXISTING ENVELOPE ELEMENT:			
1.	Location:		Poland
2.	The nearest meteorological station:		Warsaw
3.	Outside temperature:	°C	-20
4.	Indoor temperature:	°C	23
5.	Standard of the building:		built in 1990-2000, not refurbished
6.	Type of insulated envelope element:		roof/ flat roof
7.	Surface area of insulated envelope element:	m^2	400
8.	Type of insulation layer material:		mineral wool
9.	Insulation layer thickness:	cm	15
10.	Heat source used for building heating:		light heating oil boiler
11.	Calorific value:	MJ/l	36.12
12.	Price of fuel:	PLN/l	PLN 3.20
13.	Cost of 1 GJ:	PLN/GJ	PLN 88.59
14.	Reduction of energy losses resulting from heat transfer:	GJ/year	45.458
15.	Annual cost savings:	PLN/year	4027.31

Table 19. Results of calculations made with the Savings Calculator for insulation of external walls with top-quality foamed polystyrene a surface of envelope elements of 400 m^2

CALCULATION OF SAVINGS ASSOCIATED WITH INSULATION OF EXISTING ENVELOPE ELEMENT:			
1.	Location:		Poland
2.	The nearest meteorological station:		Warsaw
3.	Outside temperature:	°C	-20
4.	Indoor temperature:	°C	20
5.	Standard of the building:		built in 2000-2014, not refurbished
6.	Type of insulated envelope element:		external wall
7.	Surface area of insulated envelope element:	m^2	400
8.	Type of insulation layer material:		foamed polystyrene
9.	Insulation layer thickness:	cm	15
10.	Heat source used for building heating:		Coal boiler
11.	Calorific value:	MJ/t	26 010
12.	Price of fuel:	PLN/t	PLN 800.00
13.	Cost of 1 GJ:	PLN/GJ	PLN 30.76
14.	Reduction of energy losses resulting from heat transfer:	GJ/year	30.573
15.	Annual cost savings:	PLN/year	940.35

Table 20. Results of calculations made with the *Savings Calculator* for refurbishment of the warm service water preparation system

CALCULATION OF SAVINGS ASSOCIATED WITH REFURBISHMENT OF THE WARM SERVICE WATER PREPARATION SYSTEM:			
BEFORE REFURBISHMENT:			
Current heat source:	[-]	Compact district heating substation without housing, with a rated capacity of up to 100kW	0.91
Current type of installation:	[-]	Central water heating – systems with circulation, with uninsulated risers and insulated distribution piping – number of distribution points 30-100	0.5
Type of fuel		light heating oil boiler	
Unit price of fuel:	PLN/l	PLN 3.20	
Average annual fuel demand:	litre	10 000	
Annual demand for final energy:	GJ	361.2	
Cost of 1 GJ:	[PLN/GJ]	PLN 88.59	
AVERAGE ANNUAL HEATING COST:	[PLN/year]	PLN 32 000.00	
AFTER REFURBISHMENT:			
Heat source designed:	[-]	Compact district heating substation with housing, with a rated capacity of up to 100kW	0.98
Type of installation designed:	[-]	Central water heating – systems with circulation and limitation of operating time, with risers and insulated distribution piping – number of distribution points 30-100	0.7
Type of fuel		light heating oil boiler	
Price of fuel:	PLN/l	PLN 3.20	
Annual demand for final energy:	GJ	239.57	
Cost of 1 GJ:	[PLN/GJ]	PLN 88.59	
AVERAGE ANNUAL HEATING COST:	[PLN/year]	PLN 21 224.49	
ANNUAL COST SAVINGS:	[PLN/year]	PLN 10 775.51	

Table 21. Results of calculations made with the *Savings Calculator* for refurbishment of the heating system (1)

CALCULATION OF SAVINGS ASSOCIATED WITH REFURBISHMENT OF THE HEATING SYSTEM:			
BEFORE REFURBISHMENT:			
Current heat source:	[-]	Direct electric radiators	0.99
Current type of heating system:	[-]	Direct electric radiators with proportional P-controller	0.91
Unit price of fuel:	PLN/kWh	PLN 0.65	
Average amount of fuel needed throughout the heating season:	kWh	9 000	
Annual demand for final energy:	GJ	32.4	
Cost of 1 GJ:	[PLN/GJ]	PLN 180.56	
AVERAGE ANNUAL HEATING COST:	[PLN/year]	PLN 5 850.00	
AFTER REFURBISHMENT:			
Heat source designed:	[-]	Gas condensing boilers (55/45) with a rated capacity of up to 50kW	0.94
Type of heating system designed:	[-]	Water heating with modular or panel radiators when use is made of central and local control with a proportional thermostatic valve; with a proportional control range of P-2K	0.88
Unit price of fuel:	PLN/m^3	PLN 1.90	
Annual demand for final energy:	GJ	35.29	
Cost of 1 GJ:	[PLN/GJ]	PLN 52.78	
AVERAGE ANNUAL HEATING COST:	[PLN/year]	PLN 1 862.35	
ANNUAL HEATING COST SAVINGS:	[PLN/year]	PLN 3 987.65	

Table 22. Results of calculations made with the *Savings Calculator* for refurbishment of the heating system (2)

CALCULATION OF SAVINGS ASSOCIATED WITH REFURBISHMENT OF THE HEATING SYSTEM:			
BEFORE REFURBISHMENT:			
Current heat source:	[-]	Coal boiler manufactured before 1980.	0.6
Current type of heating system:	[-]	Water heating with modular or panel radiators when use is made of central control with no automatic local control	0.77
Unit price of fuel:	PLN/t	PLN 750.00	
Average amount of fuel needed throughout the heating season:	t	7	
Annual demand for final energy:	GJ	182.07	
Cost of 1 GJ:	[PLN/GJ]	PLN 28.84	
AVERAGE ANNUAL HEATING COST:	[PLN/year]	PLN 5 250.00	
AFTER REFURBISHMENT:			
Heat source designed:	[-]	Coal boiler manufactured in 1980-2000	0.65
Type of heating system designed:	[-]	Water heating with modular or panel radiators when use is made of central and local control with a proportional thermostatic valve; with a proportional control range of P-2K	0.88
Unit price of fuel:	PLN/t	PLN 750.00	
Annual demand for final energy:	GJ	147.06	
Cost of 1 GJ:	[PLN/GJ]	PLN 28.84	
AVERAGE ANNUAL HEATING COST:	[PLN/year]	PLN 4 240.38	
ANNUAL HEATING COST SAVINGS:	[PLN/year]	PLN 1 009.62	

2.6 The most cost-effective ways to renovate buildings based on actual data

In 2015, the Central Statistical Office published the results of its study entitled *Study of the energy efficiency of buildings of the public administration (central and local government) in 2007-2013* (Badanie efektywności energetycznej budynków administracji publicznej (rządowej i samorządowej) za lata 2007–2013) The purpose of the study was to obtain detailed information about the changes in energy intensity of public administration buildings as a result of refurbishment activities undertaken, and to assess the scale of the associated energy savings.

The scope of the study included:

- the effect of the refurbishment (e.g. insulation of walls, replacement of windows, upgrading of the central heating system) on the reduction of heat losses;
- the extent to which energy efficient electrical equipment was used (e.g. refurbishment of the lighting system);
- the extent to which renewable energy sources were used;
- sources of funding used for completed refurbishments;

and served as a basis for calculating the following indicators:

1) share of modernised buildings in all buildings under study (%), e.g.:
   - share of buildings where thermal insulation was employed;
   - share of buildings where lighting was refurbished;
   - share of buildings where heating systems were upgraded;
   - share of buildings where the internal central heating system was refurbished;
   - share of buildings where the internal warm service water system was refurbished;
   - share of buildings which were refurbished by replacement of the energy carriers and energy sources used for central heating purposes;
   - share of buildings which were refurbished by replacement of the energy carriers and energy sources used for warm service water purposes;
   - share of buildings where the air conditioning system was refurbished;
   - share of buildings where ventilation was refurbished;
   - share of refurbished buildings with district heating substations relative of all buildings having such stations.
2) share of buildings using renewable energy in the total number of buildings covered by the study (%):
   - share of buildings where solar collectors were used,
   - share of buildings in which photovoltaic cells were used,
   - share of buildings in which heat pumps were used.
3) specific energy consumption for space heating per m^2 of area, adjusted for climatic conditions, before and after refurbishment (GJ);
4) energy consumption for the needs of warm service water per m^2 of area and per 1 employee in the public administration building under study (GJ);
5) specific electricity consumption per 1 employee (GJ);

6) specific energy consumption per 1 employee (GJ);
7) amount of energy saved (GJ/year);
8) share of energy saved in total energy consumed by the population under study before refurbishment in 2007-2013 (%);
9) indicator of energy consumption savings and emissivity for the buildings of the public administration (central and local government) under study in 2007-2013 – synthetic indicator.

The report from the above study is available on the website of the Central Statistical Office at:
http://stat.gov.pl/files/gfx/portalinformacyjny/pl/defaultstronaopisowa/5808/1/1/raport_efekt_energet_.pdf
The results are a compendium of knowledge about the refurbishment of buildings, including the public building stock. Notably, the results and conclusions of the study can be used in the future for improving the energy performance of other buildings (residential and collective accommodation buildings).

In addition, in December 2016, at the request of the Ministry of Infrastructure and Construction, a review of legislation regarding the minimum requirements for the energy performance of buildings was conducted, which is obligatory for EU Member States. The aim of the review, which is performed periodically pursuant to Article 4 of Directive 2010/31/EU, is to determine whether it is appropriate to revise existing legislation as a result of technical progress in the construction sector, and to achieve cost-optimal levels.

Achieving energy independence by EU countries and improving the quality of life by reducing greenhouse gas emissions requires using energy from renewable sources and increasing energy efficiency in construction and transport, which are the sectors with the highest energy intensity rates.

The above objectives are formulated by Directives 2002/91/EC and 2010/31/EU, and have been implemented into Polish legislation through revisions of legislative and regulatory provisions.

In Poland, the key developments in this respect have translated into revision of the technical and building regulations regarding thermal protection and energy intensity of buildings.

The currently applicable requirements on the energy performance of buildings are laid down by section X and Annex No 2 of Regulation of the Minister of Infrastructure of 12 April 2002 *on the technical conditions to be met by buildings and their siting*.

Member States are obliged to review their calculations of optimal costs in time for the review of their minimum energy performance requirements, as required by Article 4(1) of Directive 2010/31/EU. The assessment of the national minimum energy performance requirements was

referred to the outcome of the cost-optimal results of the calculation taken as the national benchmark.

The analysis of Polish legislation was based on the following available sources: standards, implementing provisions, and reports. Compliance with the national requirements was evaluated on the basis of energy performance data collected by the team preparing the analysis, including data provided by BuildDesk. In order to determine the current technological standard for building materials, buildings' technical equipment systems, embedded lighting systems, and building automation, as well as the level of current market prices, use was made of data provided by manufacturers and taken from secocenbud databases. The parameters for the economic assessment were evaluated on the basis of materials available in the sectoral bulletins published by the Polish Energy Regulatory Office, and reports obtained.

Answers to study questions formulated with respect to the dataset chosen for investigation were answered through an expert survey. The dataset comprised ten buildings with various intended use located in different climatic zones of Poland. Representative buildings were identified and simulations were carried out according to WT2014, WT2017, and WT2021 for eight heat sources and three sources of warm service water.

The results of the above review will be a basis for further, possible legislative work towards the central objective, which is to ensure that by 31 December 2020 all new buildings are nearly zero-energy buildings. At the same time, it should be noted that the parameters under study, including those related to the thermal transmittance coefficient (U-factor), will also apply to buildings undergoing reconstruction.

3. Policies and measures supporting renovation at present and forward-looking perspectives

3.1 Economic aspects of projects improving energy efficiency of existing building stock

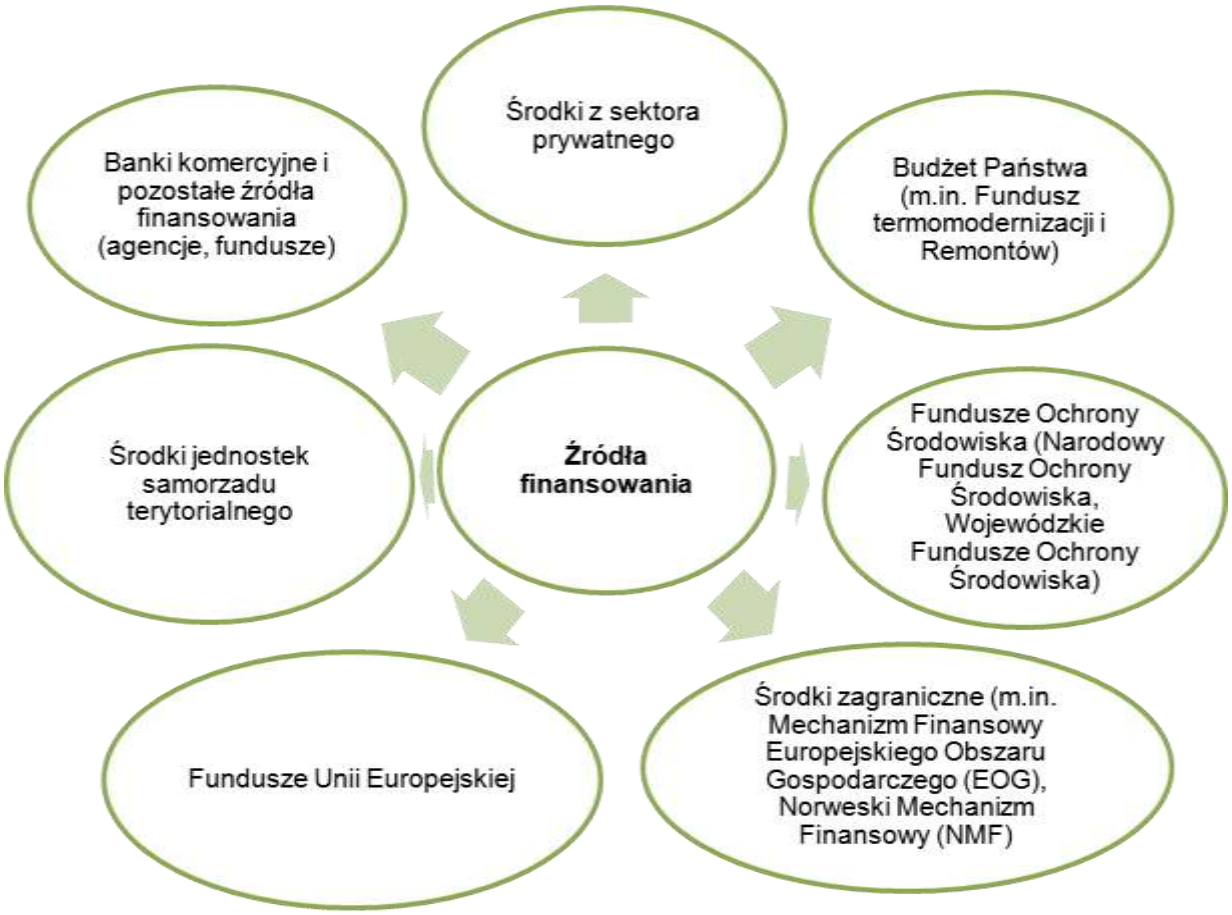
Appropriate shaping of the cost effectiveness of works to be carried out is a central issue. In many cases completing an energy audit prior to starting an investment intended to improve energy efficiency of an existing building is recommended or even required. The idea underlying such auditing is to select solutions offering the highest cost efficiency of the investment relative to the anticipated gains.

Moreover, the level of requirements set by applicable technical and building regulations is also optimal in terms of investment costs. The level has been defined, *inter alia*, on the basis of the study "Analysis of the technical and construction requirements regarding thermal protection of buildings aimed at determining the minimum energy performance requirements and proposing amendments pursuant to Directive 2010/31/EU on the energy performance of buildings" (Analiza wymagań techniczno-budowlanych dotyczących ochrony cieplnej budynków, celem ustalenia minimalnych wymagań w zakresie charakterystyki energetycznej i przedstawienia propozycji zmian zgodnie z dyrektywą 2010/31/UE w sprawie charakterystyki energetycznej budynków), while gradual change in energy performance benchmarks will bring the construction market in line with applicable legislation, and will promote the use of new, energy efficient building practices and installation solutions.

3.2 Sources of funding

Pursuant to Article 4(c) of Directive 2012/27/EU, measures indicated above constitute policies and measures to stimulate cost-effective deep renovations of buildings, including staged deep renovations, and, to a certain extent, constitute an element of a forward-looking perspective to guide investment decisions of individuals, the construction industry and financial institutions.

The measures presented below constitute the main, but not the only, sources of co-funding for investments towards developing an energy efficient construction sector and supporting the use of renewable energy sources (RES) in existing buildings. Availability of funds for different types of projects under the individual forms of co-funding means that both deep and staged renovations are supported. Another important factor is the allocation of available funds among different groups of beneficiaries or types of investments, which, in addition to providing financial and environmental benefits, should also contribute to the development of energy-efficient technologies in Poland, education, and competence building.



Fundusze Unii Europejskiej	European Union Funds
Środki jednostek samorządu terytorialnego	Funds of local governments
Banki komercyjne i pozostałe źródła finansowania (agencje, fundusze)	Commercial banks and other sources of funding (agencies, funds)
Środki z sektora prywatnego	Private sector funding
Budżet Państwa (m.in. Fundusz termomodernizacji i Remontów)	State budget (including the Thermomodernisation and Repairs Fund)
Fundusze Ochrony Środowiska (Narodowy Fundusz Ochrony Środowiska, Wojewódzkie Fundusze Ochrony Środowiska)	Environmental Funds (National Fund for Environmental Protection, Provincial Funds for Environmental Protection)
Środki zagraniczne (m.in. Mechanizm Finansowy Europejskiego Obszaru Gospodarczego (EOG), Norweski Mechanizm Finansowy (NMF)	Foreign funding (including EEA and Norway Grants)
Źródła finansowania	Sources of funding

Figure 10. Possible sources of funding

Private sector funding

There is a shortage of reliable data on the extent to which private owners of residential property invest in improving energy efficiency of existing building stock. This is due to the large number of actions which require low financial spending and, at the same time, the differences in the size and

scope of non-energy efficiency works, especially for single-dwelling residential buildings, where, as can be assumed, the private sector provides the bulk of funds for existing building renovation projects. At the same time, although the investment scale and costs in the non-housing sector are usually higher, also in this case comprehensive information for the private sector is missing.

The National Fund for Environmental Protection and Water Management

The National Fund for Environmental Protection and Water Management (NFOŚiGW) is the main source of funding for environmental investments in Poland, including the construction sector. The Fund acts pursuant to the Environmental Law of 27 April 2001 (Journal of Laws 2017, item 519, as amended) and is guided by the UE polluter-pays principle.

The sources of the Fund's revenues include, *inter alia*:

- environmental fees and administrative fines established pursuant to the Environmental Law and specific laws;
- fees determined pursuant to the Geological and Mining Law;
- fees under the Act on the Greenhouse Gas Emissions Trading Scheme and the NOx and SO_2 charges apportioned for NFOŚiGW;
- emission unit sale contracts concluded under the Act *on the system for management of greenhouse gas and other substance emissions*;
- compensation payments and fines under the Energy Law,
- compensation payments and fines under the Energy Efficiency Act and other fees and fines.

Tables 23 to 29 present the schemes and financial instruments designed to stimulate cost-effective deep renovations of buildings. The list contains both active programmes and those which are coming to an end (no further requests for co-funding can be filed), but which continue to be in place and support actions under requests submitted beforehand, within applicable pre-established timeframes. It should be remembered that, based on previous experience, the programmes which are under way (those under which allocated funds have been used up, as well as those whose planned implementation period is nearing the end) will be gradually replaced by new schemes stimulating cost-effective deep renovations of buildings, including staged ones, which will be effective both in cost and utilisation method terms.

Tables 23-27. Domestic sources of funding

Programme name	**Subsidised loans for the construction of energy‑efficient houses**
Purpose	Energy saving and reducing or avoiding CO_2 emissions through the co-funding of projects which improve the efficiency of energy use in newly constructed residential buildings.
Budget	The payments of funds under contracted and planned commitments from the

	programme's non-reimbursable co-funding instruments amount to PLN 300 million.
Implementation period	The programme spans the years 2013-2018.
Forms of co-funding	Grant for partial repayment of the principal of a bank loan, provided through a bank under a cooperation agreement with NFOŚiGW.
Beneficiaries	▪ natural persons who have been issued a valid building permit and hold the right to dispose of the property on which they will build a residential building. The right to "dispose of" a property means: a) ownership (including co-ownership); b) perpetual usufruct; ▪ natural persons entitled to be transferred the following by a developer: the ownership title to a property together with the single-dwelling house the developer will build on such property, or the right of perpetual usufruct to a land property and the ownership of the single-dwelling house which will be built on such property and will constitute a separate property, or ownership title to a dwelling. The definition of a developer includes a housing cooperative.
Description	One of the conditions for obtaining support is achieving the required demand for usable energy by meeting the conditions included in the guideline document (annexed to the scheme), which are as follows: minimum technical requirements, requirements for the construction design, requirements for completed project, and ensuring the quality of construction works. Standards NF40 and NF15 for residential buildings lay down a set of requirements developed specifically for the needs of this financing programme, and are in many respects stricter and broader than those arising under applicable laws and the definition of a low-energy building.
Effects	▪ Under the agreements concluded to date, co-funding of approximately PLN 12.4 million has been granted for the construction of 349 single-dwelling buildings. The average area of a newly constructed low-energy house is 132.5 m^2, while the indicator of the average demand for usable energy for heating and ventilation purposes (EUco) averages 26.4 kWh/(m^2·year). ▪ 17 positively verified estates of single-dwelling and multi-dwelling houses.

Programme name	**LEMUR – Energy Efficient Public Buildings**
Purpose	The aim of the scheme is to reduce energy consumption, and thus to reduce or avoid CO_2 emissions through the design and construction of new energy efficient public buildings and collective accommodation buildings.
Budget	The budget allocated for the programme is up to PLN 97.4 million, including: ▪ PLN 1.4 million under non-reimbursable forms of co-funding; ▪ PLN 96 million under reimbursable forms of co-funding.
Implementation period	The programme spans the years 2013-2020. The funds will be expended until 2020. The call for proposals under the scheme lasted until 30.06.2016.
Forms of co-funding	▪ subsidy for project documentation amounting to 60%, 40%, 20%, depending on building energy efficiency class (A, B or C); ▪ loan for the construction of new energy-efficient buildings of up to PLN 1 200.00 per m^2 for class A, and up to PLN 1 000.00 per m^2 for classes B and C, with the possibility of redemption of 60%, 40%, 20%, depending on the building energy efficiency class (A, B or C)

Beneficiaries	• public finance sector entities, excluding state budgetary entities; • legal persons established by local governments, commercial companies in which local governments hold 100% of the shares or stocks and which are established for the purposes of fulfilling own tasks of local governments; • non-governmental organisations, including foundations and associations, churches and other religious associations entered in the register of churches and other religious associations, and church legal persons which carry out public tasks under separate provisions.
Description	The scope of the programme covers the design and construction of the following types of newly constructed buildings: ▪ public buildings – intended for the needs of public administration, culture, education, higher education, science, upbringing, healthcare, welfare or social care, tourism, and sport; ▪ collective accommodation buildings – intended for temporary residence of persons (boarding houses, student hostels) and for permanent residence of persons (orphanages, pensioners' homes). To qualify for support, buildings must comply with programme-specific technical guidelines which lay down detailed principles for determining the applicable energy standard requirements and their level, and which take into account applicable technical and building regulations and rules on calculating energy characteristics of buildings.

Programme name	**Prosumer – co-financing facility for the purchase and assembly of RES microinstallations**
Purpose	The purpose of the programme "Supporting distributed renewable energy sources Part 2) Prosumer – co-financing facility for the purchase and assembly of RES microinstallations" is to reduce or avoid CO_2 emissions by increasing renewable energy production through the purchase and assembly of small RES installations or RES micro-installations for the production of electricity or heat and electricity for natural persons and housing associations or housing cooperatives. The programme promotes new RES technologies and prosumer attitudes (raising investor's and environmental awareness), and stimulates the growth of the market of equipment suppliers and installers, as well as the growth of jobs in the sector.
Budget	The programme budget is up to PLN 340 402 000, including: ▪ PLN 122 968 000 for the non-reimbursable forms of co-funding; ▪ PLN 217 434 000 for the reimbursable forms of co-funding.
Implementation period	2014-2022, whereby loan agreements can be concluded by 30 June 2017.
Forms of co-funding	loan plus subsidy which jointly finance up to 100% of eligible costs, including: ▪ a grant amounting to 20-40% of the support (15% or 30% after 2015); ▪ loan with an annual interest rate of 1% (loan/bank loan financing period up to 15 years).
Beneficiaries	▪ natural persons who have the right to dispose of a residential building; ▪ housing associations and housing cooperatives; ▪ local governments and their unions.
Description	Co-funding will be available for installations producing electricity or heat and electricity using: ▪ a biomass-fired heat sources, heat pumps, and solar collectors with installed heat generation capacity of up to 300 kWt; ▪ photovoltaic systems, small wind farms, and micro-cogeneration systems (including micro-biogas plants) with installed electricity generation capacity

	of up to 40 kWe, for the needs of single-dwelling or multi-dwelling residential buildings, including those under construction. The requirements include high quality of the equipment installed, manufacturer's warranty for the main items of equipment spanning at least 5 years, installer's warranty for at least 3 years, design and assembly by qualified staff.

Programme name	**BOCIAN – dispersed, renewable energy sources**
Purpose	To limit or avoid CO_2 emissions by increasing the production of energy by installations using renewable energy sources.
Budget	The planned commitments under the reimbursable forms of co-funding amount to PLN 570 million from NFOŚiGW resources
Implementation period	The implementation period spans the years 2014-2022.
Forms of co-funding	Loan
Beneficiaries	Entrepreneurs within the meaning of Article 43 of the Civil Code undertaking RES projects in Poland.
Description	The programme co-finances the construction, extension or reconstruction of RES installations with capacities falling within certain ranges, e.g. wind farms with a capacity of up to 3 MWe, solar systems between 200 kWp and 1 MWa, geothermal water energy from 5 MW to 20 MWt, small 5 MW hydroelectric power stations.

Programme name	**Improvement of air quality. Part 2 – Reduction of energy consumption in the construction sector**
Purpose	The aim of the programme is to improve air quality by limiting or avoiding CO_2 emissions through increased RES energy production or decreased energy consumption in buildings.
Budget	The programme budget is up to PLN 500 million, including: ▪ up to PLN 300 million for the non-reimbursable forms of co-funding, ▪ PLN 200 million for the reimbursable forms.
Implementation period	2016-2022
Forms of co-funding	Subsidy (up to 85% of eligible costs), loan (up to 100% of eligible costs).
Beneficiaries	The following entities registered in Poland are eligible: ***1)*** healthcare providers rendering stationary and round-the-clock health services, in particular: hospitals, care and treatment centres, nursing and care facilities, and hospices registered in the Register of Healthcare Providers, as referred to in the Act of 15 April 2011 on medical activities, ***2)*** entities which manage museums registered in the State Museum Register (pursuant to Regulation of the Minister of Culture and National Heritage of 13 May 2008 *laying down the procedures for keeping the State Museum Register, the model request for entry in the Register, the conditions and procedures applicable to making entries in the Register, and circumstances in which a review can be ordered to determine whether a museum continues to meet the conditions for entry in the Register*), ***3)*** entities which run student hostels, pursuant to the University Education Law 27 July 2005;

	4) entities which own a building entered in the Register of Monuments pursuant to the Act of 23 July 2003 *on the protection and care of monuments*, 5) churches and religious associations entered in the Register of churches and other religious associations, as referred to in the Act of 17 May 1989 *on safeguards for freedom of conscience and religion*.
Description	Thermomodernisation of the following types of buildings, provided they do not receive EU support: • museums; • hospitals, care and treatment centres, nursing and care institutions, hospices; • historic buildings; • sacral buildings with accompanying facilities; • student hostels. For refurnishing buildings with equipment satisfying the highest, economically justifiable energy efficiency standards, associated directly with building thermomodernisation, which includes in particular: • insulation of the building, including: walls, ground floors, ceilings, flat roofs, roofs and other elements of the envelope; • replacement of windows; • replacement of external doors; • reconstruction of heating systems (including heat source replacement); • replacement of ventilation and air conditioning systems; • use of energy management systems in buildings; • use of RES technologies; • preparation of technical documentation, including energy audits and mycological surveys, • removal of dampness and its effects on building undergoing thermomodernisation, • replacement of indoor and outdoor lighting with energy-saving lighting.

Table 28. Green Investments Scheme – GIS.

Programme name	**Green Investment Scheme – GIS. Part 1 – Energy management in public buildings**
Purpose	Reduction or elimination of carbon dioxide emissions by co‑financing projects which improve the efficiency of energy use by public buildings.
Budget	PLN 501 million – non-reimbursable forms (grants), PLN 462 million – reimbursable forms (loans)/ proceeds from the sale of allocated AAUs or from other NFOŚiGW funds:
Implementation period	The programme is implemented in 2010-2018
Forms of co-funding	▪ grant; ▪ loan
Beneficiaries	▪ local governments and their unions; ▪ entities other than entrepreneurs which provide public services to fulfil own tasks of local governments; ▪ The Voluntary Fire Service; ▪ universities, within the meaning of the University Education Law, and research institutes; ▪ autonomous public healthcare institutions (samodzielne publiczne zakłady opieki zdrowotnej), and healthcare service providers running an enterprise within the meaning of Article 55^1 of the Civil Code; ▪ non-governmental organisations, churches and other religious associations registered in the Register of churches and other religious associations, as well as church legal persons.
Description	Co-funding under this programme is available for reducing the consumption of energy by existing buildings. The activities include, *inter alia*, thermomodernisation of public buildings, in particular thermal insulation of the building, replacement of windows, replacement of external doors, reconstruction of heating systems, replacement of ventilation and air conditioning systems, preparation of project documentation for the investment, implementation of energy management systems in buildings, use of RES technologies, or replacement of indoor lighting with energy-saving lighting (as additional task delivered in parallel to thermomodernisation). Group projects can be implemented under the programme.

Operational Programme Infrastructure and Environment[38)]

Table 29. European Union Funds

Programme name	Operational Programme Infrastructure and Environment 2014-2020 Measures 1.3.1, 1.3.2 – Supporting energy efficiency in public buildings and in the public sector
Purpose	Improving energy efficiency in multi-dwelling residential buildings and in public buildings.
Budget	EUR 431.10 million (including public buildings – EUR 205.52 million and the housing sector – EUR 225.58 million), from EU funds (the Cohesion Fund).
Implementation period	2014-2023
Beneficiaries	Under the investment priority, support is granted to public authorities, including state budgetary entities and central government administration, as well as their subordinate bodies and organisational entities, housing cooperatives and housing associations, state legal persons, and energy service providers within the meaning of Directive 2012/27/EU.
Description	Support is available for deep, all-comprising energy-related refurbishment of public and residential buildings, together with their refurnishing with energy efficient equipment, *inter alia* within the following scope: ▪ insulation of the building, replacement of windows, external doors, and replacement of lighting with energy-efficient lighting; ▪ retrofit of heating systems (including heat source replacement), ventilation and air-conditioning systems, and installation of weather-sensitive building automation and building management systems; ▪ construction or refurbishment of internal receiving installations, and removal of existing heat sources; ▪ installation of micro-generation or micro-trigeneration for own needs; ▪ installation of RES in buildings undergoing thermomodernisation (if recommended by an energy audit), ▪ installation of cooling systems, including those based on RES.

Regional Operational Programmes (ROPs)

Regional Operational Programmes (ROPs) are another source of funding. Pursuant to the Partnership Agreement, 60% of the structural funding (under the European Regional Development Fund and the European Social Fund) will be allocated for 16 regional programmes in 2014-2020. Each province has been allocated a specific portion of all the financial resources available under this instrument and develops its own ROP.

The actions proposed under ROPs also include measures which work towards improving energy efficiency in the building sector. For selected ROPs, based on ex-ante analyses completed, support

[38)] In accordance with the Operational Programme Infrastructure and Environment 2014-2020, which was accepted by the European Commission by decision of 16 December 2014 and which has been in effect since 19 December 2014.

for broadly-defined energy efficiency will be made available through financial instruments. The beneficiaries, types of projects and the financing method are determined individually for each province, but subject to specific thematic objectives and investment priorities.

Detailed information on the ROPs for 2014-2020 is presented in table 30. The information covers activities planned under Investment Priority IP 4.III (IP 4.3 according to previously used numbering), which addresses improving energy efficiency of public and multi-dwelling residential buildings. However, projects falling within the above scope can be implemented under other investment priorities, in particular IP 4.II (Promoting energy efficiency and use of renewable energy sources in enterprises) and IP 4.V (Promoting low-emission strategies). However, it should be borne in mind that projects regarding energy efficiency of buildings under these investment priorities will, as a rule, be part of larger projects resulting from energy audits or low-emission strategies prepared, therefore providing such detailed information as for IP 4.III is impossible.

The total amount foreseen for Investment Priority IP 4.III in the years 2014-2020 is EUR 1 545 941 800. Under the priority, support will be channelled to tasks involving deep, all-comprising energy retrofits of public and multi-dwelling residential buildings, together with their refurnishing with energy efficient equipment, *inter alia* within the following scope:

- insulation of the building, replacement of windows, external doors, and replacement of lighting with energy-efficient lighting;
- reconstruction of heating systems (including heat source replacement and connection), ventilation, and air-conditioning systems.
- construction or refurbishment of internal receiving installations, and removal of existing heat sources;
- using RES technologies in buildings,
- installation of cooling systems, including RES-based ones.

Investments must be based on an energy audit. Often, the projects also involve the construction or reconstruction of high-efficiency cogeneration units.

Table 30. Projects under individual ROPs

Province	Purpose of intervention under IP 4.III	Anticipated amounts of support (by intervention codes according to Annex I to Commission Implementing Regulation (EU) No 215/2014 of 7 March 2014)			Anticipated type of beneficiaries under IP 4.III	Main types of projects under IP 4.III
		013 Renovation of public infrastructure for energy efficiency purposes, demonstration projects, and support measures	014 Renovation of existing residential buildings for energy efficiency purposes, demonstration projects, and support measures	Total 013+014		
Dolnośląskie	Supporting energy efficiency, intelligent energy management, and use of renewable energy sources by public infrastructure, including public buildings, and the housing sector	€101 500 000	€50 072 922	€166 572 922	Type of beneficiaries: - local governments and their unions and associations; - public entities owned by a local government or for which a local government is the founding entity;- organisational entities of local governments; - housing cooperatives and housing associations; - Social Building Societies; - managers of financial engineering instruments.	Preference will be given to the following projects: - comprehensive projects covering a large part or the entire area of a municipality or district, in the form of programmes initiated by local governments, including prosumer activities aimed at reducing low-stack emission and increasing the share of renewable energy sources in the energy balance; - projects using energy-management systems; - projects consistent with low-emission economy plans;- projects involving deep thermomodernisation.
	Implementation of low-emission strategies (4e)		€15 000 000		Type of beneficiaries: - local governments and their unions and associations; - organisational entities of local governments; - public finance sector entities other than listed above; - entrepreneurs managing infrastructure or providing public transport services in urban and suburban areas; - non-governmental organisations; - The State Forest Service (PGL Lasy Państwowe) and its organisational entities; - financial instrument implementing body.	Preference will be given to the following projects: - delivered in cities with a population of more than 20 000; - projects improving accessibility to areas with concentrated population and/or business activity, as well as to the labour market and public services; - multimodal projects which involve a combination of various low- and zero-emission modes of transport; - projects implemented in health resorts; - projects involving the purchase of fleet powered by alternative fuels (electric, gas, hydrogen, hybrid vehicles); - projects dedicated to heating systems based on non-solid fuels - projects using RES; - projects implemented in health resorts; - projects involving the use of energy management systems; - project which will reduce CO_2 emissions by more than 30%; - projects under which support is provided through energy service companies (ESCOs).

Kujawsko-Pomorskie	Improving energy efficiency of public buildings and multi-dwelling residential buildings	€60 476 294	€25 918 411	€86 394 705	Type of beneficiaries: - local governments and their unions and associations; - local governments' organisational entities with legal personality; - other public finance sector entities; - non-governmental organisations; - housing cooperatives and housing associations; - churches and religious associations, and legal persons of churches and religious associations. The programme supports projects implemented under long-term agreements concluded between public and private entities with the aim of creating infrastructure components to be used for providing public services.	The IP will support activities dedicated to comprehensive thermomodernisation of buildings, together with their refurnishing with energy efficient equipment. According to law, the public sector should play an exemplary role in the area of energy efficiency improvement measures, therefore a large share of the investments is planned to be delivered in public buildings. Supporting projects which include energy audits and comprehensive thermomodernisation, including the use of renewable energy installations and heat source replacement, will translate into noticeable reduction in heat and electricity consumption. The planned assistance is necessary for ensuring rational and efficacious governance in the Province, which will be reflected *inter alia* by sound and cost-effective management of economic and environmental resources.
Lubelskie	Improving energy efficiency of public buildings and the housing sector	€95 143 470	€22 617 544	€131 531 252	The groups of beneficiaries include, among others: - local governments and their unions and associations; - local governments' organisational entities with legal personality; - research institutions; - higher education institutions;- commercial companies in which local governments or their unions hold the majority of shares or stocks;- non-governmental organisations;- public finance sector entities with legal personality;- housing cooperatives and associations; - Social Building Societies; - emergency and public security services;- entities managing financial instruments.	The pursuit of the energy savings goal in the public and housing sectors will include supporting deep thermomodernisation of public buildings, including those owned by local governments (such as hospitals and schools) and residential buildings, including their refurnishing with equipment of the highest, economically justifiable energy-efficiency classes (for example, insulation of buildings, replacement of doors and windows, retrofits of heating systems together with heat source replacement, and modernisation of ventilation and air conditioning systems). As part of comprehensive deep thermomodernisation of buildings, support will also be available for distributed generation, i.e. construction of small local energy sources producing both electricity and heat for local needs and not requiring long-distance transmission, as well as for improving the efficiency of heat generation by replacing heat sources with high-efficiency cogeneration units.
	Promoting low-emission strategies for all types of territories, in particular urban areas, including promotion of sustainable multimodal urban mobility and adaptation measures having a mitigating effect on climate change (4e)	€13 770 238			The main groups of beneficiaries eligible for funding for projects following from sustainable urban mobility plans, low-emission economy plans, and/or ITI strategies include cities with a population of more than 30 000 and areas linked to them in functional terms, as well as the following entities located within their territories: - local governments and their unions and associations; - local governments' organisational entities with legal personality; - public finance sector entities with legal personality; - entities providing public transport services for local governments and their unions in cities covered by the measure, selected to provide such services under the Public Procurement Law. The main groups of beneficiaries eligible to receive funding for projects following from low-emission economy plans include: - local governments and their unions and associations; - local governments' organisational entities with legal personality; - public finance sector entities with legal personality; - commercial companies in which local governments or their unions hold the majority of shares or stocks; - SMEs - emergency and public security services;	As regards heat source replacement, support will be available for investments in installations with the lowest emissions of CO_2, PM 10 and other types of air pollution. Supported projects must generate CO_2 reduction by at least 30% compared to existing installations. Projects should be economically and socially justifiable and combat energy poverty. Priority will be given to projects using renewable energy sources. Support can only be obtained on condition that the investment will improve energy efficiency and reduce demand for energy in the buildings where the energy from the co-financed equipment is to be utilised. For individual items of heating equipment fired with solid fuels, Investments in urban transport must be based on those plans prepared by local governments which address transition to more environmentally friendly and sustainable transport systems in cities. Such category of documents includes low-emission economy plans, ITI strategies, or urban mobility plans.

Lubuskie	Rationalisation of energy use by the public and housing sectors	€27 441 473	€11 760 631	€39 202 104	Type of beneficiaries: - local governments and their unions and associations; - public entities owned by a local government or for which a local government is the founding entity;- owners/administrators of residential buildings.	The following will be delivered under the programme: - comprehensive thermomodernisation of public buildings;- comprehensive thermomodernisation of residential buildings;- thermomodernisation of buildings including the use of RES installations.
Łódzkie	Improving energy efficiency in the public and housing sectors	€89 079 306	€32 385 196	€213 703 958	- local governments and their unions and associations; - local governments' organisational entities with legal personality; - public finance sector entities with legal personality; - research institutions; - higher education institutions;- legal and natural persons managing schools and educational establishments;- housing cooperatives and associations, Social Building Societies; - healthcare institutions;- cultural institutions; - churches and religious associations, and legal persons of churches and religious associations;- non-governmental organisations;- The State Forest Service (PGL Lasy Państwowe) and its organisational entities.	The programme will support comprehensive thermomodernisation of public or residential buildings (common spaces of multi-dwelling residential buildings), which includes refurnishing them with energy-efficient equipment (e.g. insulation of the building, replacement of windows, external doors, and lighting with energy-saving lighting, refurbishment of heating systems together with heat source replacement and connection), ventilation and air-conditioning system retrofits, and installation of RES in buildings undergoing thermomodernisation. Projects can involve replacement of heat sources based on conventional fuels, most preferably with heat sources producing renewable energy, or connection to the district heating system. The investments to be delivered must follow from energy audits.
	Better air quality (4e)	€34 486 536			Type of beneficiaries: - local governments and their unions and associations; - local governments' organisational entities with legal personality; - entrepreneurs; - non-governmental organisations; - research institutions, educational establishments, higher education institutions, - cooperatives, housing associations, Social Building Societies.	The following will be supported by the programme: - investments in buildings with significantly improved energy parameters, taking the form of pilot and demonstration projects related to public buildings, - investments in heat source refurbishment (comprehensive replacement or renovation), extension of heat supply systems and connection of single-dwelling and multi-dwelling or public buildings to heat sources. The use of coal boilers will not be eligible. - investments related to public lighting based on energy efficient and environmentally-friendly solutions as part of wider infrastructure projects.
	Restoration or creation of public and economic functions within deprived areas (9b).	€28 392 321	€29 360 599		Type of beneficiaries: - local governments and their unions and associations; - local governments' organisational entities with legal personality; - public finance sector entities with legal personality; - central government administration bodies and their subordinate entities; - non-governmental organisations; - churches and religious associations, and legal persons of churches and religious associations - cultural institutions; - housing cooperatives and associations, Social Building Societies; - Local Action Groups; - higher education institutions; - research institutions; - entrepreneurs.	The following will be supported by the programme: - renovation, adaptation of buildings, constructions, areas and spaces leading to the restoration or assignment of new functions, including possible purchase of equipment and furnishings necessary to achieve the purpose of intervention 9b, - revitalisation of the building tissue of common parts of multi-dwelling buildings, including thermomodernisation of residential buildings (as part of a wider project). Support will be available for projects ensuing from comprehensive multi-annual revitalisation programmes prepared on the basis of the national revitalisation action framework and local revitalisation programmes or equivalent documents, e.g. ITI Strategy. Preference will be given to: - projects complementary with investments funded by the ESF, - smaller-scale infrastructure projects complementing revitalisation investments under other thematic objectives of the ROP of the Łódzkie Province for 2014-2020, - projects reducing energy consumption in revitalised buildings.

Małopolskie	The main objective of the intervention implemented under the investment priority is to increase energy efficiency and use of renewable energy sources in residential and public buildings	€70 000 000	€26 000 000	€96 000 000	Type of beneficiaries: - local governments and their unions and associations; - local governments' organisational entities with legal personality; - research institutions; - universities; - housing cooperatives and associations; - cultural institutions; - healthcare institutions operating within the public healthcare system - non-governmental organisations; - churches and religious associations, and legal persons of churches and religious associations.	The activities addressed to the housing and public building sectors will focus on comprehensive thermomodernisation of buildings, including use of RES installations. As a key aspect, such projects must achieve the assumed environmental effect in the form of a specific amount of energy savings relative to the planned financial spending. Therefore, the preconditions for undertaking such investments must include the completion of an energy audit, preparation of an energy-savings programme and an analysis of the cost-effectiveness of the actions, and finally comprehensive thermomodernisation, which includes: - insulation of the building, replacement of windows, external doors, and replacement of lighting with energy-efficient lighting;reconstruction of heating systems (including heat source replacement and connection), ventilation and air-conditioning systems, and use of weather-sensitive building automation and building management systems;- construction or retrofitting of indoor receiving installations, and removal of existing heat sources;- micro-generation or micro-trigeneration installation for own needs; - use of RES technologies in buildings,- installation of cooling systems, including those based on RES.
Mazowieckie	The main objective of the measure is to support interventions working towards improved energy efficiency, which includes use of renewable energy sources in public and residential buildings, as well as to support SMEs in reducing the losses of energy, heat, and water	€48 731 628	€20 847 340	€69 578 968	Type of beneficiaries: - local governments and their unions and associations; - local governments' organisational entities with legal personality; - entities providing public services at the request of a local government in which the local government holds the majority of shares or stocks; - central government administration; - commercial companies in which local governments or their unions hold the majority of shares or stocks; - entities entrusted public services pursuant to the Public Procurement Law of 29 January 2004 (Journal of Laws of 2015, item 2164), acting on the basis of existing agreements concluded with local governments for the provision of the respective services;- small and medium-sized enterprises;- energy service providers;- energy companies conducting economic activity in the field of the production, processing, storage, transmission, and distribution of fuels or energy, and trade in them;- The State Forest Service (PGL Lasy Państwowe) and its organisational entities;- cultural institutions;- research institutions;- higher education institutions;- housing cooperatives, housing associations, Social Building Societies;- churches and religious associations, and legal persons of churches and religious associations;- non-governmental organisations;- entities responsible for the implementation of corrective actions provided for by air protection programmes and short-term action plans.	Projects: - support for comprehensive thermomodernisation of public and residential buildings; - reducing the energy intensity of small and medium-sized enterprises;- construction or retrofit of high-efficiency cogeneration units.

Opolskie	Reducing the energy intensity of the public and housing sector	€17 400 000	€4 100 000	€21 500 000	Type of beneficiaries: - local governments and their unions and associations; - local governments' organisational entities; - public finance sector entities; - research institutions;- higher education institutions;- enterprises;- churches and religious associations, and legal persons of churches and religious associations;- non-governmental organisations;- financial intermediaries with appropriate experience and administrative capacity.	Projects: - comprehensive thermomodernisation of public buildings, together with their refurnishing with energy efficient equipment; - energy audits for the public sector as a comprehensive project component;- recapitalisation of loan funds;- recapitalisation of other public financial institutions offering reimbursable financial instruments.
Podkarpackie	Improving energy efficiency in the housing sector and public buildings	€64 898 653	€60 667 080	€143 191 674	Type of beneficiaries: - local governments and their unions and associations; - entities in which local governments or their unions and associations hold the majority of shares or stocks; - public finance sector entities; - housing cooperatives and associations, Social Building Societies; - non-governmental organisations; - healthcare institutions, as defined by the Act on medical activities	Projects: - comprehensive thermomodernisation of public buildings, together with their refurnishing with energy efficient equipment; - comprehensive energy-related refurbishment of residential buildings (multi-dwelling housing), together with their refurnishing with energy efficient equipment - putting in place energy management systems (e.g. smart metering) as a comprehensive project component
	Promoting low-emission strategies for all types of territories, in particular urban areas, including promotion of sustainable multimodal urban mobility and adaptation measures having a mitigating effect on climate change (4e)	€17 625 941			Type of beneficiaries: - local governments and their unions and associations; - entities in which local governments or their unions and associations hold the majority of shares or stocks; - public finance sector entities; - enterprises; - non-governmental organisations; - housing cooperatives and associations, Social Building Societies; - consortia of the above entities represented by a leader	Projects: - replacement or refurbishment of heat sources (support criterion – PM10, PM2.5, benzo(a)pyrene exceedance) - reducing energy losses in heat distribution, including RES - expansion of the district heating network - implementation of integrated energy sustainability strategies for urban areas, including public lighting systems - support for projects which may ensue from low-emission economy plans/low-stack emission reduction programmes for specific types of city areas and which are ineligible for co-funding under another IP, e.g. energy savings measures, passive building investments

Podlaskie	Implementation of efficient energy management programmes, including thermomodernisation measures	€22 500 000	€45 000 000	€67 500 000	Type of beneficiaries: - housing cooperatives and their unions; - housing associations; - Social Building Societies; - administrators of residential property. Projects related to public buildings will be implemented, *inter alia*, by: - local governments and their unions and associations; - local governments' organisational entities with legal personality; - entities in which local governments or their unions and associations hold the majority of shares or stocks; - entities acting on the basis of a public-private partnership; - research institutions, higher education institutions; - churches and religious associations.	In order to enhance energy efficiency, there is a need for comprehensive thermomodernisation of residential and public buildings, together with their refurnishing with energy efficient equipment; the scope of such activities includes, for example, insulation of buildings, and replacement of windows, external doors and lighting. The investments planned include reconstruction of heating systems, including heat source replacement and connection, of ventilation and air conditioning systems, and water and sewage systems. In keeping with the idea of prosumer energy, use of RES installations in the buildings undergoing thermomodernisation will be promoted. Support will be available for the installation of cooling systems, including those based on RES. The use of a renewable energy installation must be fully justified by the energy needs of the building, and only the unconsumed portion of electricity can be returned to the distribution network.
Pomorskie	Improving energy efficiency of public and residential buildings, as well as of outdoor lighting systems	€110 377 399	€27 943 630	€152 507 795	Type of beneficiaries: - local governments and their unions and associations;- local governments' organisational entities with legal personality;- central government administration entities; - other public finance sector entities; - research institutions; - educational institutions, higher education institutions; - non-governmental organisations; - churches and religious associations; - entrepreneurs; - financial Institutions.	Support will be available for investments improving the energy efficiency of public buildings, including thermomodernisation projects. Improving energy efficiency of residential buildings will also be eligible. The comprehensive projects will involve thermomodernisation of buildings along with the use of a RES installation and heat source replacement. The scope of work must be determined on the basis of an analysis of the feasible solutions, conducted previously through an energy audit, and the variant chosen must take into account a cost criterion based on the environmental effect (e.g. reduction of greenhouse gas emissions) relative to the financial outlays.
	Improved efficiency of municipal energy infrastructure (4e)	14 186 766			Type of beneficiaries: - local governments and their unions and associations;- local governments' organisational entities with legal personality;- central government administration entities; - other public finance sector entities; - non-governmental organisations; - research institutions; - educational institutions. - higher education institutions; - entrepreneurs.	As regards centralised heating systems (including heat sources), preference will be given to the following: 1) projects implemented in municipalities where air quality standards have been found to be exceeded; 2) projects which ensure the greatest environmental effect (including reduction of greenhouse gas emissions) relative to financial outlays; 3) projects in which innovative solutions are employed with respect to equipment and systems, e.g. projects forming an element of an "energy island" or using high-efficiency cogeneration, 4) projects implemented with the participation of private capital; 5) projects with the greatest possible range of impact; 6) agreed under Integrated Territorial Agreements (Zintegrowane Porozumienia Terytorialne, ZPT).

Śląskie	Counteracting adverse climate changes and improving the competitiveness of the regional economy by increasing the share of renewable energy relative to energy from conventional sources. Reducing the energy intensity of public infrastructure and the housing sector. Improving air quality in the region.	€91 003 577	€90 834 827	€231 838 404	Type of beneficiaries: - local governments and their unions and associations; - entities in which local governments or their unions and associations hold the majority of shares or stocks; - public finance sector entities (other than listed above); - healthcare institutions, as defined by the Act on medical activities, having legal personality or legal capacity;- higher education institutions;- non-governmental organisations;- housing cooperatives and associations;- Social Building Societies; - consortia of the above entities represented by a leader;- entities acting under a public-private partnership agreement (so-called hybrid projects).	Priority 4.3 will support measures leading to comprehensive thermomodernisation of public buildings and residential buildings, combined with the construction and reconstruction of infrastructure utilised to generate and distribute renewable energy in buildings undergoing thermomodernisation, and/or elimination of low-stack emissions by replacement/retrofitting of individual heat sources.
	Improved attractiveness of public transport for passengers (4e)	€50 000 000			Type of beneficiaries: - local governments and their unions whose statutory task is to perform the public transport tasks of local governments envisaged by law; - providers of public transport acting on behalf of local governments and their unions, selected under the Public Procurement Law; - entities implementing public transport-related public tasks under their respective statutes, in which the majority of shares are held by a local government or a union of local governments.	Types of projects • Construction, reconstruction of linear and point public transport infrastructure (e.g. integrated transport interchanges, bicycle routes, Park&Ride and Bike&Ride, bus lanes). • Implementation of intelligent transport systems (ITS). • Purchase of bus and tram fleet for the needs of public transport combined with the construction of infrastructure. • Construction and reconstruction of linear tram infrastructure. • Improving energy efficiency of lighting.
Świętokrzyskie	Supporting energy efficiency, intelligent energy management and use of renewable energy sources in public infrastructure, including public buildings and the housing sector	€54 754 121	€10 279 853	€87 886 445	Type of beneficiaries: - local governments and their unions and associations; - housing cooperatives and associations; - Social Building Societies; - local government organisational units with legal personality; - universities, other entities active in the sphere of public services with various organisational forms, having legal personality, e.g. foundations and associations; - The Police; - healthcare institutions which perform publically financed medical activities in the Świętokrzyskie Province; - legal persons of local governments; - units of volunteer and State Fire Service.	Projects involving comprehensive thermomodernisation of public buildings (excluding bodies of the central administration) and residential buildings forming part of the municipality's housing stock, together with their refurnishing with energy efficient equipment, *inter alia* within the following scope: insulation of the building, replacement of windows, external doors and lighting with energy efficient lighting, reconstruction of heating systems (including heat source replacement – removal of solid fuel boilers), ventilation and air conditioning systems, water and sewage systems, RES installation in buildings undergoing thermomodernisation, installation of cooling systems, including RES-based ones, installation of state-of-the-art energy efficient equipment (e.g. solar collectors).

	Promoting low-emission strategies for all types of territories, in particular for urban areas, including promotion of sustainable multimodal urban mobility and adaptation measures having a mitigating effect on climate change (4e)	€22 852 471			Type of beneficiaries: - local governments; - large, medium-sized, small, and micro enterprises providing public services in the Świętokrzyskie Province; - social and economic partners operating in the Świętokrzyskie Province; - non-governmental organisations (NGOs); - legal persons of local governments; - business environment institutions; - universities; - state budgetary entities; - cultural institutions	The co-funding will be available for projects pursuing the objectives of low-emission plans for individual areas. Support for projects based on low-emission economy plans for specific types of city areas and ineligible for co-funding under another IP, for example: 1. refurbishment of street lighting (streets, squares, public areas) by its replacement with energy efficient lighting; 2. construction or refurbishment of the district heating network; 3. replacement of heat sources; 4. micro-cogeneration; 5. information and promotion activities regarding, for example, energy savings; 6. campaigns promoting: - zero-emission buildings; - passive building investments.
Warmińsko-Mazurskie	Improving energy efficiency of residential and public buildings	€35 659 567	€15 282 672	€50 942 239	Type of beneficiaries: - local governments and their unions and associations; - local governments' organisational entities;- public finance sector entities with legal personality;- autonomous public healthcare institutions (i.e. operating within the public healthcare system) for which a local government is the founding entity; - enterprises (only entities which provide public services to fulfil own tasks of local governments);- housing cooperatives/ housing associations;	Projects: - comprehensive thermomodernisation of public buildings/ common parts of multi-dwelling residential buildings together with their refurnishing with energy efficient equipment (including insulation of the building, replacement of windows and external doors and lighting with energy-efficient lighting), reconstruction of heating systems (including heat source replacement and connection), reconstruction of ventilation and air conditioning systems, RES installation, and installation of cooling systems, including RES);- energy audits for the residential and public sector (only as a component of comprehensive thermomodernisation projects, as described above);- installation of intelligent energy management systems in public buildings/residential buildings based, *inter alia*, on ICT technologies (only as a component of comprehensive thermomodernisation projects, as described above).
Wielkopolskie	Reducing the energy intensity of the housing and public sectors	€60 060 000	€30 940 000	€91 000 000	Type of beneficiaries: - housing cooperatives and housing associations; - local governments and their unions; - local governments' organisational entities with legal personality, including entities which provide public services to fulfil own tasks of local governments; - entities operating under public-private partnership agreements.	Projects: - thermomodernisation of buildings together with their refurnishing with energy-efficient equipment, projects involving the refurbishment of the heating and energy infrastructure in buildings undergoing thermomodernisation, as well as connection of buildings to the district heating network, - RES installations in buildings undergoing thermomodernisation.

Zachodniopomorskie	Reducing the energy intensity of public and residential buildings	€20 576 416	€20 000 000	€47 576 416	Type of beneficiaries: type 1: - local governments and their unions and associations; - organisational entities of local governments; - legal persons of local governments, partnerships of the above entities. type 2: - local governments and their unions and associations;- organisational entities of local governments, Social Building Societies; - housing associations, housing cooperatives; - non-governmental organisations; - partnerships of the above entities.	Projects: - comprehensive thermomodernisation of public buildings which will be implemented on the basis of previously conducted energy audits, - comprehensive thermomodernisation of multi-dwelling residential buildings.
	Promoting low-emission strategies for all types of territories, in particular for urban areas, including promotion of sustainable multimodal urban mobility and adaptation measures with a mitigating effect on climate change (4e)	€7 000 000			Type of beneficiaries: - enterprises providing public transport services; - local governments and their unions and associations; - organisational entities of local governments; - non-governmental organisations; - railway infrastructure managers; - state budgetary entities; - enterprises;	Projects: - construction, reconstruction of facilities/ infrastructure of integrated public transport systems to limit road traffic in city centers; - projects increasing ecological awareness; - purchase or upgrading of urban transport rolling stock and fleet.

Total	cat. 013	cat. 014	013+014
	€1 157 919 117	€539 010 705	€1 696 929 822

Table 31. Availability of programmes under Investment Priority 4c of ROPs for individual provinces and specific groups of beneficiaries

Province	Type of beneficiaries																						
	- Local governments and their unions and associations;	Public entities owned by a local government or for which a local government is the founding entity;	Organisational entities of local governments;	Housing cooperatives and associations;	Social Building Societies;	Other public finance sector entities;	Non-governmental organisations (NGOs);	Churches and religious associations and legal persons of churches and religious	Higher education institutions, research institutions;	Emergency services;	Public order/security organisations;	Owners/administrators of residential buildings;	Healthcare institutions;	Cultural institutions;	State Forest Service (PGL Lasy Państwowe) and its organisational	Central government administration;	Local government organisational units with legal personality;	Enterprises			Energy service providers;	Voluntary Fire Service units;	Entities acting on the basis of a public-private partnership;
																		small	medium-sized	large			
Dolnośląskie	■	■	■	■	■	■																	
Kujawsko-Pomorskie	■		■	■		■	■	■															
Lubelskie	■		■	■	■	■	■		■	■	■						■						
Lubuskie	■	■										■											
Łódzkie	■		■	■	■	■	■	■	■				■	■	■								
Małopolskie	■		■	■			■	■	■				■	■									
Mazowieckie	■	■	■	■	■			■	■		■			■	■	■		■	■		■		
Opolskie	■		■			■	■	■	■									■	■	■			
Podkarpackie	■	■		■	■	■	■						■										
Podlaskie	■	■	■	■	■			■	■														■
Pomorskie	■		■			■	■	■	■	■						■		■	■	■			
Śląskie	■	■		■	■	■	■		■				■										■
Świętokrzyskie	■		■	■	■	■			■		■		■									■	
Warmińsko-Mazurskie	■		■			■							■ *)					■ **)	■ **)	■ **)			
Wielkopolskie	■			■	■																		■
Zachodniopomorskie	■		■	■	■		■																

*) operating within the public healthcare system/ for which a local government is the founding entity.

**) only entities which provide public services to fulfil own tasks of local governments;

■ programme available

Thermomodernisation and Repairs Fund

The rules for receiving co-funding from the Thermomodernisation and Repairs Fund are laid down by the Act of 21 November 2008 *on supporting thermomodernisation and repairs*.

The Residential Building Repair and Thermomodernisation Programme is aimed at improving the technical condition of existing housing stock, in particular common parts of multi-dwelling buildings. The key objective is to provide financial assistance to investors implementing thermomodernisation or repair projects or renovations of existing single-dwelling residential buildings using loans taken out in commercial banks. Such assistance is referred to as: "thermomodernisation bonus", "repair bonus", and "compensation bonus" respectively, and is used to repay a portion of a loan taken out for the implementation of a project or repair. The table below presents statistics of the Fund compiled by Bank Gospodarstwa Krajowego.

Table 32. Thermomodernisation and Repairs Fund

Type of bonus	Thermomodernisation and Repairs Fund
Purpose	The main objective of the Fund is to provide financial assistance to investors implementing thermomodernisation and repair projects, as well as to pay compensation to owners of residential buildings with council dwellings.
Budget/sources of funding	Sources of funding: 1) allocations from the State budget as determined annually by the Budget Act; 2) interest on the Fund's bank deposits; 3) income from investments of the Fund's money in securities; 4) donations and bequests; 5) other proceeds
Implementation period	Start: 2009 End: the Fund is a systemic measure and law does not provide for a specific end date of its operation.
Beneficiaries	A thermomodernisation bonus is available to owners and administrators of: ▪ residential buildings; ▪ collective accommodation buildings; ▪ public buildings owned by local governments and occupied by them for public tasks; ▪ local district heating networks; ▪ local heat sources. A bonus can be granted to investors irrespective of their legal status, for example to: legal persons (e.g. housing cooperatives and commercial companies), local governments, housing associations, and natural persons, including owners of single-dwelling houses. Budgetary entities and budgetary establishments are not eligible for the bonus.
Description	The detailed rules on bonus-based co-funding are laid down by the Act of 21 November 2008 *on supporting thermomodernisation and repairs*. A thermomodernisation bonus is available for thermomodernisation projects aimed at:

	▪ reducing the consumption of energy for heating and warm service water preparation in residential buildings, collective accommodation buildings, and buildings owned by local governments and occupied by them for the fulfilment of public tasks; ▪ reducing the cost of obtaining heat delivered to the above buildings by connecting them to a centralised heat source in connection with the elimination of a local heat source; ▪ reducing primary energy losses in local district heating networks and the local heat sources which supply them; ▪ partial or full replacement of energy sources with renewable sources or using high-efficiency cogeneration subject to generation energy savings requirements foreseen by law.

The effects of the Fund in the years 1999-2016 are presented below.

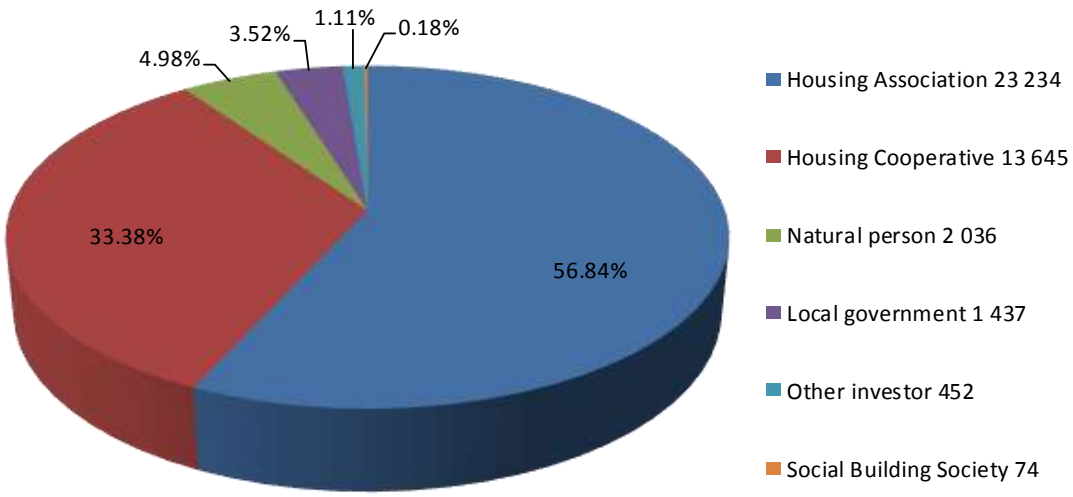


Figure 11. Structure of applications in 1999-2016 by type of investor

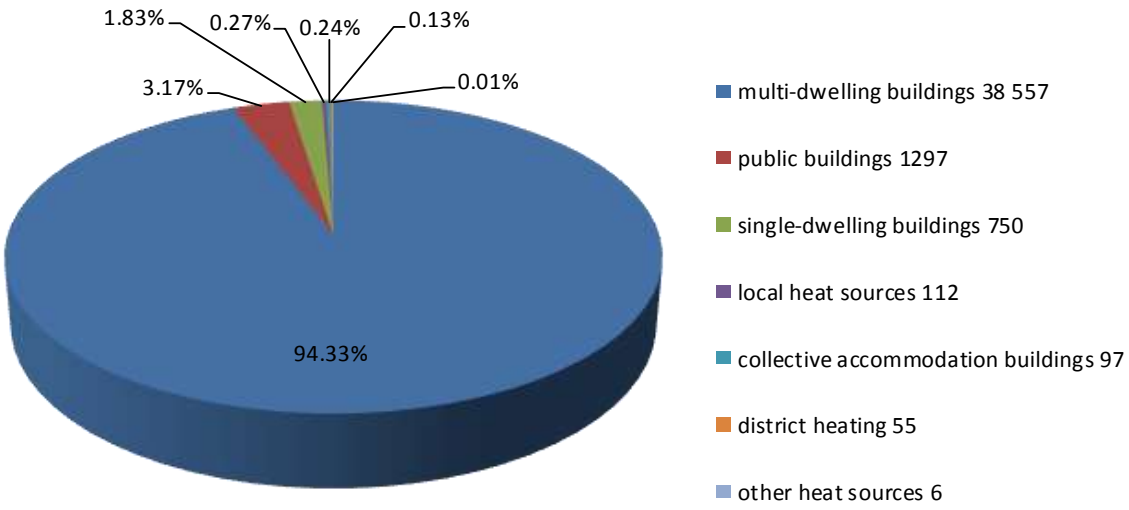


Figure 12. Structure of applications in 1999-2016 by type of modernised buildings

A thermomodernisation bonus can be obtained on condition that one of the following energy savings goals is achieved:

- reduction of annual demand for energy consumed for heating and warm service water preparation by at least:
  a) 10% in buildings where only the heating system is upgraded;
  b) 15% in buildings where the heating system was refurbished after 1984;
  c) 25% in other regions;
- reduction of annual energy losses by at least 25%;
- reduction of annual heat costs by at least 20%,
- or change of the heat source to a renewable source or use of high-efficiency cogeneration.

By 31 December 2016, the Thermomodernisation and Repairs Fund received an amount of PLN 2 055 000 000 from the sources of funding presented below.

Public-private partnerships (PPPs)

Under public-private partnership agreements, public and private sector entities jointly implement projects related to the construction of public infrastructure, including thermomodernisation of public buildings. PPPs involve entrusting public tasks to private entities. The principles of cooperation between a public body and a private partner under a public-private partnership are governed by the Act of 19 December 2008 *on public-private partnership* (Journal of Laws of 2015, item 696, as amended).

Pursuant to the act, PPPs are formed with the aim of joint implementation of undertakings based on the division of tasks and risks between the public entity and the private partner. By concluding a public-private partnership agreement, the private partner undertakes to implement a project for remuneration and to incur all or part of the expenses for its implementation. The public entity undertakes to cooperate towards achieving the goal of the undertaking. However, a PPP does not involve transferring the responsibilities of public administration to the private sector.

In addition, hybrid projects which combine PPP with European Union funds can be implemented. One example of such an investment is the comprehensive thermomodernisation of educational buildings of the Świdnica Municipality.

Other, selected sources of funding, including commercial banks

For the most part, commercial banks contribute to improving energy efficiency of existing building stock by extending loans for specific actions to various groups of investors. Incentive is provided by preferential terms of loan repayment. Financial support is also available when work is entrusted to the so-called "replacement investor", for example a specialised enterprise which performs a specific scope of work. This idea combines providing appropriate technical expertise and funding needed to implement the project. Additional incentive is the possibility of repaying the liabilities towards the third party from the energy savings obtained as a result of the investment implemented. The detailed rules governing the provision of this type of support are determined by the financing institutions.

Summary of sources of funding (excluding ROPs)

Table 33 presents a summary of funding available under the different programmes discussed in this annex (excluding ROPs).

Table 33. Division of funding available under individual programmes by type of building, type of beneficiaries and according to whether the building is existing or newly designed

Programme		Building status		Type of building		Type of beneficiaries													
		Newly constructed	Existing	Residential building	Public building	Natural persons	Housing associations and housing cooperatives	Public finance sector entities	State budgetary entities	Entities other than entrepreneurs which provide public services to fulfil own tasks of local governments	Universities, within the meaning of the University Education Law, and research institutes	Enterprises: small	Enterprises: medium-sized	Enterprises: large	Autonomous public healthcare institutions (samodzielne publiczne zakłady opieki zdrowotnej), and healthcare service providers running an enterprise within the meaning of Article 55[1] of the Civil Code	Non-governmental organisations, churches and other religious associations registered in the Register of churches and other religious associations, as well as church	WFOŚiGW	Entrepreneurs within the meaning of Article 43 of the Civil Code	The Voluntary Fire Service;
Subsidised loans for the construction of energy- efficient houses		■		■		■													
LEMUR		■			■			■	■							■			
Prosumer		■	■	■		■	■												
BOCIAN		■	■		■													■	
OPI&E Measures 1.3.1, 1.3.2			■	■	■		■		■	■									
Thermomodernisation and Repairs Fund (FTIR) bonuses	thermomodernisation bonus		■	■	■	■	■												
	repair bonus		■	■		■	■												
	compensation bonus		■	■		■													

■ programme available

3.3. Other activities – information and education

In 2016, the Ministry of Infrastructure and Construction issued a study entitled *Guide to improving the energy performance of buildings*.

The guide is a compendium of information on the energy efficiency of buildings useful in designing and constructing buildings, as well as in using buildings or their parts. The document discusses measures working towards improved energy performance of buildings and the associated legislation.

The purpose of the publication is to provide summary information about measures which can be used to improve the energy performance of buildings including their division by type, as well as to disseminate knowledge in the field of energy efficiency of buildings.

The guide is addressed to a wide range of audiences, including owners and users of buildings or their parts, investors, building administrators, local governments, construction companies, architects, engineers, persons qualified to issue energy performance certificates, qualified heating or air-conditioning system inspectors, and energy auditors.

Investors, owners, managers and users of buildings or their parts are acquainted, *inter alia*, with information about the construction, purchase or lease of buildings with high energy performance, about thermomodernisation, renewable energy sources or district heating, and behavioural changes.

The tips for designers and contractors cover such topics as: design and construction of energy-efficient buildings, thermomodernisation, renewable energy sources or district heating, and promoting change of behaviours.

The guide also contains guidance for local governments on how to shape and carry out the planning policy to ensure that district heat or renewable energy sources can be used in buildings, and how to locate buildings within plots to maximise solar gains.

Additionally, in the nearest future, the Ministry of Infrastructure and Construction will publish on its website the *Savings Calculator*, which can be used for calculating the estimated annual savings achievable after completing planned refurbishments of a house or dwelling. Examples of the use of the *Calculator* are presented in section 2.5 (tables 15-22) of this annex.

In addition, websites of the financial institutions which fund existing building stock refurbishment projects and the website of the Ministry include ample information about the financing process itself and issues related to the energy efficiency of buildings.

3.4 Analysis of barriers

As a result of the considerable progress made towards improving energy performance of buildings in recent years, an improvement in the thermal parameters has also been observed for existing buildings. Nevertheless, a proportion of them continue to generate considerable heat losses because of inadequate thermal insulation and systemic defects related to their ventilation, airtightness and heating installations, as well as warm water preparation.

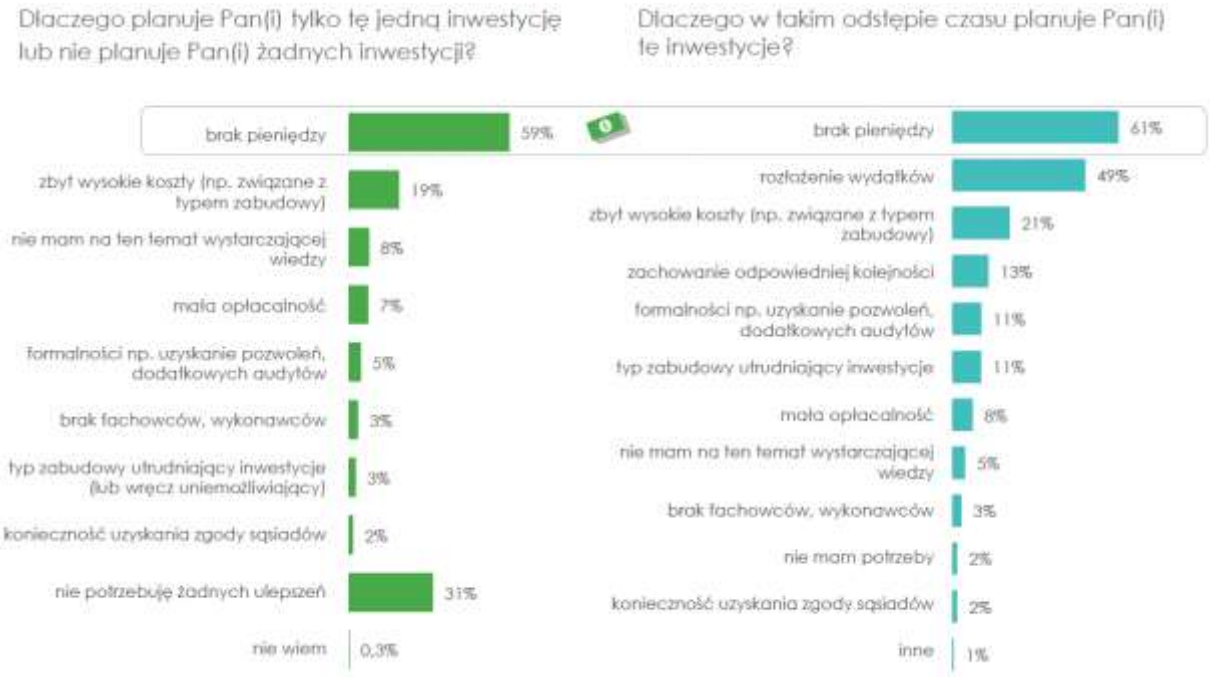
The high costs of investments in deep, comprehensive refurbishment of buildings continue to be a barrier to achieving good energy performance of buildings. There are considerable differences between the prices of standard building materials and materials characterised by good thermal insulation parameters. The same applies to the quality of construction works. There is a continued shortage of highly qualified and reliable staff.

As regards renovation of buildings, choosing the method, type, and scope of works in existing buildings poses a problem. Deep refurbishment of the entire building is required. Often, carrying out such a project is impossible without moving out the occupants. It should be noted that because of the ownership structure of Polish dwellings, in many cases successful completion of such all-comprising refurbishments may pose a serious problem.

A separate group are buildings registered as historical monuments and protected under a preservation order, in the case of which – because of important social or cultural considerations – not all works and technical solutions are feasible. On account of the historic nature and architectural values of such buildings, their investment costs increase.

The document entitled *Thermomodernisation of single-dwelling houses in Poland* (Termomodernizacja domów jednorodzinnych w Polsce), prepared for the National Fund for Environmental Protection and Water Management, names the following barriers to the undertaking of works aimed at improving the energy performance of buildings (results based on statistical surveys carried out for the purposes of this study are presented by Figures 13, 14 and 15):

Figure 13

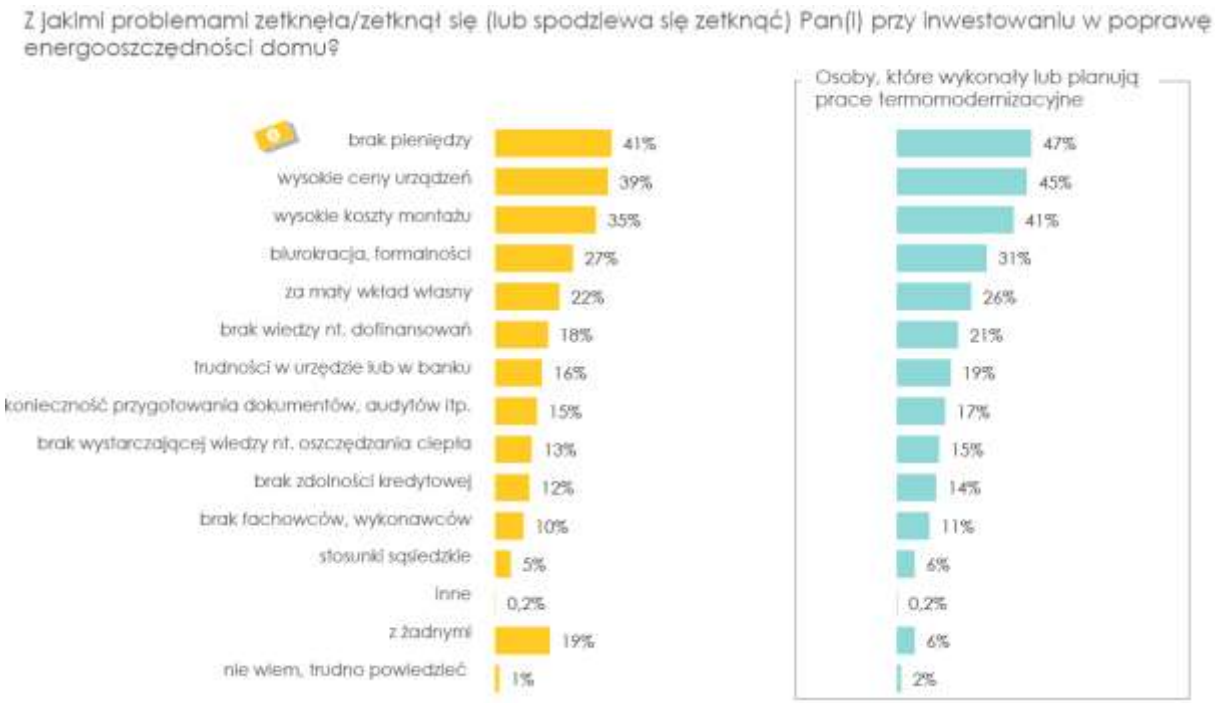


Source: National Fund for Environmental Protection and Water Management

Dlaczego planuje Pan(i) tylko tę jedną inwestycję lub nie planuje Pan(i) żadnych inwestycji?	Why do you plan only this specific investment or why don't you plan any other investments?
brak pieniędzy	I cannot afford it
zbyt wysokie koszty (np. związane z typem zabudowy)	costs are too high (e.g. in connection with building type)
nie mam na ten temat wystarczającej wiedzy	I do not have sufficient expertise
mała opłacalność	low cost-effectiveness
formalności np. uzyskanie pozwoleń, dodatkowych audytów	formalities, e.g. permits, additional audits
brak fachowców, wykonawców	non-availability of specialists or contractors
typ zabudowy utrudniający inwestycje (lub wręcz uniemożliwiający)	type of building hinders investment (or even prevents it)
konieczność uzyskania zgody sąsiadów	need to obtain neighbours' consent
nie potrzebuję żadnych ulepszeń	I do not need any improvements
nie wiem	I do not know
Dlaczego w takim odstępie czasu planuje Pan(i) te inwestycje?	Why do you plan these investments at such time intervals?
brak pieniędzy	I cannot afford it
rozłożenie wydatków	spread of expenses
zbyt wysokie koszty (np. związane z typem zabudowy)	costs are too high (e.g. in connection with building type)
zachowanie odpowiedniej kolejności	to follow the right order
formalności np. uzyskanie pozwoleń, dodatkowych audytów	formalities, e.g. permits, additional audits
typ zabudowy utrudniający inwestycje	type of building hinders investment
mata opłacalność	low cost-effectiveness
nie mam na ten temat wystarczającej wiedzy	I do not have sufficient expertise
brak fachowców, wykonawców	non-availability of specialists or contractors
nie mam potrzeby	there is no need

konieczność uzyskania zgody sąsiadów	need to obtain neighbours' consent
inne	other

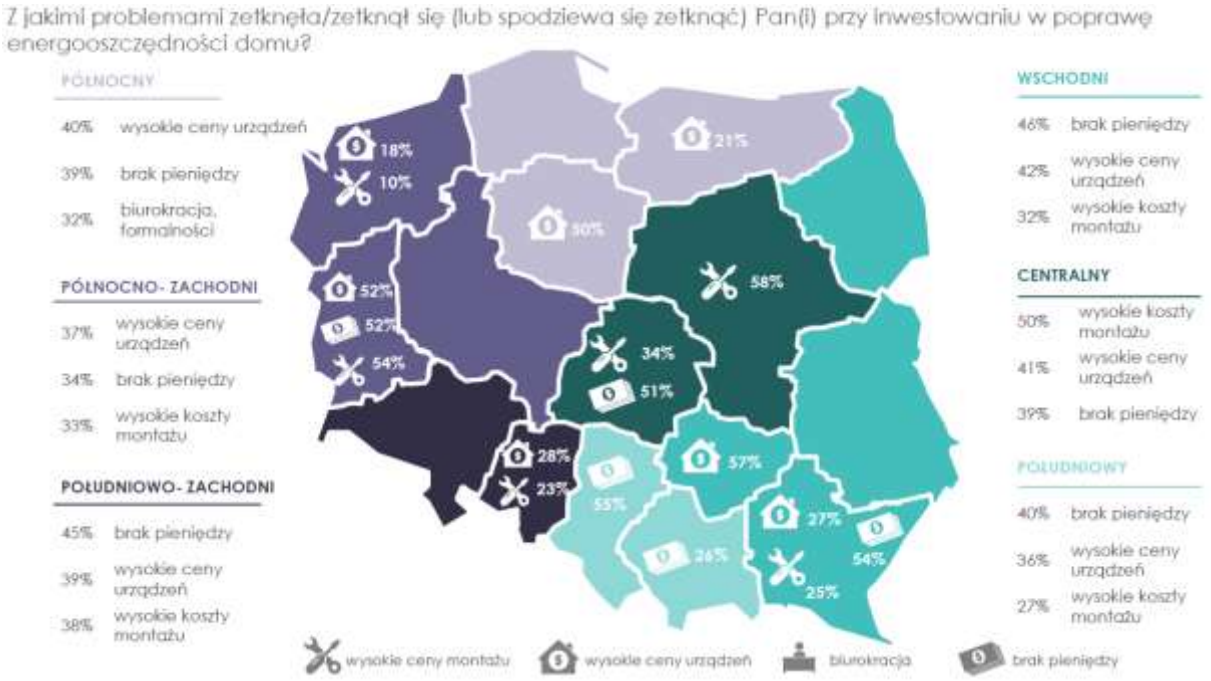
Figure 14



Source: National Fund for Environmental Protection and Water Management

Z jakimi problemami zetknęła/zetknął się (lub spodziewa się zetknąć) Pan(i) przy inwestowaniu w poprawę energooszczędności domu?	What problems have you encountered (or expect to encounter) when investing in improving the energy efficiency of your home?
brak pieniędzy	I cannot afford it
wysokie ceny urządzeń	high equipment prices
wysokie koszty montażu	high assembly costs
biurokracja, formalności	bureaucracy, formalities
za mały wkład własny	own contribution too low
brak wiedzy nt. dofinansowań	no knowledge about co-funding
trudności w urzędzie lub w banku	difficulties at the office or in the bank
konieczność przygotowania dokumentów, audytów itp.	need to prepare documents, audits, etc.
brak wystarczającej wiedzy nt. oszczędzania ciepła	lack of sufficient knowledge on how to save heat
brak zdolności kredytowej	no creditworthiness
brak fachowców, wykonawców	non-availability of specialists or contractors
stosunki sąsiedzkie	relations with neighbours
inne	other
z żadnymi	no problems
nie wiem, trudno powiedzieć	I do not know, hard to say
Osoby, które wykonały lub planują prace termomodernizacyjne	Persons who have completed or plan to carry out thermomodernisation work

Figure 15



Source: National Fund for Environmental Protection and Water Management

Z jakimi problemami zetknęła/zetknął się (lub spodziewa się zetknąć) Pan (i) przy inwestowaniu w poprawę energooszczędności domu?	What problems have you encountered (or expect to encounter) when investing in improving the energy efficiency of your home?
PÓŁNOCNY	NORTHERN
wysokie ceny urządzeń	high equipment prices
brak pieniędzy	I cannot afford it
biurokracja, formalności	bureaucracy, formalities
PÓŁNOCNO-ZACHODNI	NORTH-WESTERN
wysokie ceny urządzeń	high equipment prices
brak pieniędzy	I cannot afford it
wysokie koszty montażu	high assembly costs
POŁUDNIOWO- ZACHODNI	SOUTH-WESTERN
brak pieniędzy	I cannot afford it
wysokie ceny urządzeń	high equipment prices
wysokie koszty montażu	high assembly costs
WSCHODNI	EASTERN
brak pieniędzy	I cannot afford it
wysokie ceny urządzeń	high equipment prices
wysokie koszty montażu	high assembly costs
CENTRALNY	CENTRAL
wysokie koszty montażu	high assembly costs
wysokie ceny urządzeń	high equipment prices
brak pieniędzy	I cannot afford it
POŁUDNIOWY	SOUTHERN
brak pieniędzy	I cannot afford it
wysokie ceny urządzeń	high equipment prices
wysokie koszty montażu	high assembly costs

The expert report entitled *Measures to improve energy efficiency in the construction sector* (Środki poprawy efektywności energetycznej w budownictwie), prepared for the Ministry of Infrastructure and Construction in December 2016, analyses, *inter alia*, the practicability of using energy efficiency improvement measures in buildings depending on their intended use, including the introduction of innovative technologies, also in the field of renewable energy sources. The conclusions of the report will provide valuable input for the future policy related to the renovation of buildings and improving their energy performance.

3.5 Perspectives for the future

As is emphasised in this document, in the context of better regulation, the current Regulation of the Minister of Infrastructure of 12 April 2002 *on the technical conditions to be met by buildings and their siting* provides for gradual tightening of the requirements until 2021. This provides an incentive for achieving better parameters and using and developing new, alternative construction practices in the field discussed here.

Even though the accessibility of funds for measures improving the energy efficiency of existing building stock should be assessed positively, there is still much room for improvement and development. At the same time, support for the coming years has been secured from the above sources of financing. In addition to evaluating the activities pursued and making general summaries, efforts should always be taken to simplify the application procedures and to raise people's awareness of options for receiving financial support, especially at the local level. Interest of the private sector in loans for the area in question can be stimulated by providing objective, credible and standardised information about the term of repayment or payback period. In the area discussed here, endeavours must be made to overcome the market failures which continue to cause considerable hindrance to improving energy efficiency of buildings. The cost of investments and payback period are still considered to be a key problem.

In the future, efforts should focus on raising public awareness (both among building owners and users, but also specialists from the financial and construction sectors), providing reliable information about energy savings and broad-ranging benefits, primarily financial ones, offered by measures aimed at improving the condition of existing building stock, as well as on developing appropriate standards and methods for monitoring ongoing works and their outcomes.

In the years to come, the system of intervention in the field of energy efficiency should include at least:

- a coherent set of indicators based on the requirements of the Europe 2020 strategy, the requirements of the energy and climate package governing the rules for structural fund spending in 2014-2020, and based on this, a uniform statistical, reporting and monitoring system;
- basing energy efficiency interventions on energy audits and enforcing the requirement to conduct a full audit at least before and after intervention;
- requiring that interventions related to energy efficiency of buildings should be based on deep thermomodernisation,
- structuring the support framework in such a way as to implement the energy and climate package through structural funding,
- structuring the building energy efficiency funding system in such a way as to maximise the creation of new, sustainable jobs, and linking European Social Fund intervention with this objective;
- including activities related to the energy efficiency of buildings as a horizontal requirement for other Structural Funds interventions at the national and regional levels, e.g. revitalisation, integrated urban investments;
- using appropriate intervention tools, often hybrid ones (combining reimbursable instruments and grants) subject to state aid rules;
- structuring national interventions in a way making them complementary to structural funding in order to avoid the crowding out effect at the level of public intervention itself and not to affect competitiveness on the private intervention market;
- building a multi-level education and expert support system for all entities involved in the system and structuring adequate technical assistance measures for this purpose. This system should mitigate all existing external factors in order to overcome prevailing market failures.

The above challenges associated with the implementation of measures in the area of energy efficiency of buildings require strong integration and coordination. As is indicated by experience ensuing from the developments on the market for energy efficiency of buildings, the most effective – and often the only feasible – solution when creating a completely new intervention market, is to base activities on the best institution, which is most appropriate for this purpose in competence terms, and to require that the institution pursue educational activities and create a competence building system at the regional and local levels. This must also be supported by an obligation for it to effect such legislative amendments as to initiate the structuring of the system

and ensure sufficient financial resources for preparatory and analytical activities, and then educational and information activities.

Previous effects of the current support system for thermomodernisation, which mainly concern multi-dwelling residential buildings (e.g. by funds of the Thermomodernisation and Repairs Fund – for its results see below), but also public buildings (GIS, Structural Funds, National Fund for Environmental Protection, Provincial Environmental Protection Funds) prove that the direction of activities set is right. However, consideration should be given to adjusting the assumptions so that the support schemes can benefit owners of single-dwelling houses to a larger extent.

As regards support dedicated for single-dwelling houses, particular emphasis should be placed on achieving future broad-ranging benefits, as well as on adopting stricter requirements on the post-retrofit building standard.

Clearly, focusing on the promotion of thermomodernisation of single-dwelling buildings can be a particularly effective stimulus enhancing local development through growth of the labour market in the regions with the greatest thermomodernisation needs.

Table 34 and 35. Results of the activity of the Thermomodernisation and Repairs Fund

Period Item	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Number of applications filed	144	303	191	325	890	1 413	1 871	3 214	3 314	2 859
Number of bonuses granted	71	235	157	286	668	1 152	1 947	1 812	4 201	2 759
Amount of bonuses granted (PLN ’000)	1 061	3 859	4 014	13 042	30 304	58 554	115 737	110 033	247 860	170 062
Number of bonuses paid	3	38	107	244	499	968	1 536	1 781	2 021	3 213
Amount of bonuses paid (PLN ’000)	19	482	2 578	8 230	19 597	43 084	77 863	106 479	116 669	187 396

Period	2009	2010	2011	2012	2013	2014	2015	2016
Number of applications filed	**3 463**	**3 813**	**3 804**	**4 251**	**1 501**	**3 688**	**3 019**	**2 811**
Thermomodernisation bonus	3 363	3 168	3 007	3 328	944	2 697	2 106	1 739
Repair bonus	99	587	675	766	343	786	709	768
Compensation bonus	1	58	122	157	214	205	204	304
Number of bonuses granted	**3 332**	**3 369**	**4 135**	**3 603**	**1 348**	**3 398**	**3 160**	**2 630**
Thermomodernisation bonus	3 267	2 823	3 412	2 859	869	2 472	2 271	1 697
Repair bonus	65	520	657	658	313	741	691	687
Compensation bonus	0	26	66	86	166	185	198	246
Number of bonuses granted (PLN ’000)	**196 717**	**161 691**	**204 909**	**185 980**	**85 047**	**185 528**	**178 192**	**152 292**

Thermomodernisation bonus	193 584	133 384	162 663	139 419	47 929	131 240	117 708	88 319
Repair bonus	3 133	25 756	31 473	31 793	14 195	31 390	29 311	29 201
Compensation bonus	0	2 551	10 773	14 768	22 923	22 898	31 173	34 772
Number of bonuses paid	**3 095**	**3 450**	**3 442**	**3 627**	**3 076**	**1 989**	**2 830**	**2 787**
Thermomodernisation bonus	3 086	3 302	2 969	2 975	2 333	1 381	2 030	1 980
Repair bonus	9	147	434	595	624	431	627	639
Compensation bonus	0	1	39	57	119	177	173	168
Number of bonuses paid (PLN ʾ000)	**178 281**	**170 402**	**160 773**	**174 511**	**160 433**	**107 672**	**148 911**	**147 896**
Thermomodernisation bonus	177 954	164 429	138 859	138 284	116 400	67 604	100 138	95 664
Repair bonus	327	5 858	17 893	27 581	27 938	19 059	25 561	27 798
Compensation bonus	0	115	4 021	8 646	16 095	21 009	23 212	24 434

Source: Bank Gospodarstwa Krajowego

Based on research carried out by PricewaterhouseCoopers (PwC) as part of the 2013 final report, e.g. *Analysis and assessment of the possibilities of integrating energy efficiency activities, taking into account renewable energy sources, including energy from municipal waste and sewage sludge* (Analiza i ocena możliwości zintegrowania działań w obszarze efektywności energetycznej z uwzględnieniem odnawialnych źródeł energii, w tym z odpadów komunalnych i osadów ściekowych), the structure of thermomodernisation project financing is as in Figure 16. The structure of RES-only project financing is presented in Figure 17.

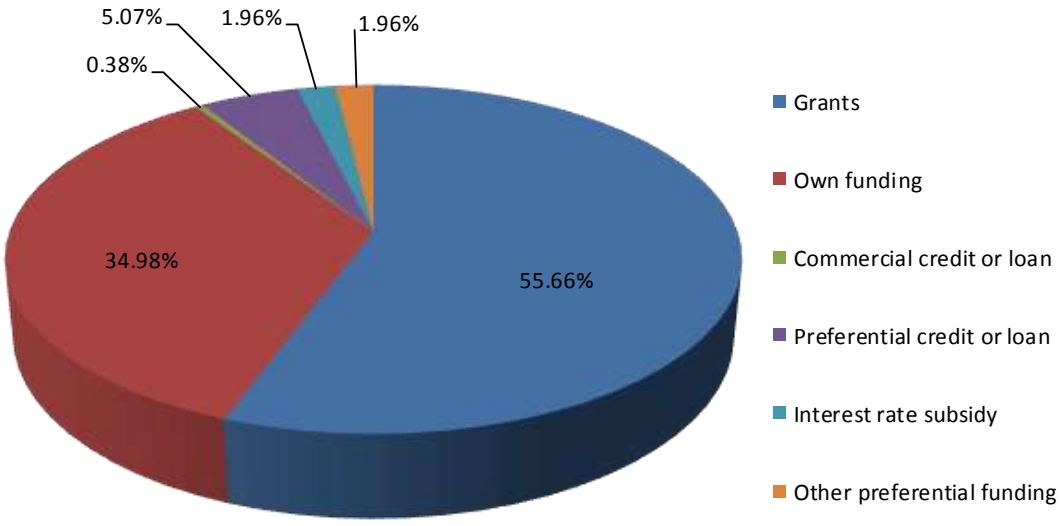


Figure 16. The structure of thermomodernisation project financing

Source: Analysis and assessment of the possibilities of integrating energy efficiency measures, taking into account renewable energy sources, including energy from municipal waste and sewage sludge, final report prepared by PwC, 2013.

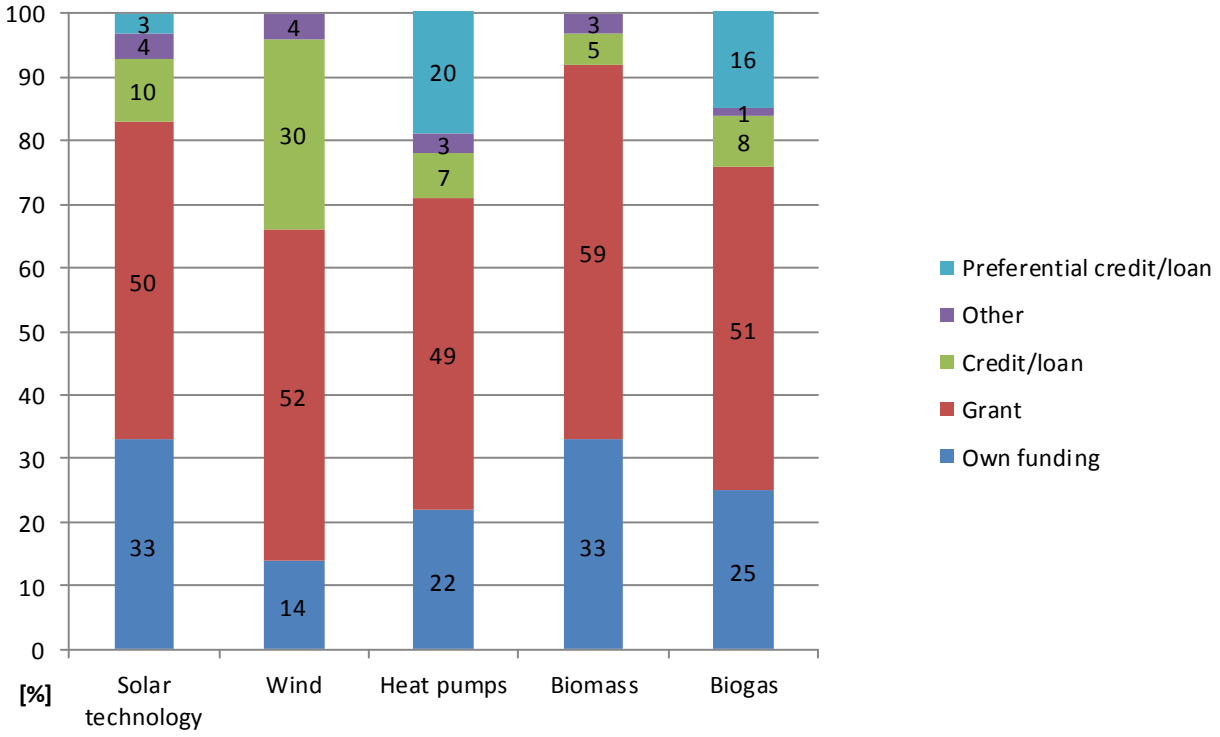
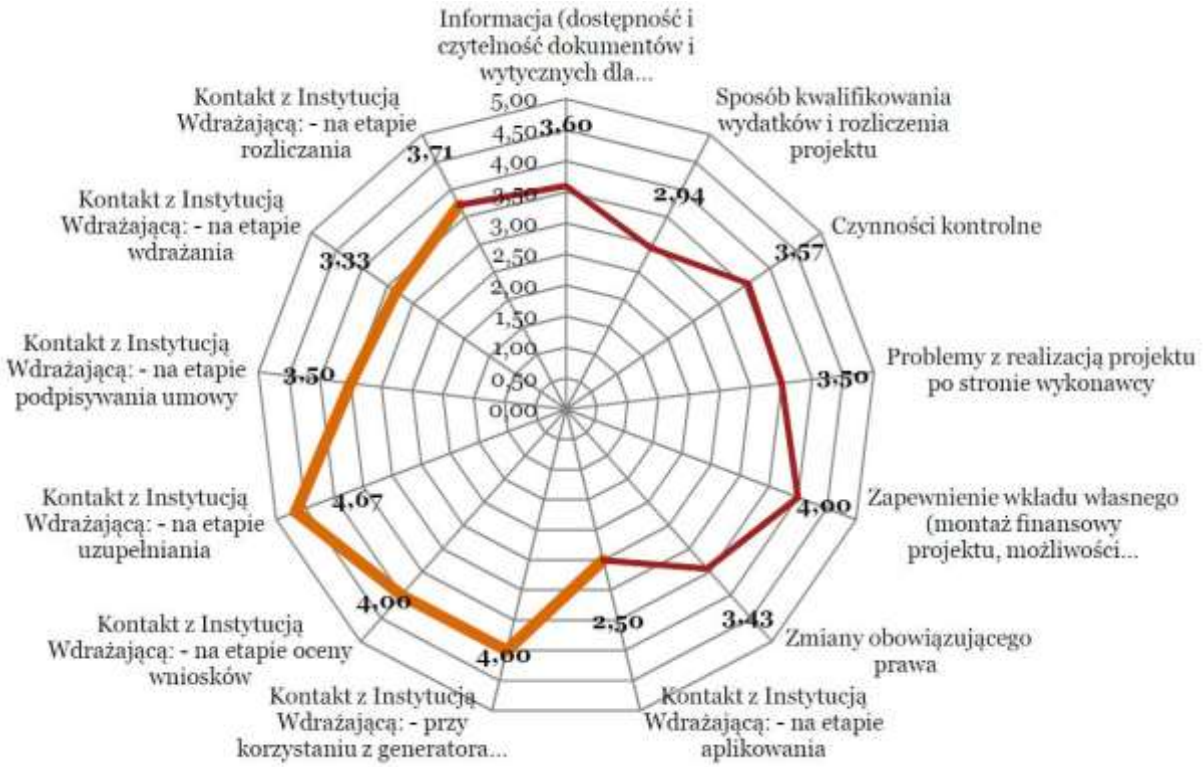


Figure 17. The structure of RES-only project financing

Source: Analysis and assessment of the possibilities of integrating energy efficiency measures, taking into account renewable energy sources, including energy from municipal waste and sewage sludge, final report prepared by PwC, 2013.

As is shown by the above graphs, the structure building thermomodernisation and RES financing with domestic and foreign public funds also includes reimbursable solutions – loans and hybrid instruments – a grant component within a reimbursable funding scheme (interest subsidy). A hybrid instrument which combines a grant component and reimbursable funding (loan) is a model example, and making a wider use of similar solutions in the future seems reasonable. Searching for hybrid solutions to replace grant-only interventions demonstrates how to mobilise the potential of the private sector in practice, so that each Polish złoty spent from public funds contributes to the mobilisation of the largest possible funds by private investors and supports the creation and maintenance of jobs. At the same time, the method for the settlement of support provided for the handling of thermomodernisation measures will be improved.

Research by PwC (Figure 18) has revealed certain problems with the individual components of the implementation or settlement of support extended under the Operational Programme Infrastructure and Environment (OPI&E) – scale 1-5, where 5 indicates the greatest problem.



Kontakt z Instytucją Wdrażającą: - na etapie rozliczania	Contact with the Implementing Body at settlement stage
Kontakt z Instytucją Wdrażającą: - na etapie wdrażania	Contact with the Implementing Body at implementation stage
Kontakt z Instytucją Wdrażającą: - na etapie podpisywania umowy	Contact with the Implementing Body at agreement signature stage
Kontakt z Instytucją Wdrażającą: - na etapie uzupełniania	Contact with the Implementing Body at dossier complementation stage
Kontakt z Instytucją Wdrażającą: - na etapie oceny wniosków	Contact with the Implementing Body at application evaluation stage
Kontakt z Instytucja Wdrażającą: - przy korzystaniu z generatora...	Contact with the Implementing Body when using the online Generator tool...
Kontakt z Instytucją Wdrażającą: - na etapie aplikowania	Contact with the Implementing Body at the application stage
Zmiany obowiązującego prawa	Amendments of legislation
Zapewnienie wkładu własnego (montaż finansowy projektu, możliwości...	Ensuring own contribution (project financial engineering, possibilities...
Problemy z realizacją projektu po stronie wykonawcy	Problems with project implementation on the contractor’s part
Czynności kontrolne	Checks and controls

Sposób kwalifikowania wydatków i rozliczenia projektu	The way expenditure is qualified and project is settled
Informacja (dostępność i czytelność dokumentów i wytycznych dla...	Information (availability and readability of documents and guidelines for...

Figure 18. Problems with individual elements of the implementation or settlement of OPI&E support

The results point to specific areas which might have caused problems to thermomodernisation investors in recent years. It should be observed here that, in the context of the above studies, the most problematic areas have already been improved or are being remedied. However, it should be remembered that proper structuring of interventions in the field of energy efficiency of buildings is crucial, and cannot lead to a monopoly of the public sector for such interventions. This is unacceptable from the perspective of state aid rules. At the same time, the EU highlights the potential of measures improving the energy efficiency of buildings for stimulating economic growth and creating sustainable jobs. For these reasons, the intervention framework should support the growth of the private energy efficiency sector and gradually limit public intervention in proportion to the growth of the private sector's capacity to perform tasks on its own.

These goals are pursued, *inter alia*, through:

- a well-planned system for ex-ante monitoring and verification of interventions with anticipated phasing-down of support intensity;
- giving preference to private sector beneficiaries;
- inclusion of the private sector, e.g. banks, into the Financial Instrument framework;
- supporting solutions which drive entrepreneurship,
- giving preference to and activation of the private sector as a provider of services necessary to implement interventions (energy audits, training and communication schemes, monitoring and reporting processes).

A crucial role for creating integrated support schemes will be played by the inclusion of what is referred to as soft project components, such as training, workshops and meetings to be used for on-going exchange of information necessary for the practical implementation of such an instrument and ensuring its efficient operation. Structuring promotional and educational support schemes for interventions which are new on the market, in particular integrated interventions, requires providing support through technical assistance to all system participants, as well as choosing appropriate tools for furthering the competence of both the bodies which intermediate in fund spending and the beneficiaries of assistance.

The projects selected must be such as to lead to the greatest energy savings in light of available resources, the timing, and characteristics of the building, as well as the processes and networks underlying the project. The choice of specific technologies should not be included in the criteria established for support schemes in the field of energy efficiency of buildings. Technologies come into play only at the energy audit stage. As a result, including a list of technologies under building energy-efficiency support schemes should be avoided because this would, in fact, be counterproductive for attaining the highest efficiency under individual projects, which is one of the underlying assumptions. Each project may have a slightly different context in terms of the technical condition, ownership status, and structure of funding, and imposing a closed list of criteria at the scheme level would limit access to financing and thus the effectiveness of the scheme as a whole.

Future projects working towards improved energy efficiency of buildings may take the form of concrete interventions selected as the most effective ones through energy auditing, for example, cogeneration installations, solar collectors, and smart metering for installed components and the rest of the system in a specific building based on interaction with consumers and demand side management mechanisms (differentiated tariffs, price signals, etc.). In order to develop appropriate financing parameters, at least the economic viability of these projects and the payback period must be estimated.

However, decisions on the amount of reimbursable funding cannot be based on financial aspects alone. In many cases, in the initial, pilot period, the intensity of support may be increased compared to what follows from purely financial aspects, such as the calculated financial gap, to promote solutions representing a given technology. Such decisions should be made on the basis of cost-benefit analyses (CBAs) or methods for calculating the economic rate of return (ERR).

It should also be remembered that actions in the field of improving energy efficiency of buildings have a certain rate of return since they generate a financial gain as a result of reducing the costs of energy consumption. This must always be taken into account when calculating the overall viability of a project.

The rate of return is also indicative of the general potential for energy efficiency projects to be financed by reimbursable funding, regardless of the solutions and technologies used.

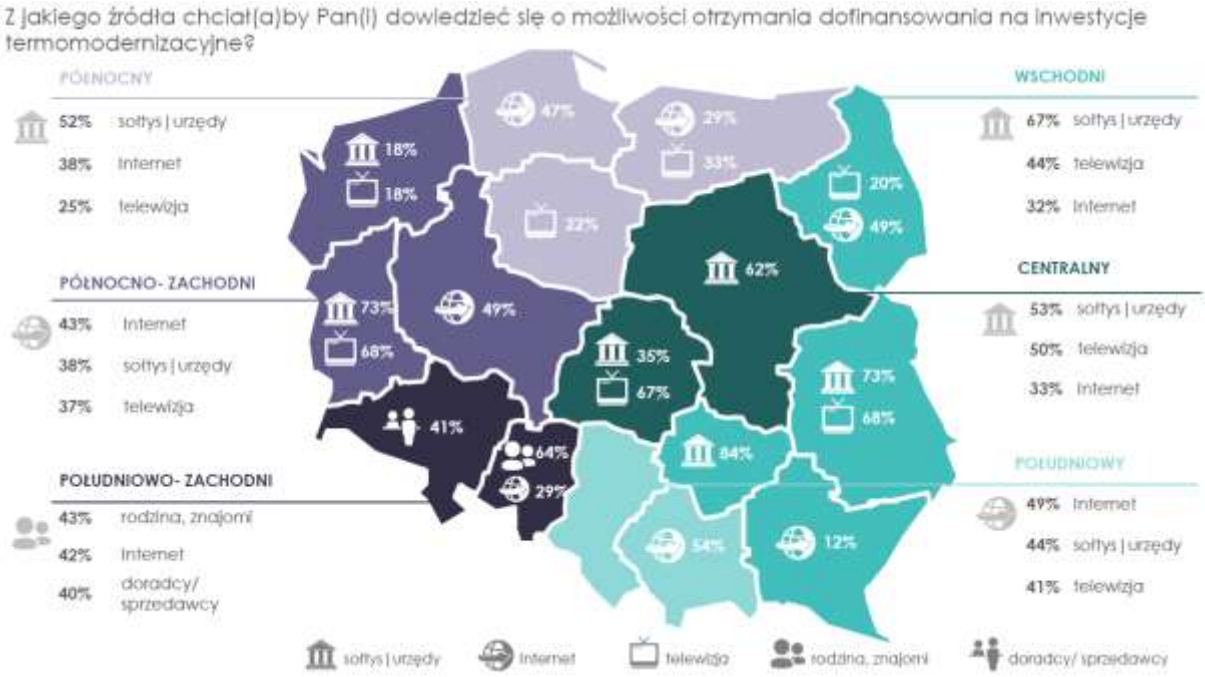
In the light of information included in the document *Thermomodernisation of single-dwelling houses in Poland* (Termomodernizacja domów jednorodzinnych w Polsce), prepared for the National Fund for Environmental Protection and Water Management, future assistance programmes related to improving the energy performance of buildings will be based on the following assumptions:

- Given that Poles do not proactively look for information about programmes supporting the thermomodernisation of houses, and small proportion of them are planning future thermomodernisation works, the aid institution must undertake active promotional and educational activities.
- The mass media, the internet and television, should be the contemplated channels since they can be employed for reaching wide audiences. In addition, self-government authorities should be a central pillar of support for the programmes themselves and promoting them.
- It is advisable that detailed information about schemes should be provided at the local level (e.g. in public offices and at consultation points), and the media be used only for spreading the key messages so as to evoke interest among potential beneficiaries.
- Regardless of the choice of the institution which will distribute the co-funding (dedicated funds, municipal/city offices, commercial banks, cooperative banks), building trust in this institution and its professional image in the context of thermomodernisation will be of crucial importance.
- The financial aspect is a significant obstacle to the thermomodernisation of a house, but also, once financial resources are available, it is an important motivator for undertaking thermomodernisation actions. Therefore, the aid institution should emphasise that the programmes offered respond to these challenges.
- Educating potential beneficiaries. The awareness of environmental solutions among the Poles is low. This is evidenced by the fact that people undertake thermomodernisation works even before ensuring that certain necessary conditions have been met (for example they replace the heat source without performing beforehand other necessary works to guarantee that the investment in the new heat source will be efficient).
- Materials promoting available schemes should respond to the motivation of the majority of the Polish public – money savings, improved living comfort in the dwelling, or health aspects.
- Education and promotion by highlighting programme benefits is not the only challenge. Most Poles assess the condition of their houses as at least sufficient, which may inhibit their motivation to undertake thermomodernisation actions. Hence the huge importance to building the Poles' awareness of the need to take pro-ecological actions and of the criteria for ensuring their quality.

– As a key message, the schemes should include information about the grant/financial support available to the beneficiary, in other words, about the financial added value, understood as an opportunity to receive bonus funds which does not have to be returned.
– There is a high potential for advice in Poland – availability of support for the preparation of the plan and technical documentation of improvements is considered as important.

At the same time, future assistance programmes aimed at improving the energy performance of buildings should take into account the preferences and expectations of Polish citizens. The preferences, including those related to obtaining information about available programmes and incentives to improve the energy performance of buildings, were researched as part of the document *Thermomodernisation of single-dwelling houses in Poland* (results based on statistical surveys carried out for the purposes of the document are shown in Figures 19, 20 and 21 below).

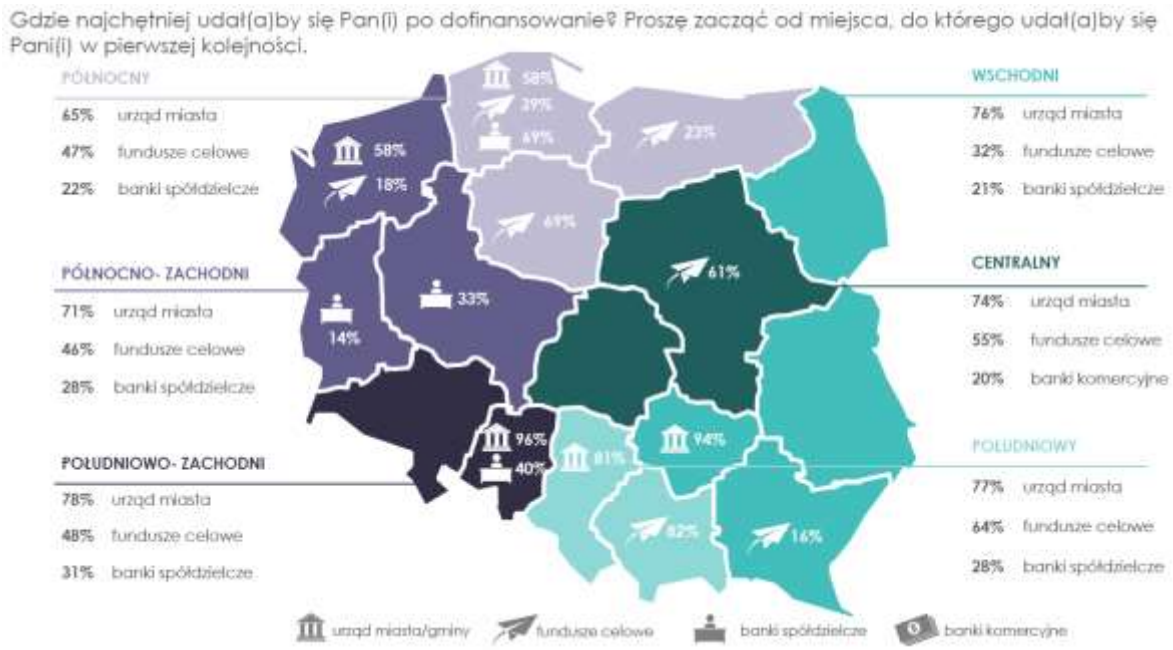
Figures: 19, 20 and 21



Z jakiego źródła chciał(a)by Pan(i) dowiedzieć się o możliwości otrzymania dofinansowania na inwestycje termomodernizacyjne?	From what source would you like to learn about availability of support for thermomodernisation investments?
PÓŁNOCNY	NORTHERN
PÓŁNOCNO- ZACHODNI	NORTH-WESTERN
POŁUDNIOWO- ZACHODNI	SOUTH-WESTERN
WSCHODNI	EASTERN
CENTRALNY	CENTRAL

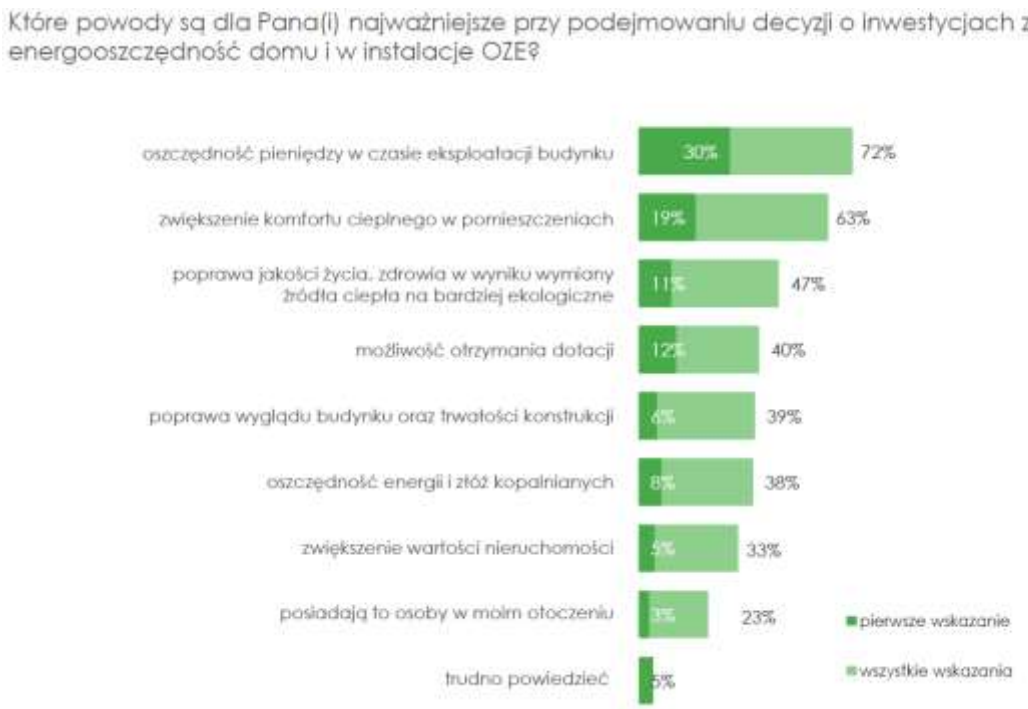
POŁUDNIOWY	SOUTHERN
sołtys | urzędy	sołtys (village administrator) | offices
Internet	Internet
telewizja	television
rodzina, znajomi	family, friends
doradcy/ sprzedawcy	advisers/ vendors

Source: National Fund for Environmental Protection and Water Management



Gdzie najchętniej udał(a)by się Pan(i) po dofinansowanie? Proszę zacząć od miejsca, do którego udał(a)by się Pani(i) w pierwszej kolejności.	Where would you be most willing to go for co-funding? Please start from the place you would go to first.
PÓŁNOCNY	NORTHERN
PÓŁNOCNO- ZACHODNI	NORTH-WESTERN
POŁUDNIOWO- ZACHODNI	SOUTH-WESTERN
WSCHODNI	EASTERN
CENTRALNY	CENTRAL
POŁUDNIOWY	SOUTHERN
urząd miasta/gminy	city office/municipal office
fundusze celowe	dedicated funds
banki spółdzielcze	cooperative banks
banki komercyjne	commercial banks

Source: National Fund for Environmental Protection and Water Management



Które powody są dla Pana(i) najważniejsze przy podejmowaniu decyzji o inwestycjach zwiększających energooszczędność domu i w instalacje OZE?	Please indicate your key motivation when deciding on investments improving the energy efficiency of your home or in RES installations?
oszczędność pieniędzy w czasie eksploatacji budynku	money savings when using the building
zwiększenie komfortu cieplnego w pomieszczeniach	improving indoor thermal comfort
poprawa jakości życia, zdrowia w wyniku wymiany źródła ciepła na bardziej ekologiczne	improving the quality of life and health by replacing the heat source with a more environmentally-friendly one
możliwość otrzymania dotacji	opportunity to receive a grant
poprawa wyglądu budynku oraz trwałości konstrukcji	improving the appearance of the building and durability of its structure
oszczędność energii i złóż kopalnianych	energy and mine deposit savings
zwiększenie wartości nieruchomości	increasing the value of the property
posiadają to osoby w moim otoczeniu	people around me have it
trudno powiedzieć	difficult to say
pierwsze wskazanie	first indicated
wszystkie wskazania	all indications

4. Benefits, including estimates of anticipated energy savings

The benefits of the refurbishment of a building can be both direct and indirect. Unfortunately, investors (building owners, administrators of buildings owned by private companies and the public sector) often underestimate the potential indirect benefits of the thermomodernisation of a

building (improvement of building use conditions, better air quality, etc.), looking exclusively at the direct benefits (reduction of the consumption of energy or energy carrier).

In Poland, extensive work related to the improvement of energy performance is under way. Its financing includes support extended, *inter alia*, through Bank Gospodarstwa Krajowego (Thermomodernisation and Repairs Fund), and NFOŚiGW (domestic funds, EU funding, EEA and Norway Grants). To date, support for investments in the sector of the thermomodernisation of residential buildings (and public buildings) granted under the Thermomodernisation and Repairs Fund alone, worth PLN 2 055 000 000, has produced the savings shown in Figure 22.

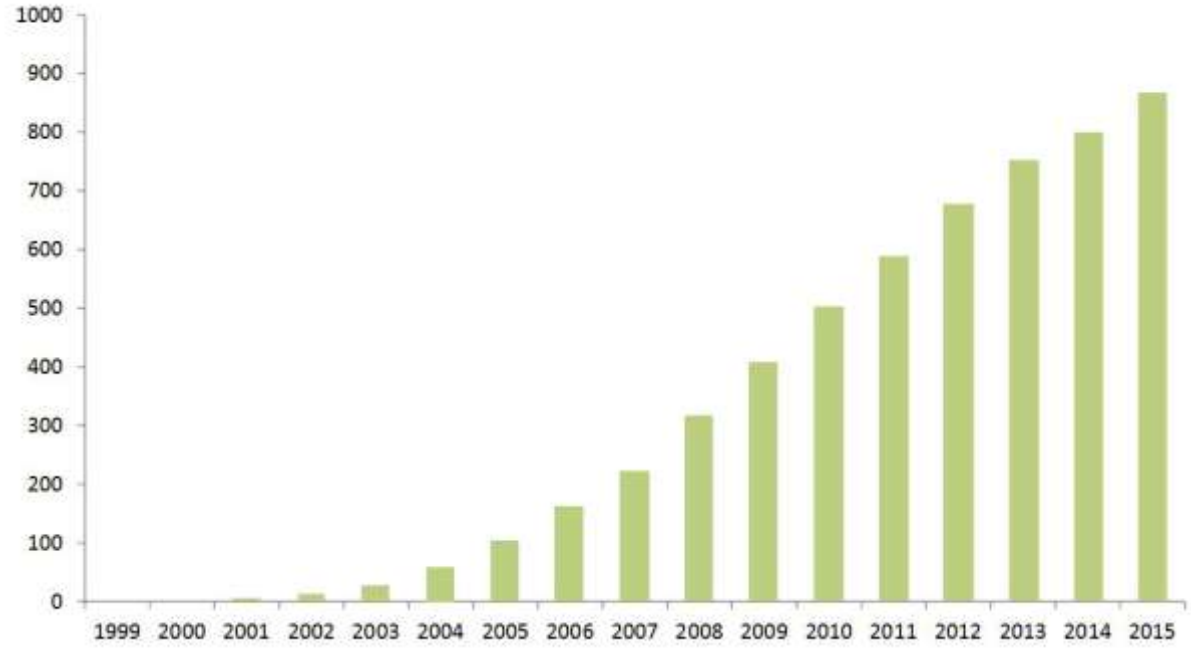


Figure 22. Savings produced by support for investments under the Thermomodernisation and Repairs Fund (cumulative savings in PLN million)
Source: Bank Gospodarstwa Krajowego

It should be noted that energy savings will accumulate over time and will soon exceed the level of expenditure incurred for completed refurbishments.

Direct benefits

The thermomodernisation of buildings does not only lead to reducing the cost of building use, but also increases the value of buildings and residential premises in these buildings. Thermomodernisation of buildings involving a basic scope of works (insulation of the envelope, replacement of the heat source, and insulation of installations) reduces the demand for energy by an average of 30% to 50%, which directly translates into reduced building maintenance costs.

Thermomodernisation has a direct positive effect on the value of dwellings. Depending on the scope of refurbishment work, this ranges between 5% and 10% of the initial value of the dwelling. A higher growth in property prices than that referred to above is observe for the oldest

buildings (with the lowest initial technical parameters) and those located in towns with a population below 50 000.

Thermomodernisation actions contribute to reducing the risk of energy poverty and improve the building use conditions.

Renovation of buildings should ensure proper temperature, suitable humidity, and efficient ventilation, which has an indirect effect on reducing the incidence of such diseases as asthma, bronchitis, allergies, and upper-respiratory tract diseases.

As described above, thermomodernisation reduces the consumption of energy carriers, which is shown in table 36.

Table 36. Decrease in the consumption of energy carriers

Characteristics of the amount of energy carriers used per 1 dwelling occupant				
Household group	Unit of measurement	2009	2012	2015
		Arithmetic average	Arithmetic average	Arithmetic average
Electricity				
All households	kWh/occupant	801.01	787.2	776.6
Households which do not use electricity for space heating		784.81	767.2	765.9
Households which do not use electricity for space heating nor for water heating		726.14	725.9	727.4
Households which only use electricity for space heating		1 744.2	1 734	1 503
District heating				
All households which use district heat for space heating	GJ/occupant	14.54	14.1	13.0
Households which use district heat for space heating, but not for water heating		21.65	14.7	10.8
Natural gas				
Households which use gas for space heating	m^3/occupant	525.7	440.7	483.07
Households which use gas only for water heating and cooking meals		145.09	146.5	110.86
Liquefied petroleum gas				
Households which use liquefied petroleum gas for space heating	kg/occupant	354.34	129.8	43.5
Fuel oil				
Households which use liquid oil for space heating	l/occupant	593.46	634.2	624.7
Hard coal				
Households which use hard coal for space heating	kg/occupant	942.52	920.1	880.0

Source: Main Statistical Office

As can be seen above, there is a noticeable downward trend in the consumption of energy carriers, and it is expected to continue in the years to come.

Indirect benefits

Thermomodernisation works, as well as the associated sale of materials, are VAT taxable (8% or 23%), which may generate additional revenue for the state. Investments in energy efficiency produce positive fiscal effects in the form of reduced government spending (e.g. unemployment benefits, social welfare payments, and costs of energy consumed by public buildings), as well as increased budget revenues (additional taxes), even though a drop in revenues resulting from the reduction of energy consumption can also be expected.

Thermomodernisation actions also create jobs. Notably, one newly created thermomodernisation-related job can indirectly help to create between two and four extra jobs needed in connection with support activities, such as production and transport (within the supply chain). This should significantly contribute to reducing the level of unemployment in the country. The needs for work force will include all levels of qualifications and expertise. As regards direct employment, there will be demand for new construction companies, new professionals with university education (such as architects and engineers), skilled workers (e.g. plumbers, electricians, and painters) and unskilled labour force.

Lower building maintenance costs should have a positive effect on the economic situation of the country, which would stimulate further thermomodernisation efforts both in the public and private sectors (snowball effect). The thus saved funds can also stimulate further investments in state-of-the-art solutions in the construction sector.

Scientific and research work will have a beneficial effect on the development, energy intensity, and competitiveness of industry. In the long term, such work can produce opportunities for exporting technologies and engineering solutions to other countries. Renovation and refurbishment of buildings would be conducive to the implementation of energy-saving solutions and technologies developed by domestic researchers. Importantly, potential success and using the developed solutions in practice can spark a positive impulse for further work in this area. Thus, thermomodernisation can become a positive stimulus for the development of research institutions and their research laboratories.

Improving the health of the population (but also providing better comfort for building occupants), which is one of the indirect results of thermomodernisation, is a very important benefit in broader terms. Spending money on healthcare (even in an indirect form) should be

treated as an investment which benefits society and individuals later on. The benefits of investments in the area of public health include:

- increased life expectancy;
- higher productivity of the professionally active population;
- lower costs for enterprises caused by employee absences due to illness;
- fewer employees on sick leaves;
- fewer people on disability pensions;
- higher earnings due to lower level of employee absence;
- increased GDP.

The effects of completed building renovations include reduced levels of pollutant emissions. Naturally, reducing energy consumption decreases the necessary levels of energy generation and the associated emissions. These benefits are important for society as a whole, but they can also encourage individual investors considering the refurbishment of a building.

Despite having large energy resources of its own, Poland is not completely independent of their imports. Secure supplies of crude oil and natural gas guarantee unhindered and stable development of the Polish economy. Thermomodernisation of buildings leading to a significant reduction in the total consumption of energy has a direct positive effect on the energy security of the country. At the same time, any refurbishment ventures should work towards better use of domestic energy resources by ensuring the most energy-efficient use of raw materials.

It should be emphasised that in the coming years energy efficiency should sought to be improved by using renewable energy, in particular such energy carriers as biomass and biogas. The use of biomass by agricultural biogas plants can produce significant benefits while providing energy for buildings. Most biogas plants are of the cogeneration type, i.e. they produce both electricity and heat, usually through high-efficiency cogeneration (over 75%). The share of renewable energy in gross final energy consumption is also relevant in the context of heat. Therefore, the commissioning of one cogeneration biogas plant with an electrical capacity of 1 MW translates into the production of as much as 16 GWh of renewable energy per year, which is achievable only in biogas or biomass installations.

The development of local agricultural biogas plants will help provide heat and electricity for buildings, especially in rural areas, where previously, for various reasons, no suitable installations or transmission networks have been available to ensure adequate access to electricity, heat, or gas. This mainly applies to single-dwelling houses which currently use fossil fuels as their source of electricity or heat.

According to the forecasts of the Ministry of Energy, by 2030, the domestic demand for primary energy will not change, remaining at approximately 102-103 Mtoe annually, to decrease by about 15% in the two following decades. Thus, the trends of demand for energy and economic growth will diverge, thanks to which Poland's GDP will increase by 160% in 2010-2050. This scenario will materialise on condition that energy efficiency, primarily in households and transport, improves significantly. This process will be made possible by improving the thermal efficiency of buildings achieved thanks to consistent thermomodernisation of existing residential and service building stock, as well as by tightening energy construction standards to be complied with by new investments.

A central role in reducing the demand of households and the service sector for electricity, and thus for primary energy carriers, will be played by increased efficiency of household appliances, electronics and lighting, required under growingly strict efficiency standards introduced across the EU. Likewise, the European policy will have a positive effect on the fuel efficiency in the European sector of road passenger and freight transport, which, along with the popularisation of hybrid cars in the second half of the period under analysis, will lead to a significant decrease in the demand for crude oil, while increasing the demand for services and transport as such.

The assumptions of the forecast are presented in tables 37-40.

Table 37. Forecast level and structure of domestic demand for primary energy carriers by fuel (Mtoe)

	2010	2015	2020	2025	2030	2035	2040	2045	2050
hard coal	43.0	36.9	35.5	32.8	31.3	30.1	29.9	27.1	24.4
lignite	11.6	14.3	13.0	11.9	9.1	2.5	2.6	2.2	2.1
crude oil	26.5	25.4	27.2	27.5	26.9	25.1	23.4	22.3	21.5
natural gas	12.8	14.1	15.2	15.3	15.2	16.1	16.1	15.8	15.5
RES	7.3	9.2	12.0	12.6	14.0	14.6	14.1	13.8	13.7
nuclear energy	0.0	0.0	0.0	2.8	5.6	10.8	10.9	10.6	10.3
other	0.6	0.3	0.4	0.4	0.4	0.4	0.4	0.4	0.4
total	101.8	100.2	103.2	103.3	102.5	99.5	97.3	92.2	87.9

Source: Ministry of Energy

Table 38. Forecast final energy demand by sector (Mtoe)

	2010	2015	2020	2025	2030	2035	2040	2045	2050
agriculture	3.8	3.2	2.8	2.4	2.3	2.1	2.0	1.9	1.7
industry, including construction	15.4	15.2	16.8	17.8	18.9	20.0	20.9	21.0	20.2
transport	17.6	18.9	20.9	21.4	21.0	19.5	17.9	16.6	16.0
services	8.5	8.6	8.7	8.2	8.1	7.9	7.5	7.5	7.2
households	21.1	21.4	22.4	22.5	22.0	21.0	19.9	18.7	17.6
total	66.5	67.2	71.6	72.3	72.3	70.4	68.2	65.7	62.7

Source: Ministry of Energy

Table 39. Forecast district heat production by fuel (PJ)

	2010	2015	2020	2025	2030	2035	2040	2045	2050
hard coal	280.6	274.5	278.1	278.0	270.1	258.4	245.1	237.5	221.4
lignite	6.4	7.0	7.7	7.9	7.9	7.8	7.5	0.1	0.1
petroleum products	6.7	6.1	6.0	5.9	5.7	5.6	5.5	5.4	5.3
natural gas	31.6	32.7	51.3	52.2	52.1	50.9	49.2	46.9	44.3
RES	12.4	28.3	24.8	26.6	27.7	28.3	28.5	28.1	27.1
other	7.1	9.1	10.1	10.6	11.1	11.6	12.1	12.1	11.5
total	344.8	357.8	378.0	381.3	374.7	362.7	347.9	330.0	309.8

Source: Ministry of Energy

Table 40. Number of dwellings by year of putting into use

2007	2008	2009	2010	2011	2012	2013	2014	2015
133 698	165189	160 002	135 835	130 954	152 904	145 136	143 166	147 711

Source: Main Statistical Office

Table 41 presents estimated savings based on the non-renewable primary energy factor (PEF) achieved as a result of refurbishment, by type of building and heat source.

Table 41. Estimated savings based on the non-renewable primary energy demand factor (PEF) achieved as a result of refurbishment by type of building and heat source

Existing buildings	Average value of the non-renewable primary energy demand factor (PEF) by heat source before refurbishment [kWh/(m^2·year)]		Average value of the non-renewable primary energy demand factor (PEF) by heat source after refurbishment [kWh/(m^2·year)]		Savings based on the non-renewable primary energy demand factor (PEF) [%]
Single-dwelling residential building	coal boiler/gas boiler	551.5	biomass boiler/ district heating/ ground source heat pump/ gas boiler	42.7-137.0	75-92
Multi-dwelling residential building	gas boiler/ coal boiler	366.2	biomass boiler/ district heating/ ground source heat pump/ gas boiler	34.8-104.3	72-90
Public building/ office building	coal boiler/gas boiler	318.2	district heating/ gas boiler	54.7-74.2	77-83