Annex
to Cabinet Resolution
No 23/2022
of 9 February 2022

Long-Term Building Renovation Strategy

Supporting renovation of the national building stock

Warsaw, February 2022

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Glossary of abbreviations

BGK	Bank Gospodarstwa Krajowego (the State Development Bank of Poland)
BIM	Building Information Modelling
BMS/HMS	Building/Home Management Systems
CH	Central heating
DHW	Domestic hot water
CEEB	Central Building Emissivity Inventory
DC	Direct current
DCV	Demand controlled ventilation
DPBT	Discounted payback time
DPS	Nursing home
DSM	Demand side management
DSR	Demand side response
EIB	European Investment Bank
ERDF	The European Regional Development Fund
FEF	Final energy
EEA	European Economic Area
PEF	Primary energy
EPC	Energy performance contracting
ESCO	Energy service company
CF	The Cohesion Fund
FTiR	Thermomodernisation and Renovation Fund
GUGiK	Główny Urząd Geodezji i Kartografii (The Main Office of Geodesy and Cartography)
GUS	Główny Urząd Statystyczny (Statistics Poland)
IRR	Internal rate of return
MA	Managing Authority
RLGU	Regional or local government unit(s)
KAPE	Krajowa Agencja Poszanowania Energii (The Polish Energy Conservation Agency)
NSS	National Smart Specialisation
OSS	One-stop-shop for investors
LCA	Lifecycle assessment
LCC	Lifecycle cost
LED	Light-emitting diode
MRiT	Ministerstwo Rozwoju i Technologii (The Ministry of Development and Technology)
SMEs	Small and medium-sized enterprises
NAPE	Narodowa Agencja Poszanowania Energii (The National Energy Conservation Agency)
NFOŚiGW	Narodowy Fundusz Ochrony Środowiska i Gospodarki Wodnej (The National Fund for Environmental Protection and Water Management)
NPV	Net present value
OGC	Organic gaseous carbon
OLED	Organic light-emitting diode
OSB	Oriented strand board
RES	Renewable energy sources
PARP	Polska Agencja Rozwoju Przedsiębiorczości (The Polish Agency for Enterprise Development)

PFR	Polski Fundusz Rozwoju (The Polish Development Fund)
LCEP	Low-carbon economy plan
IEOP	Infrastructure and Environment Operational Programme
SGOP	‘Smart Growth’ Operational Programme
LSERS	‘Low-Stack’ Emissions Reduction Programme
PPP	Public-private partnership
PV	Photovoltaics
PVT	Photovoltaic thermal collector
ROP	Regional Operational Programme
RIS	Regional Innovation Strategy
SNG	Synthetic natural gas
SPBT	Simple payback time
SPF	Seasonal performance factor
SRK	Sectoral Qualifications Framework
UDT	Urząd Dozoru Technicznego (Office of Technical Inspection)
EU	European Union
VIP	Vacuum insulated panels
WFOŚiGW	Provincial Fund for Environmental Protection and Water Management
IQS	Integrated Qualifications System

1.

Key concepts

For the purposes of this document, the definition of renovation consistent with Commission Recommendation 2019/786 of 8 May 2019 on building renovation[1] and with Communication of the European Commission COM (2020) 662 'A Renovation Wave for Europe – greening our buildings, creating jobs, improving lives'[2], hereinafter referred to as the Renovation Wave Communication, applies. This means that the various reasons why renovation actions often fail to produce improvement of energy efficiency of buildings are addressed. As the Commission estimates in the Renovation Wave Communication, although 11% of the EU existing building stock undergoes renovation each year, the weighted annual rate of renovations oriented to improving energy efficiency is only 1%. However, it is important to see the wider social, economic and environmental benefits which can be produced by investments into energy performance of buildings. Therefore this document focuses on the need to enhance the importance of energy-related considerations of renovation while addressing its other aspects.

In order to clearly present in-depth analyses and guidelines with regard to the improvement of energy efficiency of buildings, this document refers to the concept of 'energy renovation' or 'thermomodernisation' and distinguishes its various types. Given the great diversity of approaches and the lack of a uniform approach to the classification of types of energy renovation both at the national and EU levels, this document focuses on distinguishing the key features of energy renovation activities. Firstly, energy renovation is divided into 'shallow' and 'deep', with deep renovation meaning that, once specific actions are completed, the building will attain performance consistent with the applicable requirements of Regulation of the Minister of Infrastructure of 12 April 2002 on the technical conditions to be met by buildings and their siting[3], hereinafter also referred to as the Technical Conditions Regulation, so that it becomes a nearly zero-energy building. Secondly, this document distinguishes 'staged' energy renovation, whereby the activities which are to lead to the attainment of the building's targeted energy performance corresponding to the effects of deep renovation are spread over time.

Key terms used in the document:

- **Renovation of a building** – all renovation activities improving the value in use of the building. In particular, the above involves improving the energy efficiency of the building and reducing its emissivity, as well as actions which work towards improving the quality of life and health, adaptation to climate change, deployment of smart technologies or improving other aspects influencing the value in use of the building.
- **Energy renovation of a building** – thermomodernisation of a building (also referred to as energy retrofitting or refurbishment).
- **Deep energy renovation** – energy renovation meeting the energy savings and thermal insulation requirements set forth by the Technical Conditions Regulation[4], and if technically and economically feasible, such that leads to achieving values of the annual non-renewable primary energy demand factor lower than those specified by the Technical Conditions Regulation.
- **Shallow energy renovation** – one of the stages of energy renovation which contributes to producing a deep energy renovation effect in the future.
- **Staged energy renovation** – a process whereby successive energy renovation activities are spread over time and which can ultimately produce deep energy renovation, insofar as

[1] Commission Recommendation (EU) 2019/786 of 8 May 2019 on building renovation (link).

[2] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions – A Renovation Wave for Europe - greening our buildings, creating jobs, improving lives (COM(2020) 662 (link)).

[3] Journal of Laws 2019, item 1065, as amended.

[4] Section X and Annex 2.

technically and economically feasible. Staged energy renovation is planned with a view to attaining both the final effect and the milestones, which ensures consistency between the individual stages, prevents duplication of actions and associated costs from one stage to another, and allows any technical obstacles to the commencement of the next thermomodernisation stage to be avoided. The completion timeframes and the scope of the individual stages of work are adjusted to the financing available and the preferences and needs of building users/owners.

It should be emphasised that the above definitions do not constitute a legal definition, but are formulated for the purposes of this Strategy. However, support programmes may rely on the definitions adopted for the purposes of this document.

Where the document describes support programmes using other definitions (e.g. comprehensive deep energy renovation), they are given in the description of the relevant instrument.

Summary

This Long-Term Building Renovation Strategy identifies the actions necessary to ensure high energy efficiency and low emission of the private and public building stock in Poland by 2050. The recommended renovation scenario and guidelines on how to support building renovation in Poland presented in the Strategy will be conducive to a cost-effective transformation of the national building stock into nearly zero-energy buildings.

The renovation of the building stock is one of Poland's greatest infrastructural challenges until 2050. As in other EU Member States, in the long run, Polish building stock should be refurbished in a way reflecting the transition to a climate-neutral economy. In parallel, national public policies must respond to the urgent need for replacement of the most carbon-intensive heat sources in order to improve air quality, while ensuring that renovation is cost-effective and that building refurbishment investment costs are distributed equitably. Reducing energy consumption and CO_2 emissions should be the main focus of building renovation as considered in this Strategy, but this must go hand in hand with efforts to improve the standard of buildings, especially in terms of the health and safety of the people who live and work in buildings. This Strategy offers a multi-faceted diagnosis of this challenge and presents the recommended scenario for large-scale and deep energy renovation of the building stock in Poland in the 2050 perspective.

The document also sets the lines for future public policies in support of building stock renovation with a view to realising the recommended scenario, and proposes a set of indicators to monitor the implementation of the Strategy.

The national building stock consists of 14.2 million buildings, of which almost 40% are single-family buildings (detached houses, semi-detached houses and terraced houses with not more than two dwellings or one dwelling and one business premises). The data show large variations in the energy efficiency of Polish buildings depending on both their intended use and the year of commissioning. All categories of buildings are seeing a long-term trend towards improved energy efficiency, which has been driven, inter alia, by growingly stringent technical requirements and technology developments. However, while buildings commissioned for use in the 21st century are characterised by relatively high energy efficiency, older building stocks demonstrate a high demand for energy and are in need of energy renovation. In particular, the above applies to single-family buildings, where solid fuel boilers remain the primary heat source. As regards multi-family buildings (with more than two dwellings), recent surveys show that after 2020, 30% of them will continue to require energy renovation. This share may additionally increase under the influence of upward trends in the prices of energy carriers. It follows from an overview of the national building stock that a large proportion of it is characterised by low energy efficiency and will require energy renovation in the years to come *(Chapter 2).*

As is shown by an analysis of possible thermomodernisation activities, there is a need for ongoing inspection of the building elements responsible for energy losses and consumption, completion of low-cost actions, and gradual implementation of capital-intensive investments such as to ensure far-reaching and lasting improvement in energy efficiency and emission reduction. An assessment of the economic efficiency of shallow and deep energy renovation confirms that, in the current market environment, energy renovation will be viable in the case of a high share of the building stock. However, in the case of single-family buildings using solid fuels and buildings completed in the last two decades and characterised by relatively good energy efficiency, thermomodernisation investments are currently characterised by a relatively long payback time, which may not be attractive to investors. However, this will change considerably in the long term, along with the transition of the economy towards climate neutrality, which will necessitate the phasing out of direct use of fossil fuels in buildings and the decarbonisation of power and district heating systems. With the expected increase in unit heating costs, energy renovation will prove economically viable for a vast majority of buildings. Generally, in the case of residential buildings, economically viable energy renovation can reduce final energy demand by 75%, total annual greenhouse gas emissions by approx. 10%, and total emissions of particulate matter in Poland by one fourth compared to the current levels *(Chapter 3).*

The potential for economically viable renovation is limited by a number of market barriers and shortcomings, which include financial, technical and organisational barriers, as well as split of incentives. The latter problem can be linked to conflicting interests, for example when energy end-users are not responsible for paying the energy bill, when decisions are made jointly, or when

there is a high rotation in the use of the property. In Poland, the share of people living in rented buildings is about two times lower than the EU average, which reduces the split-incentive effect. On the other hand, a major challenge when it comes to renovation of buildings is posed by the synchronisation of demand and supply in local district heating systems *(Chapter 4).*

Poland is delivering comprehensive measures to support renovation of buildings, which comprise legislative, planning and organisational tools, as well as EU and domestic financial support. Bank Gospodarstwa Krajowego (inter alia with its Thermomodernisation and Renovation Fund) and the National Fund for Environmental Protection and Water Management (and its 'Clean Air' Programme) are the key domestic institutions supporting building stock renovation efforts. In 2017-2020, a number of actions were taken towards streamlining the system of support for long-term improvement of the energy efficiency of buildings, reduction of greenhouse gas emissions, and improvement of air quality. They comprise, inter alia, new quality requirements for solid fuels, requirements for solid fuel boilers, the commencement of work on the Central Building Emissivity Inventory, the launching of the 'Clean Air' and 'Stop Smog' Programmes, a thermomodernisation tax allowance (deductibility of energy renovation costs from the tax base for single-family building owners) and efforts towards revising the rules of the Thermomodernisation and Renovation Fund (*Chapter 5*).

Poland also supports the development of smart technologies and well-connected buildings and communities. Smart and energy-efficient construction is one of the National Smart Specialisations. Projects related to the popularisation of smart meters, smart city solutions and other smart building innovations are implemented with the support of EU and national funds, inter alia through projects of the National Centre for Research and Development and programmes of the National Fund for Environmental Protection and Water Management. Legislative work has been completed with a view to popularising smart metering both in the power sector and in the case of remotely readable heat meters, heat cost allocators and water meters *(Chapter 6)*.

A major challenge for the success of large-scale and deep energy renovation is posed by the need to ensure an appropriate level of skills and high-quality education in the construction and energy efficiency sectors. This is to be achieved by the Sectoral Qualifications Framework for Construction published in 2017, as well as the Sectoral Qualifications Framework for the Real Estate sector that is currently being developed. An important role is also bound to be played by the regional and local balancing of the demand and supply of workforce needed to complete energy retrofits of buildings *(Chapter 7).*

Increasing the scale and depth of the energy renovation of buildings in Poland will also require mobilising additional funds. In 2014-2019, public funds which amounted to ca. PLN 14.7 billion were utilised to deliver investment projects worth approximately PLN 22.8 billion. For most of the period, the main focus was on EU co-funded investments in public buildings and on multi-family building energy renovation projects financed by both national and EU funds. However, 2019 saw a steep increase in public contribution to single-family building energy renovation projects as a result of the introduction of a thermomodernisation allowance and the launch of the 'Clean Air' Programme. In the years to follow, efforts should be made to enhance the mobilisation of private funds, which may be supported by activities promoting ESCOs/PPPs, the setting up of one-stop shops for investors, and project aggregation activities *(Chapter 8)*.

For the purposes of determining the recommended scenario for the energy renovation of building stock until 2050, three paths of investing in thermomodernisation of buildings in Poland are analysed. Given the constraints both on the supply side (the need to boost the potential of the domestic industrial and construction sectors in terms of the supply of goods and services for the needs of deep energy retrofits) and on the demand side (limited ability to finance investments in deep retrofits, varied degrees of interest among different groups of investors), combining rapid scaling-up of shallow energy renovation with gradual scaling-up of deep renovations is opted for as the recommended path in the 2030 perspective. This will be conducive to supporting mass replacement of high-carbon heat sources with a view to improving air quality in the coming years and will lay a foundation for widespread deep energy renovation of buildings in line with the transition to a climate-neutral economy in the upcoming decades. The recommended scenario assumes an average annual rate of energy renovation of approx. 3.8% and a gradual growth in the share of deep refurbishment, with simultaneous deployment of the staged approach to energy renovation of the other buildings, which will allow near-zero energy consumption to be attained in the long term. According to the scenario, by 2050, 65% of buildings will have achieved PEFs of up to 50 kWh/(m2·year). Approximately 7.5 million energy renovation investments will have been completed by 2050, with 4.7 million buildings to undergo deep (including staged) energy renovation. A major role in the energy retrofitting process will be played by a review of legislation related to the broadly understood energy efficiency of buildings, which may reveal a need for developing tools to facilitate making investment decisions (Chapter 9).

Guidelines on how to support renovation of buildings in Poland

A strategic approach to renovation by 2050

The new 2050 perspective for the transformation of Poland's building stock towards climate neutrality means a series of gradual shifts in the energy carriers utilised:

- complete discontinuation of the use of coal for heating purposes:
    - phasing out the use of coal by 2040 in all residential buildings, and by 2030 in cities, with the use of smokeless fuel allowed until 2040,
    - disallowing as soon as possible direct combustion of coal for heating purposes in buildings which undergo energy renovation or have the heat source replaced,
- phasing out the use of other fossil fuels, in particular natural gas, in residential and non-residential buildings by 2050:
    - phasing out the use of sources based on fossil fuels (including natural gas) as the key energy carriers in the context of the energy renovation of residential and non-residential buildings by 2030, while maintaining the use of hybrid solutions and sources adapted to the use of zero-emission alternatives,
    - phasing out the use of fossil fuels by replacing heat sources or using zero-emission alternatives (e.g. biomethane, synthetic fuels, hydrogen) in the other buildings with parallel deep energy renovation by 2050.[5]

Thus, the viability of the scale and depth of energy renovation does not only depend on current fuel costs, but also on the costs of securing zero-emission energy carriers (notably electricity and district heat) in the long term. In a zero-emission economy, energy renovation will be viable in the case of nearly all the existing buildings (*Chapter 3*). However, this process requires a staged approach, given the short-term supply constraints (availability of qualified workforce and technologies on the domestic market) and the urgent need to replace heat sources in order to improve air quality. For this reason, the recommended renovation scenario proposes the combination of two processes (*Chapter 9*):

- mass replacement of heat sources combined with shallow energy renovation by 2030. These investments should take into account the perspective of further renovation (staged energy renovation) to a zero-emission standard by 2050,
- enhancing the scale of deep energy renovation to the level of approx. 3% annually in the perspective of the next dozen or so years.

A crucial role for the above processes will be played by a review of legislation related to the broad energy efficiency of buildings, which may reveal a need for developing tools to facilitate making investment decisions, a system of energy classes or solutions based on the concept of a building energy passport. It is also important that building energy performance certificates and energy audits be supported as key energy renovation planning elements.

[5] With the use of fossil fuels allowed only in the rare cases where the use of zero-emission alternatives will be less economically viable than actions in other sectors leading to the attainment of net zero emissions on the scale of the entire economy.

Table 1.Summary of the recommended building stock renovation scenario – indicative milestones for 2030, 2040 and 2050

	Total number of energy renovations to be completed in a given period (million units)	Number of deep energy renovations to be completed in a given period (million units)
2021-2030	2.4	0.5
2031-2040	2.7	1.8
2041-2050	2.4	2.4
2021-2050	**7.5**	**4.7**

Note: the 'total number of energy renovations to be completed' includes staged energy retrofitting, which means that more than one energy retrofit may be completed in one building. Meanwhile, 'the number of deep energy renovations to be completed' corresponds to the number of buildings to undergo deep energy renovation, with no further activity planned once the building attains performance corresponding to the requirements set forth by the Technical Conditions Regulation.

Source: KAPE and WiseEuropa calculations.

Considering that the area of publicly owned buildings or buildings occupied by public institutions represents a significant percentage of Poland's building stock, and given the significant role of the public sector in the promotion of good practices and setting new energy efficiency policy lines, supporting energy renovation of public buildings should be continued, so that every year, at least 3% of the total surface area of buildings owned and occupied by governmental institutions undergo thermomodernisation consistent with at least the minimum energy performance requirements. In parallel, measures should be taken to support RLGUs in attaining a similar pace of renovation.

Support should also continue to be provided for the thermomodernisation of multi-family buildings and single-family buildings, most of which date several dozen years back, when, given the centrally planned economy model, prices of energy were low and did not reflect its economic value. The technical solutions employed at the time did not take into consideration proper thermal insulation of buildings, and the desirable indoor temperature was ensured by robust district heating systems which consumed relatively high quantities of energy. These buildings are characterised by a much higher level of demand for non-renewable primary energy than modern buildings. Moreover, a large proportion of these buildings, which have been in use for decades, are in a poor technical condition and require deep renovation, and the heat sources which prevail in single-family buildings, namely coal-fired boilers, need to be replaced with more effective and less emissive heat sources.

The links between the building renovation support system and the national system for the protection of air against pollution should also be taken into account. Given the complexity of both systems, there is a need for cooperation between the central and regional government administration, regional and local governments and private stakeholders. It is necessary to create sectoral and comprehensive support schemes based on uniform assumptions and requirements, which will cause various support tools to complement one another. Support can also be channelled for activities accompanying building stock renovation efforts, such as enhancing the quality of the surroundings (e.g. regeneration schemes), adaptation of buildings to the needs of disabled people, preferably through reasonable accommodation[6], development of electromobility (installation of electric vehicle recharging stations), promoting transition to a circular economy,

[6] The primary tool for ensuring accessibility as defined in Article 2 of the UN Convention on the Rights of Persons with Disabilities is reasonable accommodation, that is: *'necessary and appropriate modification and adjustments not imposing a disproportionate or undue burden, where needed in a particular case, to ensure to persons with disabilities the enjoyment or exercise on an equal basis with others of all human rights and fundamental freedoms.'*

and removal of harmful hazardous substances, including asbestos, from buildings. As the transition of the economy to climate neutrality progresses and emissions related to the use of energy in buildings is reduced, it will also be increasingly important to take into account embedded emissions, so that renovation reduces the cumulative emissions throughout the building's life cycle.

Evolution of the key public building renovation support programmes designed to improve energy efficiency and promote transition to a climate-neutral economy

Thermomodernisation allowance (ulga termomodernizacyjna):

- maintaining the nature of the tax allowance as a broad instrument for supporting energy renovation and heat source replacement in single-family buildings,
- introducing a requirement for further stage of renovation to the zero-emission standard in the long term to be taken into account,
- when photovoltaic installations are supported – preferences for integrated investments, i.e. such that also cover the heat source,
- putting in place a requirement that harmful hazardous substances, including asbestos, be removed from single-family buildings.

The 'Clean Air' and 'Stop Smog' Programmes:

- discontinuation of public support for investments in coal-fired heat sources from 1 January 2022 under the 'Clean Air' Programme[7],
- gradual increase in the number of energy retrofitted buildings in the 2020s in accordance with the recommended renovation scenario,
- by 2030: parallel support for mass replacement of heat sources and energy renovation,
- putting in place a requirement that harmful hazardous substances, including asbestos, be removed from modernised buildings
- gradual channelling of EU funds intended for energy efficiency of single-family buildings, including resources from the National Recovery Plan, to the 'Clean Air' Programme.

The Thermomodernisation and Renovation Fund (Fundusz Termomodernizacji i Remontów – FTiR):

- gradual re-channelling of FTiR support funds to deep energy renovation of multi-family buildings (with the amount of the bonus depending on the degree to which the building's energy performance is to be improved),
- combining the process for supporting energy renovation of buildings with the installation of renewable energy sources,
- support for the renovation of buildings which, for legal reasons (conservation protection), cannot undergo standard energy renovation,
- putting in place a requirement that harmful hazardous substances, including asbestos, be included in the energy renovation of multi-family buildings,
- gradual allocation of some EU resources intended for improving energy efficiency of multi-family buildings, including the National Recovery Plan to the FTiR.

EU Funds (including the National Recovery Plan) – expended inter alia through specialised support instruments:

- orientating support to improvement of energy efficiency of residential and public buildings (along with energy auditing), inter alia those which are to act as public administration buildings exemplary in energy efficiency terms, reducing energy poverty, giving preference to comprehensive solutions, e.g. connection to district heating/cooling networks, replacement of high-carbon heat sources, installation of renewable energy devices and in-building heating installation retrofits,
- supporting improvement of energy efficiency in enterprises (along with energy audits), including deep and comprehensive energy refurbishment of buildings in enterprises by means

[7] In accordance with information published by the Minister for Climate and Environment (link)

of the installation of energy recovery devices, replacement of devices into energy-saving ones, including renewable energy equipment and replacement of capacities based on

- the combustion of solid fuels by low-emission sources,coordination of building renovation schemes with district heating activities, including investments in district heat generation units. This is to involve expending EU funds on investments in district heat sources such as to work towards low-carbon transition and produce ‘efficient district heating’, including the construction and retrofitting of: high-efficiency cogeneration and trigeneration units, gas installations, also with the use of decarbonised gases, renewable energy, recovery of energy from waste and use of waste heat,
- strengthening synergy between urban regeneration programmes and renovation of buildings, bearing in mind the wide-ranging effects of renovation on improving the living standard of inhabitants of regenerated areas,
- allocating funds for improving the energy efficiency of historic buildings, including support for activities tailored to their specificity,
- incorporating climate change adaptation actions, inter alia investments in blue-green infrastructure, into building stock renovation projects,
- addressing comfort issues and the effect of buildings, especially public ones, on the health of their users, as well as issues linked to the growth of electromobility (installation of electric vehicle recharging stations) and transition to a circular economy,
- continuation of existing and creation of new schemes promoting, advising, and raising the awareness and knowledge of residents, entrepreneurs and local authorities on how to improve energy efficiency of buildings and take advantage of RES,
- putting in place a requirement that harmful hazardous substances, including asbestos, be removed from renovated residential and public buildings.

The final scope and form of EU support will depend on the 2021-2027 Cohesion Policy legislative package, the results of the final negotiations with the European Commission, *ex-ante* analyses regarding the use of financial instruments, as well as on decisions of the institutions in charge of the implementation of operational programmes, including monitoring committees. All the above programmes and instruments will require that coherent support rules be adopted so as to avoid inconsistencies and ‘rivalry’ between the various instruments (avoiding duplication of support tools or conflicts between them). It must be ensured that there is only one renovation programme or instrument for a specific building type or that renovation activities supported by different programmes and instruments benefit from consistent co-funding levels and are subject to similar eligibility conditions, in compliance with state aid legislation, including uniform requirements for energy efficiency, climate performance and other characteristics of buildings, with a uniform list of eligible costs.

Attention must also be paid to the specificities of historic buildings, in the case of which the need to preserve their historic value can make attaining high energy efficiency, in particular of the envelope, difficult. The conditions created by the system of public support for energy renovation should be sufficiently flexible to allow the potential for reduction of energy consumption in historic buildings to be tapped also when the effect achievable is poorer than in the case of non-historic buildings.

Therefore, it seems advisable that financing for renovation of buildings under the most effective, specialised support instruments dedicated to specific types of investments, e.g. FTiR for multi-family buildings and the ‘Clean Air’ and ‘Stop Smog’ Programmes for single-family buildings be gradually integrated. All support instruments, including EU funded ones, designed for similar types of investments, should be subject to eligibility rules similar to those applicable to the abovementioned specialised programmes or complementary to them, and should be governed by the same policies regarding the data on the implementation of these instruments to be collected. Importantly, the monitoring of the level and allocation of public fund spending on energy renovation at the national, regional and local levels should be enhanced.

Area: Smart Technologies

- Supporting the development of smart technologies – the implementation of smart energy management systems at building and city level in order to optimise energy consumption, for example by introducing the Smart Readiness Indicator (SRI) with a view to raising awareness of the benefits of smart technologies and ICT in buildings.

- Legal and financial framework – adopting legislation and financial instruments aiding the implementation and use of smart technologies, in particular installation of smart meters and smart metering systems.
- Supporting research and development on innovative economically viable, zero-emission building energy renovation technologies, i.e. those for which the NPV will be greater than zero, and on technologies enabling buildings to be adapted to climate change.
- Supporting the implementation of systems for cooperation between designers representing different disciplines in keeping with the idea of integrated design (BIM technology), including support for developing tools facilitating the design, optimisation, modelling and use of low-energy buildings.
- Smart energy management in cities – fostering support for the monitoring and deployment of energy management systems in building complexes and cities for optimal management of the municipal economy and power infrastructure, taking into account the potential for transmission of electricity between buildings.
- Further support for the development and implementation of the smart technologies which fall within the framework of National Smart Specialisation 5 *Smart and energy-efficient construction* (including demonstration and pilot projects), in particular modular (prefabricated) construction, green materials and technologies with low embedded emission and recycled materials and technologies, hybrid technologies (integration of energy systems with the building structure/envelope), trigeneration (generation of heat, cold and electricity), energy-saving building technologies.

Area: Skills and education

- Ongoing monitoring of the demand of the energy-efficient construction and RES sector for professions and skills needed to prepare workforce for the sector's needs, inter alia for the needs of the forecast of nationwide and regional demand for industry-specific teachers published annually by the minister competent for education.
- Introducing a distinction between construction and building renovation workforce by levels of qualifications in the construction workforce statistics based on the Polish Classification of Activities 2007 and the Classification of Professions and Specialisations – KZIS (for selected surveys), taking into account educational attainment.
- Improving and verifying on a continual basis the skills of construction workforce with regard to thermal performance of buildings, installation techniques and heat sources in collaboration with employers, educational establishments and the scientific community.
- Preparing and monitoring regional and nationwide building renovation workforce supply and demand balances.
- Building competences for systemic innovations. Supporting regional/local government units in developing competences in planning, implementing and managing innovative projects related to deep energy renovation of buildings, inter alia with regard to solutions specific to historic buildings and combining them with other activities, such as regeneration programmes.

Area: Support for investors in funding building stock renovation

Popularisation of the one-stop-shop (OSS) formula:

It is recommended that a regional pilot project of 'one stop shop' network integrators be conducted, which will include the following activities:[8]

- elaborating the concept of a regional network of one-stop-shops with competences and experience in energy efficiency projects, i.e. institutions, which will consist, in particular, of institutions, i.e. banks, the National Fund for Environmental Protection and Water

[8] Report from the Second Round Table on the financing of energy efficiency in Poland, Warsaw 2018, p 15 (link).

Management (NFOŚiGW), external experts, suppliers, contractors, designers, construction supervision authorities, etc.,
- standardisation and verification of the services to be provided by the one-stop-shops,
- pilot network in one of the provinces based on a publicly co-funded project, which will include the development of solutions for a gradual transition to a system that sustains itself by providing the 'one-stop-shop' services.

Promoting ESCOs

Creation of a national ESCO cooperation platform, with the Ministry of Climate and Environment as the initiator and responsible entity and with the Ministry of Development Funds and Regional Policy as the collaborating institution (competent for PPP-related issues), including:

- identification of the energy service providers needed (based on the list of available energy service providers published at gov.pl/klimat) and their customers for the purposes of the ESCO platform,
- research of market needs and analysis of the existing legal, technical and economic environment,
- defining the platform's goals and tasks for public and private stakeholders,
- creating an ESCO knowledge centre modelled on the ppp.gov.pl portal, including development of energy performance contracting guidelines by the minister competent for climate,
- deploying an approach whereby local governments' EPC commitments would be treated as extra-budgetary ones, which will considerably improve the environment for the operation of ESCOs in this sector of the economy. For this purpose, a power is delegated under statutes to the competent minister to enact a regulation governing the methodology of the impact of EPC commitments on the state's public debt.

Aggregation of projects

- Improving the energy efficiency of local government buildings and street lighting – establishing city exchanges of energy efficiency projects with a view to matching the needs of local governments with regard to building renovation and improvement of other urban infrastructure with the offer of contracting companies, also in the form of ESCOs on local markets.
- Developing a procedure for identifying planned/unplanned energy efficiency improvement projects in public utility facilities and other buildings managed by local governments (e.g. municipal swimming pools, municipal companies' facilities, etc.), including removal of asbestos-containing products.
- Developing a procedure for selecting potential partners for the implementation of energy efficiency projects based on the EPC or ESCO formulas.
- Implementation of a pilot project in a selected medium-sized municipality with the use of public funds.

Area: Supervision, Advice and Information to the Public

- The staffing and funding of construction supervision authorities should be boosted (task of the minister responsible for construction, planning and spatial development and housing) so as to increase considerably the ratio of marketed construction products checked for consistency with parameters declared by manufacturers of building materials and construction installations and to intensify checks into the consistency of the performance of built-in materials with manufacturers' declarations, especially in single-family housing.
- There is a need to continue and intensify awareness-raising and incentive campaigns addressed to building users, to incentivise them into change of behaviours in order to reduce energy consumption in buildings and to highlight the economic, health and environmental benefits of energy renovation of buildings. Local authorities and building managers should set a good example in this regard.
- Education on the environmental impacts of the building stock, in particular regarding energy consumption and related emissions, should be furthered.

- The development of energy advice in support of the planning and preparation of the technical documentation necessary for the completion of renovation investments should be continued. In particular, the preparation of projects involving the energy renovation of buildings registered as monuments or protected under a conservator's decision should be supported.

Area: Legislation

- Review of legislation related to the broad energy efficiency of buildings, which may reveal a need for developing tools to facilitate making investment decisions.

1. Introduction

This document has been prepared on the basis of Article 2a of Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (OJ L 153, 18.6.2010, p. 13, as amended[9]), hereinafter referred to as Directive 2010/31.

This document fulfils enabling condition 2.1 ‘Strategic policy framework to support energy efficiency renovation of residential and non-residential buildings’ under the 2021-2027 financial perspective, which is set out in Article 11 of the Proposal for a Regulation of the European Parliament and of the Council laying down common provisions on the European Regional Development Fund, the European Social Fund Plus, the Cohesion Fund, and the European Maritime and Fisheries Fund and financial rules for those and for the Asylum and Migration Fund, the Internal Security Fund and the Border Management and Visa Instrument, COM(2018) 375 and in Annex IV to the Proposal. For a detailed summary of the fulfilment of the above condition see Annex 6.

In accordance with Directive 2010/31, long-term renovation strategies to support the renovation of national building stock into highly energy efficient and decarbonised buildings by 2050, thus enabling the cost-effective conversion of existing buildings, facilitating the cost-effective transformation of existing buildings into nearly zero-energy buildings, has been defined. Directive 2010/31 provides that the delivery of the strategies will be supported by financial mechanisms for the mobilisation of investment in building renovation needed to achieve the goals.

This strategy presents both a comprehensive diagnosis of the existing situation and an assessment of future prospects for the renovation of buildings in Poland under the conditions of transition to a climate-neutral economy, along with an indication of the recommended orientation of further activities in this area. The actions proposed in this document take into account the approach and optics presented in the Renovation Wave Communication. The long-term building stock renovation strategy is also consistent with the framework of the European Strategy for Energy System Integration. The second chapter presents the key data on the building stock in Poland, taking into account its diversity in energy performance terms. Particular attention is paid to energy consumption in residential buildings and to the current progress in the thermomodernisation of the housing stock. The third chapter provides a comprehensive assessment of cost-effective ways to renovate buildings. It covers the various types of buildings, providing examples of energy renovation of historic buildings and the predicted viability of deep energy renovation of the building stock under the conditions of a transition to a climate-neutral economy and the resulting growth in the unit costs of energy carriers (higher cost of zero-emission electricity and district heating compared to the fossil fuels currently used for heating purposes). The chapter also includes an estimate of the total potential for energy savings associated with cost-effective renovation, as well as discussion of the energy renovation trigger points in the building’s life-cycle. Chapter four discusses the market failures that may hinder tapping the potential for viable energy renovation, with a focus on the problem of split of incentives. The fifth chapter presents an overview of the various public policy instruments which address market failures and support the renovation of buildings in Poland. Different types of instruments and lines of intervention (e.g. public buildings, energy poverty) are distinguished. Chapters six and seven discuss issues linked to the deployment of innovative technologies and building the competences necessary to deliver large-scale deep energy renovation programmes respectively. Chapter eight presents the current scale of mobilisation of investments in low-carbon construction solutions based on public funds, and discusses ways to boost the efficiency of financing renovation in the future. Chapter nine presents the recommended scenario for the energy renovation of buildings until 2050 and the resulting indicators which form the basis for the 2030, 2040 and 2050 action plans.

[9]) Amendments to the Directive were announced in OJ L 156, 19.6.2018, p. 75 and OJ UE L 328 of 21.12.2018, p. 1.

No projects within the meaning of Cabinet Regulation of 10 September 2019 on projects which can have a material impact on the environment (Journal of Laws, item 1839) are to be implemented within the framework of this document or with a view to achieving its assumptions.

2. Overview of Poland’s building stock

> Pursuant to Article 2a(1)(a) of Directive 2010/31, each Member State is required to complete an overview of the national building stock, based, as appropriate, on statistical sampling and expected share of renovated buildings in 2020.

2.1. Introduction

This overview of the national building stock only comprises buildings within the meaning of the Construction Law of 7 July 1994 (Journal of Laws 2021, item 2351, as amended)[10]. It does not provide information on other constructions.

When preparing the overview, it was reasonable to adopt the classification of buildings included in the Construction Law of 7 July 1994, technical and building regulations, the Polish Classification of Construction Works[11], and the Classification of Fixed Assets[12].

The overview is based on the following criteria: the function, age structure and form of ownership, as well as on statistical data retrieved from the Central Building Energy Performance Register, data of the GUS, the Main Construction Supervision Office, and the GUGiK. Other indicators taken into account include the thermal properties of the building envelope and the heat supply method, because the energy efficiency of buildings depends primarily on the thermal insulation of the envelope, the technical equipment, and the heat source used for heating and preparation of hot water.

2.2. Energy performance of buildings in Poland by purpose and age

The overview of buildings by their purpose is based on GUS data for residential buildings and collective accommodation buildings (results of the 2011 National General Population and Housing Census, updated with data on new buildings put into use in 2012-2019), and on GUGiK data (national building statistics as of 1 January 2020). The structure of Polish building stock is presented in Table 2.

Table 2. Polish building stock by building type as of 1 January 2020

Category	Number of buildings, in thousand
multi-family	553
single-family	5 604
collective accommodation buildings	3.9
public buildings	420
production, utility and warehouse buildings	5 116
other non-residential	2 491

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[10] In accordance with Article 3(2) of the Construction Law of 7 July 1994, a building means a structure which is permanently attached to a plot of land, separated from the space by building envelope, and which has foundations and a roof.

[11] The Polish Classification of Construction Works (PKOB) was established by Cabinet Regulation of 30 December 1999 on the Polish Classification of Construction Works (Journal of Laws, item 1316, as amended) and constitutes a systematic list of construction works understood as finished products of construction activities. It was prepared on the basis of the European Classification of Types of Construction.

[12] The Classification of Fixed Assets (Klasyfikacja Środków Trwałych – KŚT) was established by Cabinet Regulation of 3 October 2016 on the Classification of Fixed Assets (KŚT) (Journal of Laws, item 1864). The Classification of Fixed Assets is a systematic list of fixed asset items which is used, inter alia, for reporting purposes, for determining depreciation rates, and for statistical research.

Total	14 189

Source: Own compilation on the basis of GUS and GUGiK data.

Many single-family and multi-family buildings can be made of asbestos-containing products. They can be found on roofs or elevations, but can also form part of external walls, rubbish chutes, or elevator and ventilation shafts. The responsibility for verifying the condition of asbestos-containing products and their location, as well as for notifying the competent mayor (in the case of natural persons) or the competent province marshal rests on the owner, administrator or leaseholder of the real estate. Over 560 000 real estates with residential buildings containing asbestos materials are registered in the Asbestos Database[13].

The tables below present the median of PEFs for various categories of buildings, as determined on the basis of energy performance certificates produced by reference to the Central Building Energy Performance Register. The table field shading corresponds to the factor levels: from the highest (red) to the lowest (blue) ones.

Table 3. Median of annual PEF values for residential buildings by building purpose and age [kWh/(m²·year)]

	<1994	1994-1998	1999-2008	2009-2013	2014-2016	2017-2018	2019-2020
single-family	263.7	147.9	143.5	126.3	109.1	94.0	89.3
multi-family	258.9	139.0	110.0	142.7	97.5	87.0	84.9

Source: Own compilation based on the Central Building Energy Performance Register

Table 4. Median of annual non-renewable PEF values for public buildings by building purpose and age [kWh/(m²·year)]

	<1994	1994-1998	1999-2008	2009-2013	2014-2016	2017-2018	2019-2020
office building	272.8	268.3	236.9	210.3	155.9	155.2	152.2
public administration building	229.0	234.7	217.3	192.3	180.5	158.9	136.6
building for culture needs	232.2		182.7	200.8	250.7	109.2	164.0
building for healthcare needs	341.7	442.9	257.2	387.9	374.5	358.9	320.2
building for sporting needs	370.4	214.8	232.1	165.9	164.2	132.8	146.5
court building	267.2	181.7	217.3	180.5	186.6	171.4	165.9
building for: schooling, university education and research needs	196.4	218.4	166.4	142.6	156.9	122.6	103.2

Source: Own compilation based on the Central Building Energy Performance Register

[13] Asbestos Database (link).

Table 5. Median of annual non-renewable PEF values for collective accommodation buildings by building purpose and age [kWh/(m²·year)]

	<1994	1994-1998	1999-2008	2009-2013	2014-2016	2017-2018	2019-2020
student dorm	219.3	357.2	284.1		145.6	121.7	143.6
hotel	334.8	351.9	277.1	302.6	193.2	213.2	184.3
boarding house	286.7	272.3	201.3		137.2	159.2	124.9
guesthouse, rest home or hostel	383.0	393.2	206.8	299.5	173.5	174.3	181.2

Source: Own compilation based on the Central Building Energy Performance Register

A more detailed assessment of the energy performance of residential buildings erected in the 20th century has been carried out on the basis of the publication *Inhabited Buildings* (Zamieszkane budynki), which presents the results of the National General Population and Housing Census conducted in 2011[14], the publication entitled *Opracowanie optymalnych energetycznie typowych rozwiązań strukturalno-materiałowych i instalacyjnych budynków (Developing energy-optimal standard solutions for the design, materials and installations of buildings)*[15], and own research.

Table 6 presents the age structure of Poland's pre-2002 housing stock, together with estimates regarding their unitary demand for non-renewable primary energy (PEF) and final energy (FEF) of the stock before the energy renovation. PEF is an indicator describing the annual demand for non-renewable primary energy per unit of floor area of spaces with controlled air temperature, expressed in kWh/(m²·year), while FEF is an indicator describing the annual demand for final energy per unit of floor area of spaces with controlled air temperature in kWh/(m²·rok).

Table 6. Age structure of Polish pre-2002 housing stock and its baseline unitary annual energy factors

Year built	Buildings	Dwellings	PEF	FEF
years	**thousand**	**million**	**kWh/(m²·year)**	**kWh/(m²·year)**
pre-1918	404.7	1.18	>350	>300
1918-1944	803.9	1.45	300-350	260-300
1945-1970	1 363.9	3.11	250-300	220-260
1971-1978	659.8	2.07	210-250	190-220
1979-1988	754.0	2.15	160-210	140-190
1989-2002	670.9	1.52	140-180	125-160

Source: Inhabited Buildings. 2011 National General Population and Housing Census GUS 2013, Collaborative study edited by Stanisław Mańkowski and Edward Szczechowiak: 'Opracowanie optymalnych energetycznie typowych rozwiązań strukturalno-materiałowych i instalacyjnych budynków'.

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[14] Zamieszkane budynki. Narodowy Spis Powszechny Ludności i Mieszkań 2011 (Inhabited Buildings. National General Population and Housing Census), GUS, Warsaw 2013.

[15] Collaborative study edited by Stanisław Mańkowski and Edward Szczechowiak: 'Opracowanie optymalnych energetycznie typowych rozwiązań strukturalno-materiałowych i instalacyjnych budynków'. Tom pierwszy Część A Uwarunkowania przekształceń w budownictwie. Zadanie badawcze nr 2 wykonane w ramach Strategicznego Projektu Badawczego pt. „Zintegrowany system zmniejszenia eksploatacyjnej energochłonności budynków" na zamówienie Narodowego Centrum Badań i Rozwoju.

Most Polish buildings, in particular multi-family buildings, were put into use several dozen years ago, that is in a period when, under the conditions of a centrally planned economy, the prices of energy were low and did not reflect its economic value. The technical solutions used at that time took into account the thermal insulation of buildings to a much lesser extent than today, and appropriate indoor temperature was ensured by robust heating systems which consumed relatively large amounts of energy. Pre-2002 buildings are characterised by a much higher level of demand for primary energy than currently erected buildings.

A building's energy standard depends on the age of the building, the way it is used, the construction works completed inside it, the technologies and construction products used, as well as the requirements which applied while they were being erected. One should also take into account reduction of energy efficiency of buildings through their use, and, on the other hand, improvements in energy efficiency as a result of construction, installation and assembly works carried out.

The construction technologies in Poland are highly diversified. In pre-war urban housing apartment houses dominate. These are mostly brick and mortar structures, usually several floors high. Many buildings of this type are still in a poor technical condition and require deep renovation, most often in consultation with the monument conservator and with respect to the historic value of these buildings. Heating and domestic hot water preparation methods vary. Coal boilers continue to be the main heat source. Electric instantaneous water heaters are also popular. Some dwellings are equipped with central heating systems with a gas boiler or a solid fuel boiler.

The years 1946-1990 saw an intensification of the construction of buildings (see Table 6),and the mid-1960s observed rapid development of large panel technologies. Most of the latter type are high-rise or four-floor buildings, many of 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 connected to district heating networks.

A comparison of the ratios for the individual age groups of buildings displays a gradual improvement in energy efficiency in newer buildings, which, coupled with the steady upward movement in commissioned buildings in recent years, has translated into improved average energy efficiency of the building stock. An important role in this process is played by the requirements for energy savings and thermal insulation, which have been gradually tightened over the years. They apply to newly designed or erected buildings and to altered and re-designated buildings, and are set forth by the Technical Conditions Regulation.

Table 7 presents the evolution of thermal insulation requirements towards improved energy standard of buildings over the years.

Table 7. Requirements concerning maximum values of the heat penetration coefficient for envelope elements of heated building spaces.

Standard/provision	**Heat penetration coefficient U_{max} [W/(m^2 · K)]**				
	External wall	**Flat roof**	**Ceiling over an unheated cellar**	**Ceiling under an attic**	**Balcony windows and doors**
PN-57/B-024051[a)]	1.16 ÷1.42	0.87	1.16	1.04 ÷1.163	-
PN-64/B-034041[a)]	1.16	0.87	1.16	1.04 ÷1.163	-
PN-74/B-034042[b)]	1.16	0.70	1.16	0.93	-
PN-82/B-020202[b)]	0.75	0.45	1.16	0.40	2.0 ÷2.6
PN-91/B-020202[b)]	0.55 ÷ 0.70[d)]	0.30	0.60	0.30	2.0 ÷2.6
Technical and building regulations (year 1997)[b)]	0.30 ÷ 0.65[c)]	0.30	0.60	0.30	2.0 ÷2.6
Technical and building regulations (year 2002)[b)]	0.30 ÷ 0.65[d)]	0.30	0.60	0.30	2.0 ÷2.6

Standard/provision	Heat penetration coefficient U_{max} [W/(m² · K)]				
	External wall	Flat roof	Ceiling over an unheated cellar	Ceiling under an attic	Balcony windows and doors
Technical and building regulations (year 2009)[b)]	0.30	0.25	0.45	0.25	1.7 ÷1.8
Technical and building regulations (year 2014)[b)]	0.25	0.20	0.25	0.20	1.3 ÷1.5
Technical and building regulations (year 2017)[b)]	0.23	0.18	0.25	0.18	1.1 ÷1.3
Technical and building regulations (year 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 MRiT.Explanatory notes: [a)] θ_{and} = 18 °C, [b)] θ_i = 20°C, [c)] depending on the type of wall (with or without openings), [d)] depending on the type and design of the wall.

The regulations which have been in effect since 31 December 2020 will lead to a situation in which all newly designed, constructed and converted buildings or buildings whose purpose is being changed should be nearly zero-energy buildings.

In the case of historic buildings, the greatest possible energy savings should be sought.

2.3. Ownership structure and energy consumption in residential buildings

Ownership structure of residential buildings

The latest complete data on the structure of inhabited residential buildings by ownership form come from the 2011 National General Population and Housing Census. As a result of the adoption of new legal regulations regarding ownership of premises and the activities of housing cooperatives, the period between the 2002 and 2011 Censuses observed changes in the structure of ownership of residential buildings and dwellings. Compared with the 2002 Census, the number of inhabited residential buildings in co-ownership, with separated ownership rights to dwellings grew considerably[16]. The number of residential buildings owned by natural persons and social building societies increased, too. In parallel, the shares of other forms of ownership in the structure of the housing stock decreased.

In 2011, most buildings were owned by natural persons (83.3 % of the total number of inhabited residential buildings). These persons were the owners of more than 4.6 million of residential buildings, with approximately 5.4 million dwellings. Compared to 2002, the number of residential buildings owned by natural persons increased by 9.8 %. Buildings in co-ownership with separated ownership rights to dwellings ranked second in terms of the share in the housing stock (9.1%). In 2011, the number of residential buildings with such ownership exceeded 500 000 and there were more than 6.5 million dwellings in them.

Compared with the previous Census the number of residential buildings in co-ownership with separated ownership rights to dwellings increased by 88%, and the number of flats in such

[16] Buildings in co-ownership, with separated ownership rights to dwellings: these are buildings which are a joint property, in which all, or only some dwellings are in separate ownership of natural and/or legal persons (e.g. co-ownership of natural persons, co-ownership of natural persons and a municipality, co-ownership of natural persons and an employer). All the owners with separated ownership rights to flats in a building constitute a so-called 'association of flat owners' (after the entry into force of the Act of 15 December 2000 (Journal of Laws 2021, item 1208) on housing cooperatives, separated ownership rights to some dwellings were established for natural persons).

buildings more than doubled. The upward movement in the number of buildings representing such property was associated with the completion of new buildings in co-ownership, as well as with the establishment of separate ownership titles to dwellings in buildings previously owned by a single entity. In the years 2002-2011, approximately 172 thousand residential buildings changed the ownership status to co-ownership with separated ownership rights to dwellings.

Table 8. Inhabited residential buildings and dwellings in inhabited residential buildings in the years 2002 and 2011.

Owner		Buildings ('000)		Dwellings ('000)	
		year 2002	**year 2011**	**year 2002**	**year 2011**
ownership	natural persons	4 204.8	4616.1	4 819.0	5 408.8
	housing cooperatives	82.3	20.4	3 031.5	239.3
	municipalities	95.0	56.8	595.5	282.6
	State-owned	27.1	19.6	146.4	62
	work establishments	39.4	28.3	192.6	84.7
	Social Housing Associations	2.0	3.1	33.2	43.1
	other entities	12.8	12.0	33.0	22.9
co-ownership	with separated ownership rights to dwellings	268.3	505.1	2 935.3	6 505.0
	without separated ownership rights to dwellings	42.0	36.7	79.1	50.6
Total		**4 773.6**	**5 298.1**	**11 865.8**	**12 966**

Source: Inhabited Buildings. National General Population and Housing Census 2011, GUS 2013

Structure of energy consumption

The tables below present national building stock statistics from the latest GUS studies (*Energy consumption in households in 2018*[17]).

The largest share in consumption of energy by Polish households is that of solid fuels, mainly hard coal and firewood. They were the sources of energy most often used for space heating (by 45.4% of households). These fuels were also used for water heating (25.6% of households), and much less so for cooking (3.2%). The consumption of solid fuel in households decreased by 7.2% in the period 2002-2018.

District heating was a key source of energy, supplying about 40.4% of all dwellings in 2018, primarily in big cities, where it was the prevalent heating carrier (58.3%). Furthermore, 31.5% of households, i.e. 78.2% of district heat consumers, had their domestic hot water prepared with the use of district heating.

Natural gas was utilised by 55.7% of households, but more than half of its consumers (51.9%) used it solely for cooking, and only 14% for heating their homes. 26.7% of households used natural gas for water heating. In areas of the country where a natural gas network was not available, the use of LPG was common (34.0%), with the gas used almost entirely for cooking purposes (33.9%).

Firewood was used by 29.9% of households as the only widely used renewable fuel. 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 52, and heat pumps only by one household in 200.

Households used electricity widely, to a small extent for heating purposes (5.1%) due to its high prices and availability of cheaper substitutes. Electricity was used for cooking meals and space heating rather as an additional source. The high share (24%) of this energy carrier in the

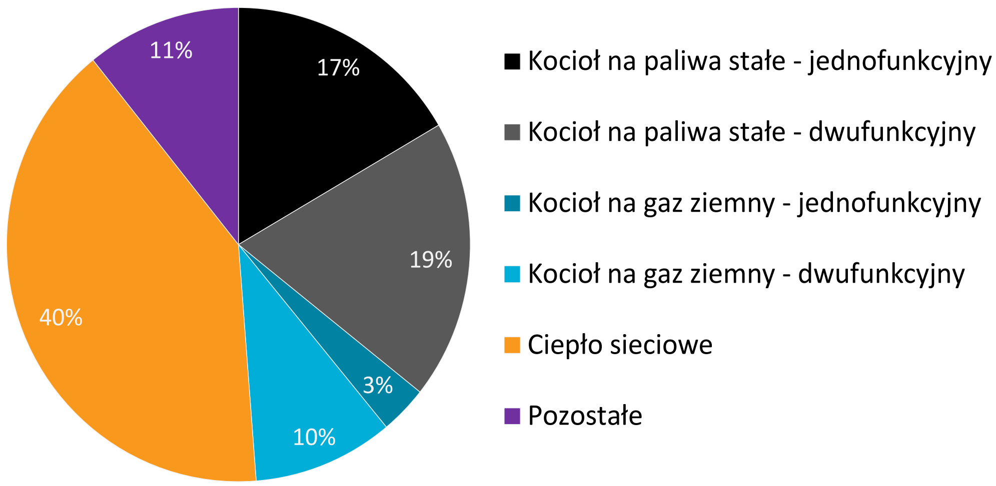
[17] Energy consumption in households in 2018, GUS, Warsaw 2019.

preparation of domestic hot water is attributable to the lack of access of many households to district heating and gas networks.

Space and water heating equipment and sources of light

In the years 2002-2018, use was made 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 (28.9%), which were also used for the preparation of hot water. Single-purpose boilers were less popular (19.9%), and fireplaces were even less common (1.8%). In some old buildings, solid fuel stoves or solid fuel cookers were the only heating devices (4.9%).

Chart 1. Space heating by heating techniques in 2018 (in %)

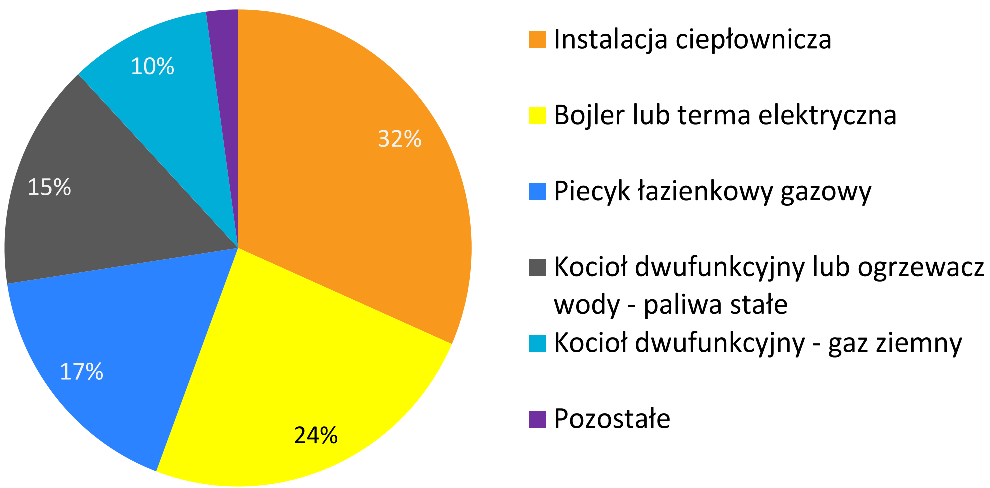


Source: Energy consumption in households in 2018, GUS.

Kocioł na paliwa stałe - jednofunkcyjny	Solid fuel boiler - single-function
Kocioł na paliwa stałe - dwufunkcyjny	Solid fuel boiler - dual function
Kocioł na gaz ziemny - jednofunkcyjny	Natural gas boiler - single function
Kocioł na gaz ziemny - dwufunkcyjny	Natural gas boiler - dual function
Ciepło sieciowe	District heat
Pozostałe	Other

Hot water was most often acquired from district heating installations (31.6% of households), with a large share also represented by electric boilers or electric storage water heaters (24.1%) and bathroom gas water heaters (16.9%). Dual-purpose boilers or water heaters fired with solid fuels were utilised by 15.4% of households, and those fuelled with natural gas by 9.8%.

Chart 2. Water heating by heating techniques in 2018



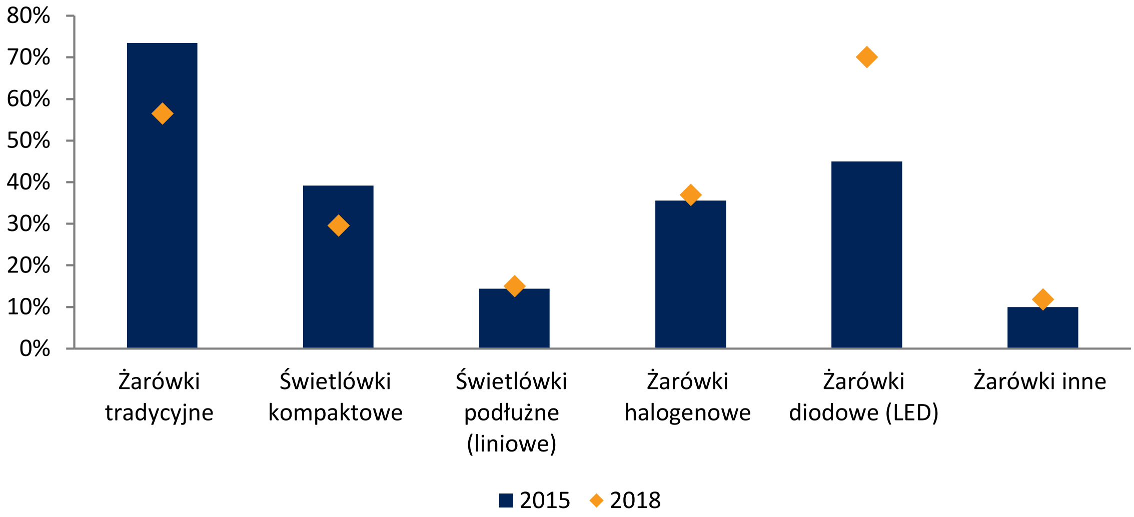
Source: Energy consumption in households in 2018, GUS.

Instalacja ciepłownicza	Heat supply system
Boiler lub terma elektryczna	Water heater or electric water heater
Piecyk łazienkowy gazowy	Bathroom gas water heater
Kocioł dwufunkcyjny lub ogrzewacz wody - paliwa stałe	Dual function boiler or water heater - solid fuel
Kocioł dwufunkcyjny - gaz ziemny	Dual function boiler - natural gas
Pozostałe	Other

Most households were well furnished with the essential energy consuming devices, both those which satisfied their basic heating needs and those improving the living comfort of occupants. A vast majority of households had essential electrical appliances, i.e. combined refrigerator-freezers (82.3%), automatic washing machines (92.1%), vacuum cleaners, and TV sets (93.9%).

LED lamps accounted for the largest share in the light sources – 44.9%, and started to prevail over conventional sources in number terms in the 2018 survey. In previous surveys, conventional incandescent light bulbs had ranked highest among all the types of light sources (34.5% in 2015, 20.5% in 2018).

Chart 3. Households by light sources used in 2015 and 2018



Source: Energy consumption in households in 2018, GUS.

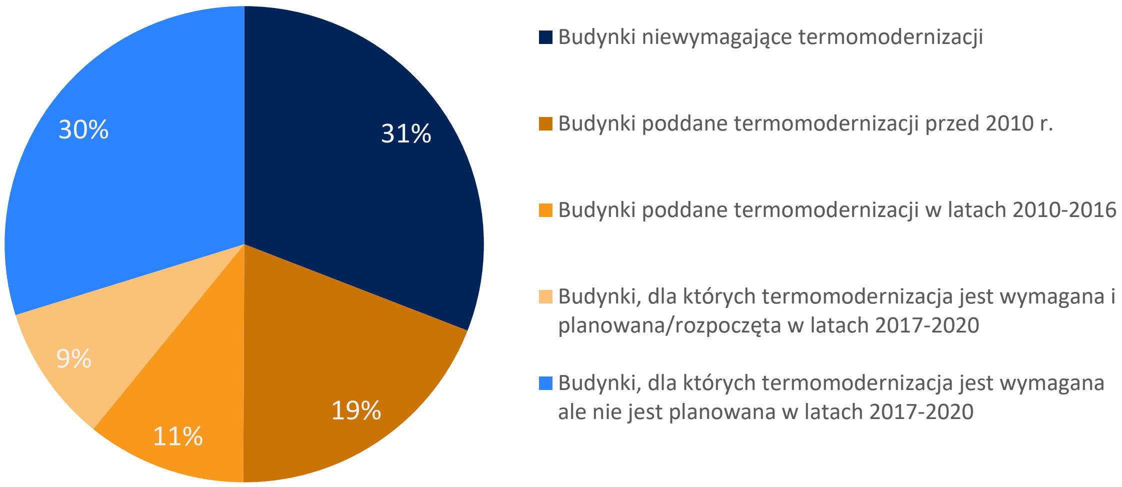
Żarówki tradycyjne	Incandescent light bulbs
Świetlówki kompaktowe	Compact fluorescent lamps
Świetlówki podłużne (liniowe)	Fluorescent tubes (linear)
Żarówki halogenowe	Halogen light bulbs
Żarówki diodowe (LED)	Light emitting diodes (LED)
Żarówki inne	Other light bulbs

2.4. Multi-family buildings which underwent energy renovation in previous years – findings of statistical surveys

A survey conducted by the GUS in 2019 as part of the study entitled: *Opracowanie metodologii i przeprowadzenie badania skali działań termomodernizacyjnych budynków mieszkalnych wielomieszkaniowych w celu poprawy ich energochłonności oraz ocena potrzeb i planowanych działań w tym kierunku* (Developing the methodology and conduct of a survey on the scale of thermomodernisation of multi-dwelling buildings completed to improve their energy performance, and assessing the needs and planned activities in this respect), to which owners or managers of 189 289 buildings responded, showed that:

- 60.7% of multi-dwelling buildings did not require energy renovation, including 29.7% because they had undergone energy renovation before 2016, and 31.0% because they were not in need of energy retrofitting (e.g. because energy-efficient technologies had been used to construct them),
- 39.3% of multi-family buildings required energy renovation in order for their technical condition to be brought to modern energy standards, with energy renovation planned or under way for 9.4% of the buildings in 2017-2020, and not planned in the case of 29.9%.

Chart 4. Thermomodernisation needs of the multi-family buildings included in the survey



Source: Opracowanie metodologii i przeprowadzenie badania skali działań termomodernizacyjnych budynków mieszkalnych wielomieszkaniowych w celu poprawy ich energochłonności oraz ocena potrzeb i planowanych działań w tym kierunku, GUS 2019.

Budynki niewymagające termomodernizacji	Building which do not require energy renovation
Budynki poddane termomodernizacji przed 2010 r.	Buildings which underwent energy renovation before 2010
Budynki poddane termomodernizacji w latach 2010-2016	Building which underwent energy renovation in the years 2010-2016
Budynki, dla których termomodernizacja jest wymagana i planowana/rozpoczęta w latach 2017-2020	Buildings for which energy renovation is required and planned/started in the years 2017-2020
Budynki, dla których termomodernizacja jest wymagana ale nie jest planowana w latach 2017-2020	Buildings for which energy renovation is required but is not planned in the years 2017-2020

By extrapolating the above results to the entire stock of multi-family buildings in Poland (assuming that the findings of the survey are also true for the 64.6% of the stock which was not surveyed), it can be assumed that around 210 000 multi-dwelling buildings are still in need of thermomodernisation.

Notably, the scale of energy renovation needs identified is based on the opinions of those surveyed and may grow in the future (e.g. due to rising prices of energy carriers), which will reduce the pool of buildings in no need of energy renovation. In addition, even if retrofitted in previous years, a building may need further activities in this regard in the 2050 perspective, which means that the 30% ratio of building stock in need of energy renovation should be interpreted as reflecting short-term post-2020 needs, rather than the total energy renovation needs of multi-family housing in Poland until 2050.

The survey shows that thermal insulation of the building's external walls was the most popular thermomodernisation activity, regardless of the province or type of building ownership. This was the case with 93.0% of the retrofitted buildings surveyed. The share ranged from 80.5% in the Małopolskie Province and 82.0% in Kujawsko-Pomorskie to 100.0% in Świętokrzyskie and 98.7% in Lubuskie.

Natural persons who owned multi-dwelling buildings completed thermal insulation in all the buildings they renovated in energy terms in 2010-2016. Housing cooperatives had external walls insulated in 94% of all the buildings which underwent such energy renovation. A similar scale of activities was observed among associations of flat owners, who had 94% of their building stock insulated. The share of insulated state-owned buildings (88.0%) was most likely related to two factors. Firstly, the envelope of such buildings had been insulated in earlier years, not covered by the survey, and secondly, there is a larger proportion of historic buildings in this category than in the others, which means that thermomodernisation work is more difficult since it must be approved by the provincial monument conservator and the architectural and historical qualities of such buildings must be preserved.

As it is commonly perceived, energy renovation involves the replacement of windows or balcony doors, but the survey demonstrates that only 36.5% of renovated buildings had these replaced. The greatest intensity of window and balcony door replacement was observed among municipal units (68.7%) and for state-owned buildings (56.0%.). The greatest number of buildings where windows and balcony doors were replaced in 2010-2016 was declared by housing cooperatives and associations of flat owners, but the shares in relation to the total number of modernised buildings were much lower – 34.5% and 29.6%, respectively.

The survey shows that thermal insulation of external walls went hand in hand with other energy retrofits, mainly insulation of the roof, ceiling or flat roof (60.0% of cases) or replacement of joinery (45.9% – external doors, 36.5% – windows or balcony doors). There was less activity related to the technical equipment of buildings: heat source or district heating substation (retrofitting or replacement of the heat source – 12.5%, upgrading of the district heating substation – 14.3%, retrofit of the interior heating installation – 25.2%, refurbishment of the domestic hot water installation – 13.3%, upgrade or replacement of the ventilation system – 5.6%, retrofit of the lighting system in common building parts – 22.5%).

The survey shows that after the energy renovation project, district heating continued to be the most popular heat source with a share of 65.9% (an increase by 28.9 pp). This is largely attributable to the considerable reduction in the use of coal-fired boilers (the share of buildings with this heat source after the energy retrofit was only 5.1%, i.e. it dropped by 17.8 pp) and to the deinstallation of tiled stoves (after the energy renovation, none of the buildings in question was equipped with this heat source anymore). Before the energy renovation, this share was as high as 22.5% of the buildings included in the survey. In addition, coal-fired boilers and tiled stoves were being widely replaced by gas-fired boilers, the share of which after the heat source retrofit was 23.7% (in 127 instances of energy renovation or heat source replacement, coal-fired boilers were replaced with gas-fired boilers, and in 54 cases gas-fired boilers were installed instead of tiled stoves). Notably, in 42 cases district heating was replaced with gas-fired boilers, and in 41 cases district heating took the place of gas-fired boilers.

Table 9. Heat source in the buildings surveyed before and after energy renovation

	before energy renovation	**after energy renovation**
district heating substation/district heating network	37.0%	65.9%
coal-fired boiler/stove	22.9%	5.1%
tiled stove	22.5%	0.0%
gas-fired boiler/stove	10.0%	23.7%
liquid fuel boiler/stove	3.0%	1.8%
other	2.7%	1.8%
electric heating	1.9%	0.3%
biomass-fired boiler/stove	0.1%	0.9%
heat pump	0.0%	0.5%

Source: Opracowanie metodologii i przeprowadzenie badania skali działań termomodernizacyjnych budynków mieszkalnych wielomieszkaniowych w celu poprawy ich energochłonności oraz ocena potrzeb i planowanych działań w tym kierunku, GUS 2019.

In some instances, renovation did not involve changing the heat source. It involved replacing old boilers with new ones fired with the same fuel or retrofitting the devices used. The heat source was replaced with another one of the same kind in 51 cases for coal-fired boilers, 90 cases for gas-fired boilers, and 493 cases for the district heating network. The relatively large number of district heating retrofits stems from the great potential in this area, which – in addition to the refurbishment of the heat source itself, also involves the upgrading of heat exchangers, replacement of circulation pumps, automation, and stabilisation and metering systems.

Table 10. Average PEFs before and after energy renovation and savings gained

	Average PEF [kWh/(m^2·year)]		Savings gained in %
	before energy renovation	**after energy renovation**	
Poland	**225.6**	**141.5**	**37.27**
Poland – 2010	250.3	156.0	37.67
Poland – 2011	242.9	152.4	37.25
Poland – 2012	224.0	141.1	37.02
Poland – 2013	218.3	146.3	32.97
Poland – 2014	217.7	136.7	37.20
Poland – 2015	217.5	129.6	40.42
Poland – 2016	214.7	132.6	38.22

Source: Opracowanie metodologii i przeprowadzenie badania skali działań termomodernizacyjnych budynków mieszkalnych wielomieszkaniowych w celu poprawy ich energochłonności oraz ocena potrzeb i planowanych działań w tym kierunku, GUS 2019.

Table 11. Average PEFs before and after energy renovation and savings gained by type of owner or manager

	Average PEF [kWh/(m^2·year)]		Savings gained in %
	before energy renovation	**after energy renovation**	
Poland	**225.6**	**141.5**	**37.27**
municipal unit	327.3	154.5	52.81
work establishment	136.0	104.3	23.29
State-owned	342.4	119.4	65.12
housing cooperative	176.1	121.0	31.29
Social Housing Association	298.2	184.7	38.07
association of flat owners	280.2	169.3	39.59
natural person	262.0	193.3	26.21
other unit	252.6	130.3	48.42

Source: Opracowanie metodologii i przeprowadzenie badania skali działań termomodernizacyjnych budynków mieszkalnych wielomieszkaniowych w celu poprawy ich energochłonności oraz ocena potrzeb i planowanych działań w tym kierunku, GUS 2019.

Table 12. Average values of annual energy consumption for central heating before and after energy renovation and savings gained, by types of owners or managers

	Average value of annual energy consumption for central heating [GJ]		Savings gained in %
	before energy renovation	**after energy renovation**	
POLAND	**1 295.1**	**973.5**	**24.8**
municipal unit	773.4	436.1	43.6
work establishment	1 654.8	1 133.3	31.5
State-owned	660.9	489.8	25.9
housing cooperative	1 384.0	1 067.1	22.9
Social Housing Association	877.6	443.9	49.4
association of flat owners	1 185.8	858.5	27.6

natural person	1 004.6	737.0	26.6

Source: Opracowanie metodologii i przeprowadzenie badania skali działań termomodernizacyjnych budynków mieszkalnych wielomieszkaniowych w celu poprawy ich energochłonności oraz ocena potrzeb i planowanych działań w tym kierunku, GUS 2019.

3. Determining cost-effective building renovation methods

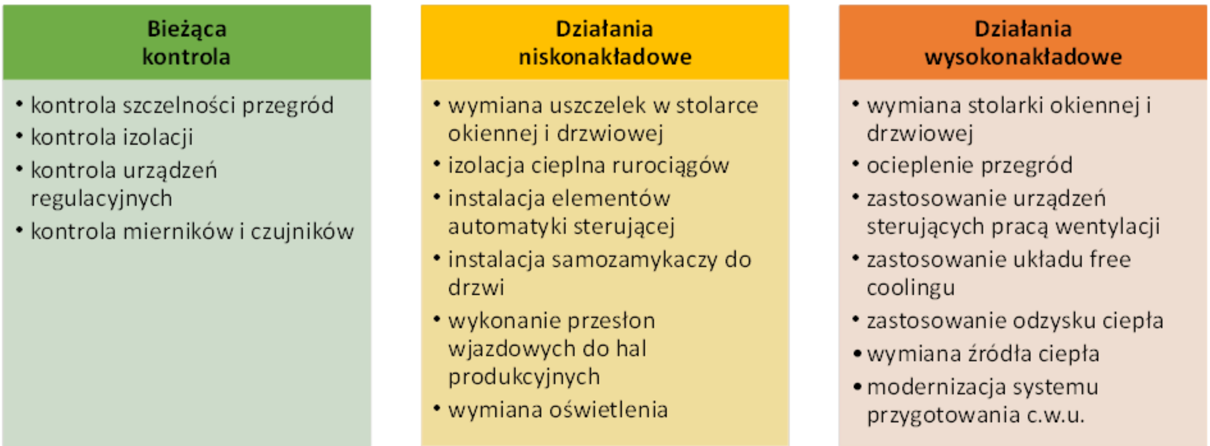
Pursuant to Article 2a(1)(b) and (g) of Directive 2010/31, each Member State is required to identify cost-effective approaches to renovation relevant to building type and climate zone,

considering potential relevant trigger points, where applicable,

in the life-cycle of the building, and provide an evidence-based estimate of expected energy savings and wider benefits, such as those related to health, safety and air quality.

The sequence of thermomodernisation activities should be such as to produce the greatest possible effects in terms of reduced energy consumption and costs relative to engaged funds. Therefore, when considering the activities to be implemented to reduce energy demand, it should be remembered that they are divided into certain types and stages, which are described below.

Model 1. Types of energy renovation activities



Source: KAPE's own study.

Bieżąca kontrola	On-going inspection
• kontrola szczelności przegród	• inspection of the tightness of space dividing elements
• kontrola izolacji	• inspection of insulation
• kontrola urządzeń regulacyjnych	• inspection of control devices
• kontrola mierników i czujników	• inspection of meters and sensors
Działania niskonakładowe	Low-expenditure measures
• wymiana uszczelek w stolarce okiennej i drzwiowej	• replacement of seals in window and door frames
• izolacja cieplna rurociągów	• thermal insulation of pipelines
• instalacja elementów automatyki sterującej	• installation of control automatics elements
• instalacja samozamykaczy do drzwi	• installation of closers for doors
• wykonanie przesłon wjazdowych do hal produkcyjnych	• construction of vehicle entrance screens for production halls
• wymiana oświetlenia	• replacement of lighting
Działania wysokonakładowe	High-expenditure measures
• wymiana stolarki okiennej i drzwiowej	• replacement of window and door frames
• ocieplenie przegród	• heat insulation of space dividing elements

• zastosowanie urządzeń sterujących pracą wentylacji	• use of ventilation control devices
• zastosowanie układu free coolingu	• use of the free cooling method
• zastosowanie odzysku ciepła	• use of heat recovery
• wymiana źródła ciepła	• heat source replacement
• modernizacja systemu przygotowania c.w.u.	• upgrade of the DHW system

Ongoing service and maintenance, which ensures proper functioning of the elements responsible for energy losses and consumption (this encompasses all areas of energy consumption for the needs of heating, preparation of DHW, cooling and production of electricity) through:

- prevention of dampness of the envelope and its thermal insulation,
- ensuring that the envelope is kept air tight (elimination of cracks, damage, maintaining good condition of window seals, locks, frames and joinery, etc.),
- ensuring appropriate quality of the elements and fittings of heating, cooling, ventilation (and process) installations, in particular of control elements and devices – valves, actuators, sensors and metering devices used for monitoring energy consumption,
- checking whether the algorithms which control the operation of installations and devices work properly,
- elimination of leaks and non-tightness of installations (which applies to all systems in industrial buildings: heating, DHW, process, cooling, compressed air, and ventilation),
- checking the roof for waterproofness and damage and removing asbestos-containing products from the roof and replacing them with proof asbestos-free products.

No-cost and low-cost activities (sometimes reduced to maintenance) create ample opportunities for generating considerable energy savings (major improvement is possible at low cost) and are usually relatively simple and quick to implement, e.g.

- replacing insulation or supplementing missing insulation of heating, DHW or process installation pipelines and fittings,
- replacement or installation of control elements and equipment to ensure better control of operation,
- insulation of pipelines, accessories and fittings (pumps, valves, regulating elements),
- preparation and use of schedules for the operation of heating, domestic hot water, ventilation, air conditioning, etc. installations, in line with the needs and the use made of spaces or the production process,
- replacement of seals in window and door woodwork and joinery,
- use of closers for entrance doors,
- building entrance door vestibules,
- installation of production hall or warehouse entrance curtains and screens which close automatically after a vehicle or an employee passes through,
- use of waste heat from technological processes (e.g.
- from chillers, compressor or product cooling) when this is not too complex,
- exploiting the potential for direct space cooling with no use of air-conditioning units and installations.

Low-cost activities, which, however, require some expenditure, include:

- using external shading elements to prevent the overheating of interiors in summer, which includes planting vegetation to cut off excess sunlight coming through glass partitions,
- replacement of lighting with LED-based technologies,
- installation of automatic controls (sensors, valves, actuators, regulators), such as to optimise the work of the installation, and use of timers,
- installation of remotely readable heat meters and heat cost allocators, compatible with individual billing systems.

High-cost thermomodernisation activities, which require greater outlays, are also recommendable because they generate significant energy savings. If they are opted for, the following principles should be followed:

- energy renovation works should be carried out in the order from the most cost-effective to the least cost-effective ones (the investment payback time may be crucial here), with removal of asbestos-containing products included, in parallel to activities aimed at reducing energy consumption, efforts should be taken to ensure the measurability of the resultant effects by means of metering devices.

If, as a result of retrofit activities, the demand for heat for space heating, DHW, or cooling purposes is significantly reduced, the operation of heating (and other) installations should also be adapted to the lower needs. It is not optimal for a building which has undergone energy renovation to use a boiler, district heating substation and pumps which are oversized twice or a heating system which is not adequately controlled in hydraulic terms.

Therefore, practically every energy renovation project should go hand in hand with efforts to adjust the operation of heating installations to the reduced heat needs. Many a time, the dilemma will arise in what order and to what extent these activities should be completed. An energy audit can be useful in taking a sensible decision, since it can indicate the optimal sequence and scope of work and can help optimise capital expenditure and make an informed investment decision based on objective information and reliable data analysis. In addition, the cost of performing an energy audit is usually negligible compared to the outlays needed to carry out energy renovation. Therefore an energy audit should be an integral part of the building energy renovation process.

A rule of thumb which applies to energy renovation is that such investments should be completed in a comprehensive manner since this definitely produces the greatest advantages. This means that after the completion of all the possible and reasonable activities reducing the demand for heat (insulation of the envelope, replacement or refurbishment of window frames, recovery of heat from ventilated air, replacement of the roof covering with asbestos-free products plus insulation, etc.), it is worthwhile to upgrade the heating system. This will minimise the costs of the renovation and subsequent utilisation of the system (smaller radiators, pipeline diameters, control valves, boilers and heat exchangers, etc.) and ensure that the installation operating conditions are optimised. This produces higher heat generation and installation control efficiencies.

However, investors often do not have sufficient funds for deep energy renovation. In such a situation, they should narrow down energy renovation so as to ensure that the money is utilised in an optimal way, both in economic and energy terms. The choice of the solution should also be based on an energy audit. The audit algorithm comprises an analysis of a range of variants involving scopes narrower than comprehensive energy renovation, especially such that take into account the specificities and possibilities of energy renovation of buildings and structures protected under a conservator's decision. As a result of the analysis, retrofitting work which is the least favourable from the investor's point of view is scaled down, with the resultant solution comprising a narrower scope of refurbishment but produces optimal savings under the existing conditions.

Energy auditing is also helpful because the impact assessment it involves addresses the differences in weather conditions between the climate zones in Poland and the disparities between work standards from one location to another. Poland is characterised by large variations in the environmental conditions which are relevant for the selection of the optimal solution and therefore should be taken into account when making investment decisions. The relevance of this impact in Poland is evidenced by the fact that the demand for heat for identical buildings (factory hall, office or residential building) may differ by as much as 20% from one location to another. Therefore the country has been divided into five climate zones with highly differing weather conditions. In each of these areas, different design temperatures are adopted for analysis.

In accordance with the energy audit procedures, each of the energy renovation variants analysed should always involve an upgrade of the heating system (which also applies to air conditioning and ventilation systems) and parallel heat demand reduction projects. In particular, such basic energy renovation includes:

- insulation of the building envelope (roofs, walls, ground slabs and basement ceilings),
- replacement or refurbishment of window and door frames and joinery, installation of door closers,
- use of heat recovery in ventilation systems,
- use of ventilation control devices (air inlet vents, power exhaust ventilation),
- use of demand controlled ventilation (DCV),
- use of solutions to reduce cooling needs in summer,
- deployment of solutions for passive and active optimisation of the use of solar radiation in winter and prevention of interior overheating in summer,
- use of remotely readable heat meters and heat cost allocators, compatible with individual billings systems, and of remotely readable DHW meters,
- upgrade of the DHW system

There are many different envelope insulation technologies available on the market, such that can be used for insulating nearly any type of envelope element. The above applies both to envelopes made of standard technologies and those of industrial buildings based on advanced construction technologies. In each case, the energy auditor (or designer) is able to find the right solutions. Generally, there are wet methods, which require using adhesive mortars and plasters, and dry methods, in which the insulation is attached to the surface with mechanical fasteners and the wall is finished with ready-made cladding systems (metal sheet, curtain wall panels, concrete panels, etc.).

The market also offers a wide choice of window frame and joinery systems, with a great variety of solar transmittance performance and parameters (which influence heat gains from solar radiation, favourable in winter, but usually undesirable in summer). Therefore the type and parameters of window frames should be chosen by an energy auditor or the designer, after the local specificities related to the use of interior spaces are considered carefully. This is important from the point of view of optimising heat losses and gains in the interiors. In addition, the window frame/joinery installation systems should be chosen carefully. Consideration should be given to the tightness of installation (inter alia to prevent condensation of water vapour in high-humidity interiors and heat losses due to uncontrolled ventilation) and the need to the frames and joinery in a way eliminating thermal bridges. The above aspects will be less important in the case of storage rooms (where indoor temperatures are relatively low) or production spaces (where heat gains from production equipment are high), but will be relevant in the case of office or laboratory spaces, which must satisfy greater room usability and stability parameters.

Heat recovery in ventilation systems can produce considerable savings in terms of energy consumption so its use should be considered whenever thermal building renovation is planned. Heat recovery may also increase the qualities and use-related standard of interiors and ensure a higher comfort for users (which in turn improves the comfort of work and performance of employees).

The use of power extract ventilation systems or air inlet vents (automatic, humidity-controlled or manual) provides greater possibilities of controlling the ventilated air stream. By limiting the volume of such airflow at times when spaces are not used or are used to a limited extent, the demand of the ventilation system for heat can be reduced.

To some extent, power ventilation can also contribute to reducing the demand for cold in summer, since it can be used to store cold indoors at times of lower outdoor temperatures (e.g. at night). This allows for ventilation efficiency to be increased and interior spaces cooled, and then for the cold to be stored (in partitions and room furnishings) to be used at times of increased outdoor temperatures (during the day). The possibilities of such a system are limited, but often yield appreciable effects, especially in rooms with massive partitions, which have a greater potential for accumulation of heat or cold within their structure.

In the face of climate change, upward outdoor temperature trends and ever stricter building thermal protection standards, removing excess heat from buildings in summer and transitional periods will become a greater challenge than heating them. Therefore, an important role will be played by limiting heat gains from solar radiation penetrating through transparent envelope elements. This will be ensured, inter alia, by solutions for passive and active control of solar gains depending on the season (reduction in summer and maximisation in winter). They include a range of fixed (passive) external shading elements (green roofs and walls, trees, properly designed roofs and fixed shutters) and active elements (movable roller shutters, blinds, awnings and other external devices). Movable interior shading elements (indoor curtains and blinds) also give some control over solar gains, but their efficiency will be lower than that of external roller shutters and blinds.

When it comes to the use of waste heat from technological processes, it is key to ensure that the operation of the heating installation can be properly regulated. At times when waste heat flows, the automatic controls should be able to cut off or reduce the inflow of heat from the heating system into rooms (indoor temperature will then be maintained at a specific level thanks to the use of waste heat).

Waste heat can be obtained from various sources. It can be recovered from technological processes (machinery and devices), installations (e.g. air conditioning, compressed air systems), from exhaust gases or from product cooling in manufacturing processes, as well as from refrigeration equipment (e.g. refrigerated furniture in supermarkets or from data centre cooling systems). It is difficult to describe efficient heat recovery technologies, systems and installations in a general way. Every heat recovery system must be designed individually with the participation of a production technologist in such a way as to ensure that the proposed solutions do not disturb the production process and its efficiency and do not affect the product quality. Sometimes these can be complex solutions requiring the involvement of many professionals and specialised designers. Sometimes, as in the case of supermarkets, simpler solutions can be put in place to recover and reuse waste heat in the same building or to heat neighbouring buildings by using local low-temperature heat supply networks.

The heating installations (responsible for supplying heat to spaces) used in such solutions should have low thermal inertia (due to the need to ensure greater controllability). With low losses of heat through the building’s envelope and ventilation system (after deep energy renovation), the building should be heated by air heaters or heating elements with low thermal inertia. This allows for the amount of heat supplied to the building’s spaces to be managed dynamically, ensuring that heating elements can be shut off quickly when heat gains rise. Continued use of cast iron or tubular heaters will reduce the benefits produced by the utilisation of heat recovery from technological processes – such heaters will continue to supply heat to interiors for some time, affecting energy consumption.

The energy renovation principles described above apply to all types of buildings. Building types differ in internal design temperatures, ventilation air streams, temperature stability requirements, use schedules, indoor heat gains flux and air quality requirements. The diversity and variability of these parameters and their impact on the results of energy and economic efficiency analyses for a specific project can only be addressed on the basis of detailed technical analyses. The search for optimal solutions and scope of energy renovation should be carried out on the basis of energy audit procedures. This will prevent situations in which limited financial resources are expended on low-efficiency or even inefficient energy renovation investments.

It is also worth performing an audit on account of the potential availability of subsidies for activities related to the reduction of energy consumption and abatement of emissions and pollutants. In many cases, applying for such funds is conditional upon the need to have an energy audit performed in order to identify the optimal scope of work and estimate the achievable environmental effect.

Finally, it should be added that every planned renovation should encompass the preparation of design documentation. In addition, those in charge of energy renovation should make sure that the products and devices used in energy renovation have suitable certificates and documents, such as to allow them to be marketed on the EU market for construction products. It is also important to take into account issues related to the protection of the designer's copyright on the renovated building, especially if material-related solutions are to be changed in a way affecting the look and functionality of the building. Renovation should also take into account removal of harmful hazardous substances from the building, including asbestos, improvement of indoor air quality, as well as adaptation to climate change, in particular through the use of blue-green infrastructure (e.g. green roofs or rainwater management systems).

3.1. Energy efficiency and cost effectiveness of energy renovation investments

Most often, the energy efficiency of an energy renovation investment is measured as the percentage of post-renovation energy savings relative to the pre-renovation situation. There are many measures of the cost-effectiveness of an investment, i.e.:

- simple payback time (SPBT),
- discounted payback time (DPBT),
- net present value (NPV),
- internal rate of return (IRR);
- building life cycle cost or energy renovation investment life cycle cost (LCC).

For the purposes of this strategy an energy renovation, an investment is considered cost-effective if the cost of 1 GJ (277.78 kWh) of final energy savings, assuming that the outcomes of the energy renovation investment last fifteen years and that the prices on the investment completion date remain stable, is lower than the cost of 1 GJ (277.78 kWh) of final energy consumed before the renovation.

The cost of energy savings gained as a result of energy renovation, depending on its scope and existing heat source, may be lower than the energy price, which makes energy renovation economically viable. However, in some cases (actually only when buildings use cheap energy), despite the achievement of high energy and environmental efficiency, the viability of the investment may be questionable. In such situations, various systems of financial support for energy renovation must be put in place in order to encourage owners of buildings to renovate them. The cases analysed show that, given the considerable energy and environmental effects, the investments described should be carried out irrespective of economic efficiency.

The efficiency of energy renovation is much higher when its scope includes replacement of the heat source and of the central heating system (of course, if it is technically or economically viable).

3.2. Energy savings calculation methods

The energy savings calculations for the individual buildings have been made using monthly balances and hourly simulation methods with the following programs: Kocyk[18], Design Builder, Audytor OZC, CERTO, ATERM.

In the analysis, use has been made of the methodology described in:

- *Regulation of the Minister of Infrastructure of 17 March 2009 on the detailed scope and form of energy audits and parts of renovation audits, model audit sheets, and on the algorithm for evaluating the cost-effectiveness of energy renovation projects (Journal of Laws, item 346, as amended),*

- *Regulation of the Minister for Infrastructure and Development of 27 February 2015 on the methodology for calculating the energy performance of a building or part of a building and drafting energy performance certificates (Journal of Laws, item 376, as amended)* ,

- Standard PN-EN ISO 13790:2009 Energy performance characteristics of buildings – Calculation of energy consumption for heating and cooling purposes.

Examples of Kocyk calculations:

1. Entering the building data into the program.
2. Checking the results of the calculation of the building's key energy parameters (heat loss ratio, demand for usable, final and auxiliary energy).
3. Entering data on CO_2 emission factors and analysis of emission volumes.
4. Entering unit energy cost data and energy cost analysis.
5. Analysis of energy renovation variants.
6. Adoption or correction of the proposed post-renovation CO_2 emission factors for energy carriers.
7. Adoption or correction of the proposed post-renovation unit energy prices for energy carriers.
8. Entering data on renovation costs.
9. Printing the results of the analyses and summaries.

Once the data has been entered, Kocyk calculates the key transmission- and ventilation-related heat loss coefficients, as well as the absolute values of demand for usable and final energy for heating and DHW purposes, which provide an insight into the energy quality of the building. Additionally, it calculates the demand for electricity for auxiliary purposes.

The calculated values can be used for further energy audit-related analyses and if the data is changed – for analyses of energy renovation variants and variants linked to change in the building's energy standard.

Ultimately, Kocyk produces, inter alia, a summary of the effects of renovation, which includes the following:

- demand for usable energy for heating purposes (including DHW), kWh/year,
- pre-renovation heating system efficiency,
- post-renovation heating system efficiency,
- pre-renovation demand for auxiliary energy, kWh/year,
- post-renovation demand for auxiliary energy, kWh/year,
- pre-renovation energy costs, PLN/year,
- post-renovation energy costs, PLN/year,

[18] Kocyk is an application created by Krajowa Agencja Poszanowania Energii, which can be used for estimating the heat demand in a building and for conducting energy, economic and environmental simulations related to energy consumption in buildings.

- annual cost saving, PLN/year,
- total heating system upgrading cost, PLN,
- simple payback time, years,
- reduction of CO_2 emissions, tonnes/year.

3.3. The scope of shallow and deep energy renovation as illustrated by examples of actual buildings

The following sub-chapter presents examples of completed energy renovation projects for five types of buildings:

- single-family,
- multi-family,
- public,
- utility-industrial,
- warehouse.

The analysis covers two types of energy renovation (deep and shallow), as defined for the purposes of this Strategy (see: overview of key terms at the beginning of the document). Additionally, in the case of shallow energy renovation, for the purposes of this chapter, sets of activities providing the greatest cost-effectiveness (for a given building), such as to generate final energy savings of at least 25% of the baseline final energy consumption, are analysed. Such an approach can be used for comparing similar projects: comprehensive investments involving multiple actions aimed at material improvement of energy efficiency. The key difference between them lies in the fact that shallow energy renovation focuses on maximising the economic effect (selecting the most cost-effective actions), while deep energy renovation on maximising the energy effect (achieving performance consistent with the requirements of the Technical Conditions Regulation).

Table 13. Buildings which have undergone shallow energy renovation

Building type	Single-family	Multi-family	Public (primary school)	Utility-industrial	Warehouse
Climate zone	III	III	IV	III	III
Year built	1935	1982	1974	1962	1962
Area	145 m^2	3 700 m^2	3 312 m^2	885 m^2	201 m^2

Scope of renovation	upgrade of CH installation, upgrade of DHW installation, basement ceiling, new external entrance door, old external entrance door, aboveground external wall, basement's external wall, flat roof,	upgrade of CH installation, upgrade of DHW installation, flat roof over vestibule, external vestibule windows, external basement windows, basement ceiling, external entrance doors, base course, external structural wall, external curtain wall.	upgrade of CH installation, roof, external windows, external entrance doors, external walls.	upgrade of CH installation, thermal insulation of roof, replacement of external and glass block windows, door replacement.	upgrade of CH installation, thermal insulation of roof, door replacement.

Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

Table 14. Buildings which have undergone deep energy renovation

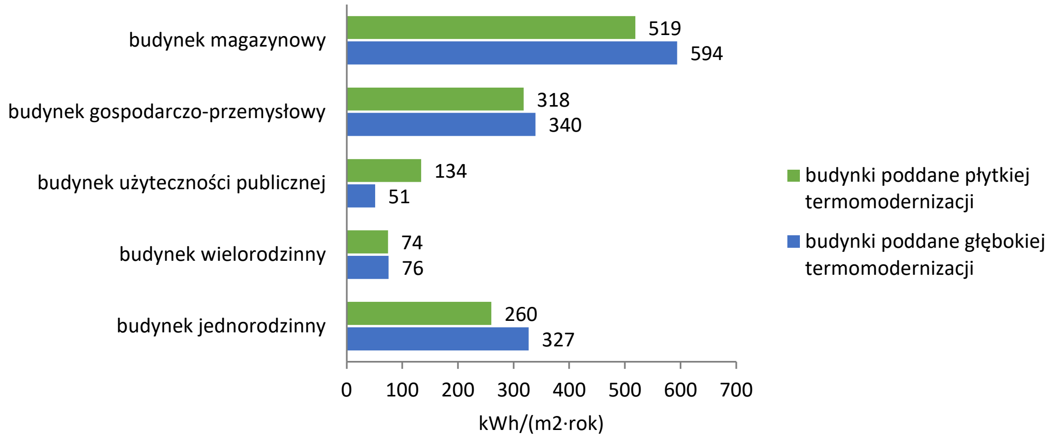
Building type	Single-family	Multi-family	Public (hospital)	Utility-industrial	Warehouse
Climate zone	IV	III	III	III	III
Year built	1960	1979	2002	1962	1962
Area	142 m^2	2 264 m^2	33 731 m^2	885 m^2	201 m^2
Scope of renovation	upgrade of CH installation with PV panels, non-ventilated flat roof, bay window external wall, ground floor external wall,	upgrade of CH installation, upgrade of DHW installation, flat roof over vestibule, basement external windows, external entrance doors, basement ceiling, base course, external structural wall, external curtain wall.	upgrade of CH installation, upgrade of DHW installation, external entrance doors, external windows, upgrade of chilled water installation, aboveground external walls, ceiling under unheated attic, flat roof, basement ceiling, ground wall.	upgrade of CH installation, thermal insulation of roof, replacement of external and glass block windows, door replacement. thermal insulation of external walls, upgrade of DHW installation,	upgrade of CH installation, thermal insulation of roof, door replacement. replacement of external windows; thermal insulation of external walls.

Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

3.4. Energy efficiency and economic efficiency of energy renovation as exemplified by real buildings

The charts below show the results of the analysis of the energy efficiency and economic efficiency for shallow and deep energy renovation of the buildings described in the previous sub-chapter.

Chart 5. Final energy savings in the buildings analysed after shallow and deep energy renovation

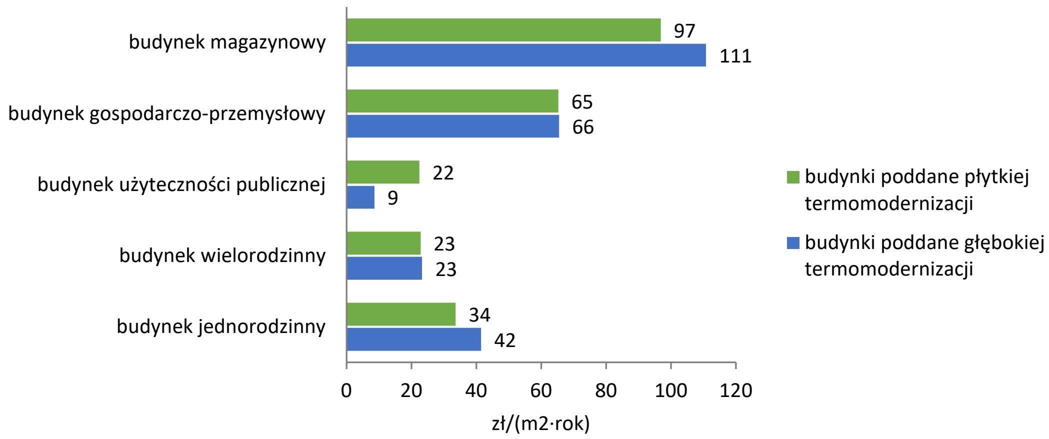


Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

budynek magazynowy	warehouse building
budynek gospodarczo-przemysłowy	utility-industrial building
budynek użyteczności publicznej	public building
budynek wielorodzinny	multi-family building
budynek jednorodzinny	single-family building
kWh/(m2·rok)	kWh/(m2·year)
budynki poddane płytkiej termomodernizacji	buildings which have undergone shallow energy renovation
budynki poddane głębokiej termomodernizacji	buildings which have undergone deep energy renovation

Energy savings have been recalculated for the usable floor area of the building. Deep energy renovation generates higher energy savings (10%) than shallow thermomodernisation. The public buildings, namely primary school (shallow energy renovation) and hospital (deep energy renovation), are specific cases in this analysis. Given the relatively late year when the hospital was erected (2002), the savings per square metre gained are much lower than in the primary school (1974), which has only undergone shallow energy renovation. The above shows that a greater energy effect can be achieved for older buildings. It follows from the analysis that potential for energy savings exists not only in residential buildings, but also in utility and industrial buildings.

Chart 6. Cost savings in the buildings analysed after shallow and deep energy renovation

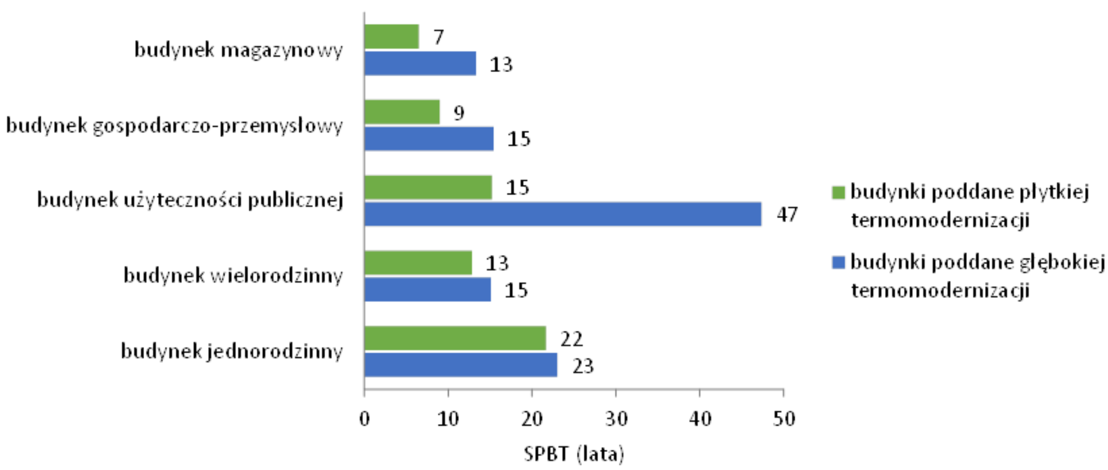


Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

budynek magazynowy	warehouse building
budynek gospodarczo-przemysłowy	utility-industrial buildings
budynek użyteczności publicznej	public buildings
budynek wielorodzinny	multi-family buildings
budynek jednorodzinny	single-family buildings
zł/(m2·rok)	PLN/(m2·year)
budynki poddane płytkiej termomodernizacji	buildings which have undergone shallow energy renovation
budynki poddane głębokiej termomodernizacji	buildings which have undergone deep energy renovation

The cost savings have also been recalculated for the building area. The relations between cost savings generated by shallow energy renovation and deep energy renovation and cost savings from one building to another are similar as in the case of energy savings. This reveals a close relationship between energy savings and savings on the costs of energy purchase.

Chart 7. Simple payback times (SPBT) for shallow and deep energy renovation as exemplified by the buildings analysed



Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego *typu budynków i strefy klimatycznej', KAPE 2020.*

budynek magazynowy	warehouse building
budynek gospodarczo-przemysłowy	utility-industrial buildings
budynek użyteczności publicznej	public buildings
budynek wielorodzinny	multi-family buildings
budynek jednorodzinny	single-family buildings
SPBT (lata)	SPBT (years)
budynki poddane płytkiej termomodernizacji	buildings which have undergone shallow energy renovation
budynki poddane głębokiej termomodernizacji	buildings which have undergone deep energy renovation

Simple payback time for renovation will vary strongly depending on the type of building, its location, year of erection, technical condition, amount of capex, current and future prices of energy carriers. However, it can be assumed that for residential buildings, energy renovation will pay off after 10-25 years, and for industrial and utility buildings after about 5-15 years. As can be seen in the charts above, for some public buildings the SPBT can be up to 50 years.

As is shown by the case studies, energy renovation of a building is a very complex process which requires addressing a range of factors influencing the viability of the renovation effort. This means that popularising energy audits is of crucial importance.

3.5. Energy efficiency of renovation of actual historic buildings

Energy renovation of historic buildings is specific due to conservation-related limitations (for example with regard to thermal insulation of external walls). It should be pointed out that despite these limitations, a range of solutions improving energy efficiency and reducing the emissivity of buildings can be utilised in individual cases, including: replacement of the energy source, thermal insulation of the attic ceiling, replacement or refurbishment of window frames and replacement of window glazing with energy-saving panes, replacement of lighting, wall drying and applying heat-insulating plasters (modern materials dedicated to thermal insulation of historic buildings, based on natural components such as silicon and lime) from outside or inside. The above allow for conservation activities to be combined with improvement of energy efficiency. However, despite the fast progress in the development of energy renovation technologies for historic buildings, there is still a need for research and development towards new solutions and materials in this area.

The calculations of energy savings resulting from energy renovation of historic buildings presented below are based on data for selected, existing buildings. Buildings with high energy consumption and typical functionalities have been selected for the calculations. However, it should be emphasised that energy renovation of a historic building requires analysing the possible solutions to improve energy efficiency while maintaining the historic value of a given building on a case-by-case basis. This means that it is not possible to define an exhaustive, detailed list of cost-effective energy renovation activities for the entire stock of historic buildings in this Strategy.

Information on the historic buildings analysed is provided in the table below.

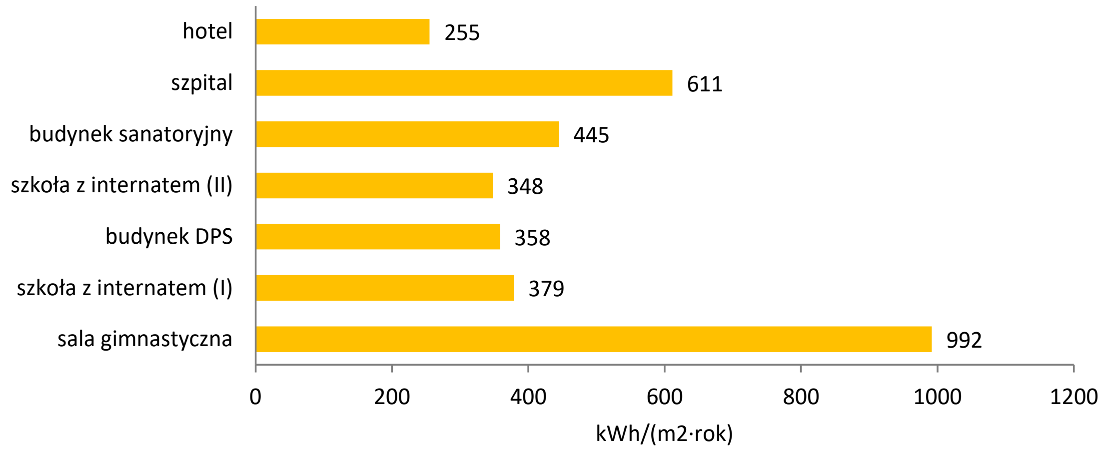
Table 15. Examples of energy renovation of historic buildings

Building type	Gym	Boarding school (I)	Nursing home building	Boarding school (II)	Sanatorium building	Hospital	Hotel
Climate zone	III	III	III	II	III	III	III
Year built	18th century	18th century	18th century	20th century	19th century	18th century	20th century
Area	858 m^2	7 563 m^2	3 382 m^2	4 390 m^2	7 831 m^2	3 404 m^2	7 347 m^2
Scope of renovation	upgrade of CH installation with heat pump, upgrade of DHW installation with heat pump, insulation of flat roof; insulation of ground slab, insulation of internal walls, replacement of window and door frames, installation of power ventilation.	upgrade of CH installation with heat pump, upgrade of DHW installation with heat pump, insulation of flat roof; insulation of attic ceiling, replacement of window and door frames,	upgrade of CH installation with heat pump, upgrade of DHW installation with heat pump, insulation of attic ceiling, insulation of underground wall, insulation of external wall, replacement of window and door frames, replacement of lighting.	upgrade of CH installation with connection to the district heating network, upgrade of DHW installation with an electric instantaneous water heater, insulation of ground slab, insulation of ceilings, insulation of underground wall, insulation of external wall, replacement of window and door frames, installation of power ventilation.	upgrade of CH installation with a gas boiler, upgrade of DHW installation with a gas boiler, insulation of ceiling, insulation of roof and flat roof, insulation of underground wall, thermal insulation of external wall, insulation of external wall, replacement of window and door frames,	upgrade of CH installation with a heat pump and gas boiler system, upgrade of DHW installation with a heat pump and gas boiler system, insulation of roof and flat roof, insulation of underground wall, insulation of external wall, thermal insulation of external wall, installation of a power ventilation system with heat recovery, replacement of window and door frames, replacement of lighting.	upgrade of CH installation with a gas boiler, upgrade of DHW installation with a gas boiler, insulation of roof, flat roof and ceilings, insulation of underground wall, insulation of external wall, replacement of window and door frames,

Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

The results of energy and cost analysis for the energy renovation of the above buildings are presented in the charts below.

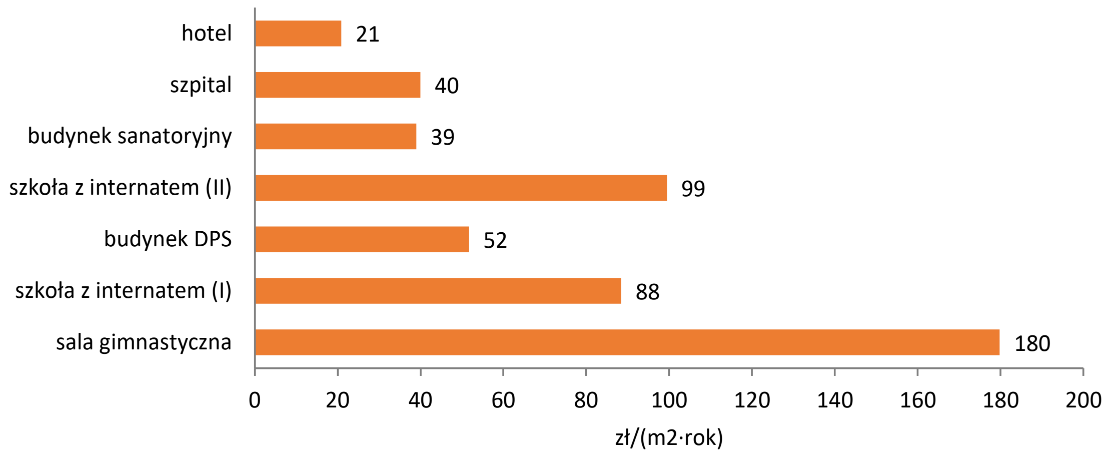
Chart 8. Final energy savings generated by renovation of the historic buildings analysed



Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

hotel	hotel
szpital	hospital
budynek sanatoryjny	sanatorium building
szkoła z internatem (II)	boarding school (II)
budynek DPS	nursing home building
szkoła z internatem (I)	boarding school (I)
sala gimnastyczna	gym
kWh/(m2·rok)	kWh/(m2·year)

Chart 9. Energy cost savings generated by renovation of the historic buildings analysed

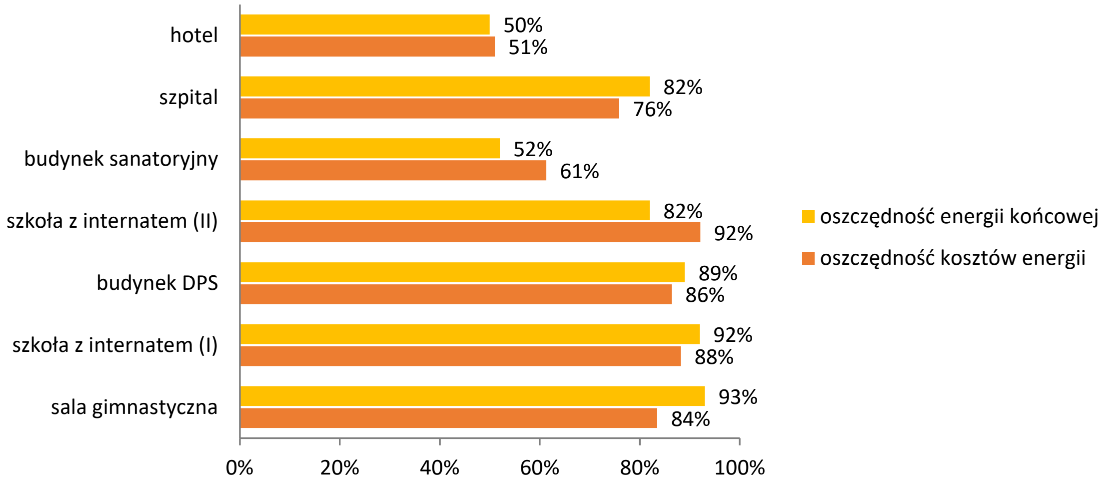


Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

hotel	hotel
szpital	hospital
budynek sanatoryjny	sanatorium building
szkoła z internatem (II)	boarding school (II)
budynek DPS	nursing home building
szkoła z internatem (I)	boarding school (I)
sala gimnastyczna	gym
zł/(m2·rok)	PLN/(m2·year)

The savings potential for both final energy and its costs for historic public buildings is very high. FE savings range from 50% to even 93%. Given their respective functions, the renovated historic public buildings which have undergone the energy renovation whose results are presented in Chart 10 were characterised by high energy consumption before the renovation. The monument conservator agreed to shallow energy renovation. With shallow energy renovation, coupled with the use of RES (heat pumps with solar panels), of buildings under a conservator's protection and built before 1961, the achievable reduction in energy consumption will amount to 60-90%.

Chart 10. Percentage final energy and FE cost savings generated by energy renovation of the historic buildings analysed



Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

hotel	hotel
szpital	hospital
budynek sanatoryjny	sanatorium building
szkoła z internatem (II)	boarding school (II)
budynek DPS	nursing home building
szkoła z internatem (I)	boarding school (I)
sala gimnastyczna	gym
oszczędność energii końcowej	final energy savings [kWh]
oszczędność kosztów energii	energy cost savings

It should be remembered that historic buildings are subject to special protection and the specificities of renovation must be consulted with the monument conservator. However, given that the savings potential in this area is high, it should be exploited optimally.

3.6. Forecast viability of deep energy renovation under conditions of climate neutrality

In a climate-neutral economy, widespread zero-emissivity of the building stock can be achieved through:

- the connection of buildings to zero-emission district heating networks,
- the installation of heat sources powered by zero-emission power systems:
  - heat pumps,
  - electric heating, including the use of heating cables and mats,
- the installation of biomass sources (to a limited extent of up to 10-12% of the building stock, which results from the potential for sustainable biomass sourcing),

- the connection of buildings to a gas network supplied by zero-emission fuels (biomethane, hydrogen, SNG),
- the installation of zero-emission heat sources based on solar radiation heat (solar collectors, photovoltaic thermal collectors with heat storage functions).

Given the limited potential of biomass sources, the rest of the analysis focuses on buildings connected to a zero-emission heating network or zero-emission heat sources powered by electricity[19]. Deep energy renovation of these buildings will include at least:

- insulation of the envelope plus removal of asbestos-containing products and selection of materials with a view to reducing embedded emissions, i.e. those arising during production,
- replacement of window and door frames.

In the case of electrically heated buildings, consideration is also given to deep energy renovation, which includes replacement of the heat source with a heat pump.

In buildings supplied by a district heating network and heated electrically, deep energy renovation should produce a target final energy factor for heating, ventilation and domestic hot water preparation of not more than 60 kWh/(m^2·year). However, in the case of heat pump-supplied buildings and buildings where a heat pump has been installed as a result of deep energy renovation, the target final energy factor for heating, ventilation and domestic hot water preparation should not be higher than 30 kWh/(m^2·year). It should be emphasised that the above assumptions apply only to analyses of the viability of deep energy renovation under the climate neutrality conditions presented in this sub-chapter and should not be transposed to analyses of the economic efficiency and energy efficiency of energy renovation in the current market and regulatory environment, as described in sub-chapters 3.4 and 3.5.

The condition of the building before energy renovation is described by the final energy factor for heating, ventilation and domestic hot water preparation.

Table 16. Pre-renovation FEFs for the buildings analysed

Pre-renovation condition	**Pre-renovation FEFs for the buildings analysed**	
	Buildings supplied by a district heating network and electrically heated	**Buildings supplied by heat pumps**
Critical	300 kWh/(m^2·year)	150 kWh/(m^2·year)
Very poor	250 kWh/(m^2·year)	125 kWh/(m^2·year)
Poor	200 kWh/(m^2·year)	100 kWh/(m^2·year)
Average	150 kWh/(m^2·year)	75 kWh/(m^2·year)

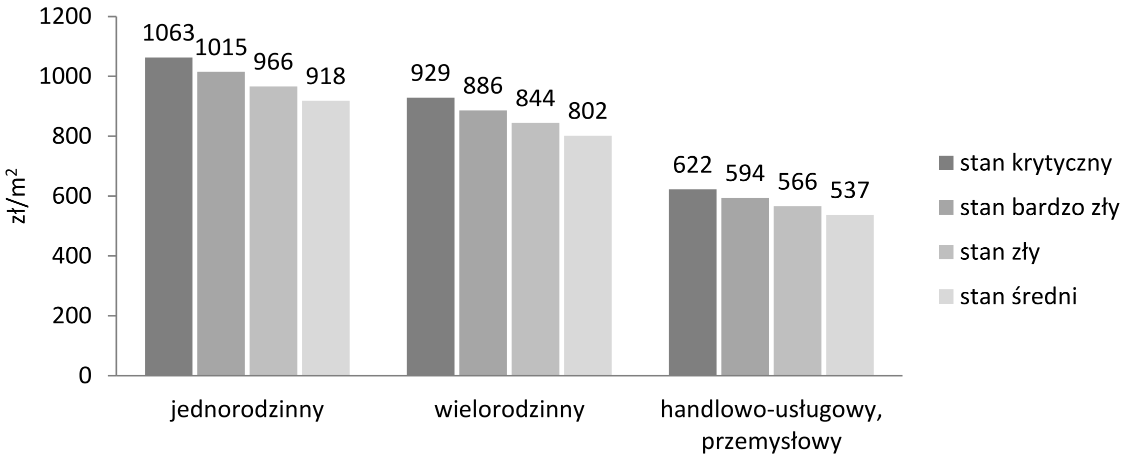
Source: KAPE's own assumptions.

The distinction between the FEF in buildings supplied by a district heating network and heated electrically and the FEF in heat pump-supplied buildings stems from the fact that, for the same demand for usable energy (i.e. for a similar building insulation standard), the final energy for heat pump-supplied buildings is about twice lower (assuming the average heat pump seasonal performance factor of 2).

[19] The findings of the analyses also apply to zero-emission gaseous fuels. Given the relatively high energy intensity of their production, the unit costs of using these fuels are not expected to be lower than those of electricity in the future. Nevertheless, their use may be reasonable for other reasons, such as the availability of suitable energy infrastructure. Regardless of what zero-emission energy carrier is chosen, the viability of deep energy renovation improves significantly when the pre- and post-renovation situations are compared.

The chart below shows the estimated costs of deep energy renovation with no replacement of the heat source in 2035 for the various types of buildings depending on the pre-renovation condition of the building.

Chart 11. Estimated costs of deep energy renovation with no replacement of the heat source in 2035 for single-family, multi-family, and commercial and industrial buildings, depending on the pre-renovation condition

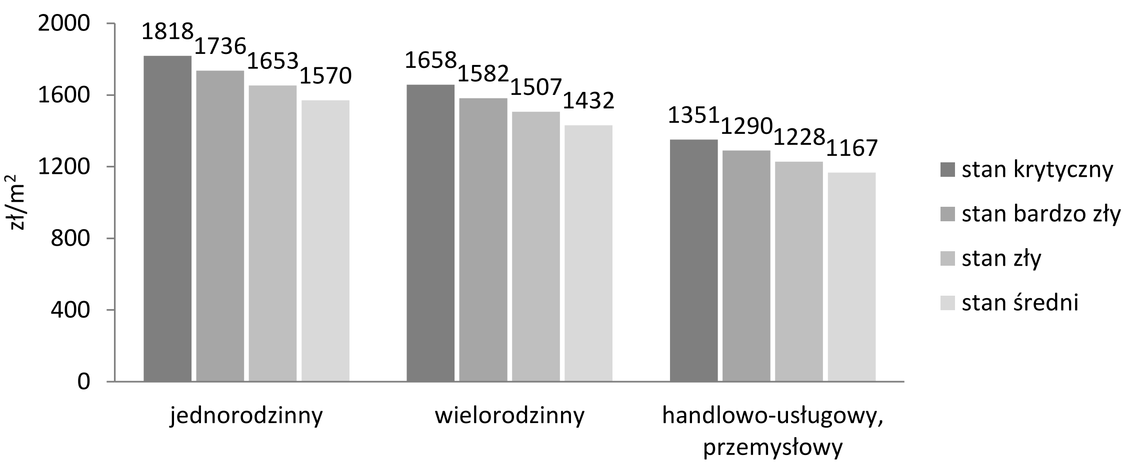


Source: KAPE estimates based on Biuletyny Zagregowane SEKOCENBUD.

zł/m^2	PLN/m^2
stan krytyczny	critical condition
stan bardzo zły	very poor condition
stan zły	poor condition
stan średni	average condition
jednorodzinny	single-family
wielorodzinny	multi-family
handlowo-usługowy, przemysłowy	commercial and industrial

The cost of deep energy renovation of electrically heated buildings with the installation of a heat pump is as follows.

Chart 12. Estimated costs of deep energy renovation with the installation of a heat pump in 2035 for single-family, multi-family, and commercial and industrial buildings, depending on the pre-renovation condition

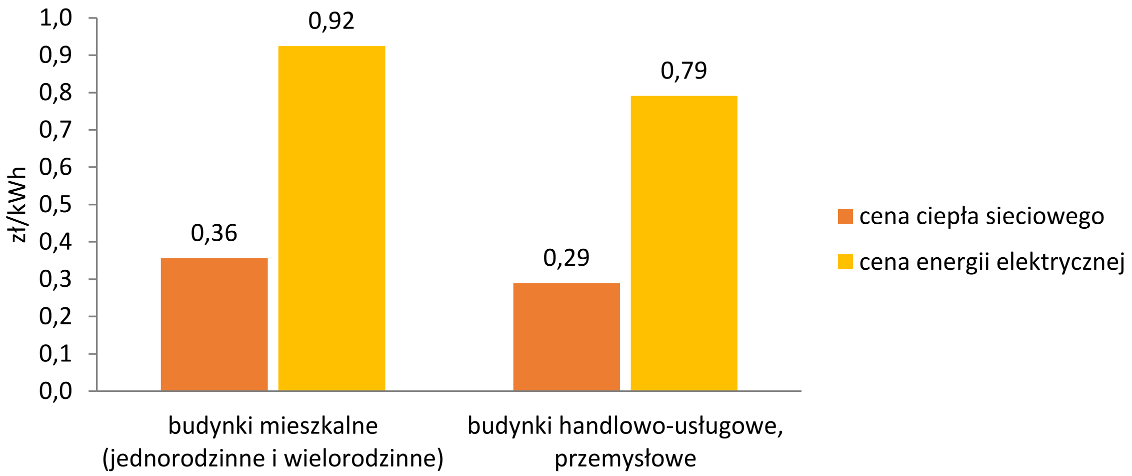


Source: KAPE estimates based on Biuletyny Zagregowane SEKOCENBUD.

zł/m²	PLN/m²
stan krytyczny	critical condition
stan bardzo zły	very poor condition
stan zły	poor condition
stan średni	average condition
jednorodzinny	single-family
wielorodzinny	multi-family
handlowo-usługowy, przemysłowy	commercial and industrial

The energy system modelling has also produced the average price of heat and electricity for the final consumer in a zero-emission economy (2035-2050 average). The analyses completed show that these prices will almost double compared to 2020.

Chart 13. Estimated price of district heat and electricity in 2035-2050 under conditions of climate neutrality (PLN / kWh)



Source: WiseEuropa and KAPE calculations based on the modelling of scenarios of transition to a climate-neutral economy using the PRIMES model.

zł/kWh	PLN/kWh
budynki mieszkalne (jednorodzinne i wielorodzinne)	residential (single-family and multi-family) buildings
budynki handlowo-usługowe, przemysłowe	commercial and industrial buildings
cena ciepła sieciowego	district heat price
cena energii elektrycznej	electricity price

The calculations of the viability of deep energy renovation under conditions of climate neutrality based on the estimated 2035 costs of deep energy renovation and the forecast price of district heat and electricity in a zero-emission economy are presented below.

For convenience purposes, a colour scale is used for the individual energy renovation simple payback times:

- SPBT < 5 years dark green
- SPBT < 10 years light green
- SPBT < 15 years yellow
- SPBT < 20 years dark yellow
- SPBT ≥ 20 years orange

Table 17. Deep energy renovation simple payback times under conditions of climate neutrality for single-family buildings [years]

	pre-renovation building condition			
scope of energy renovation for a single-family building	critical	very poor	poor	average
thermal insulation of walls and roof, replacement of windows and doors (building supplied by a district heating network)	12.4	15.0	19.4	28.6
thermal insulation of walls and roof, replacement of windows and doors (electrically heated building)	4.1	4.9	6.4	9.4
thermal insulation of walls and roof, replacement of windows and doors (building with a heat pump)	8.2	9.9	12.8	18.9
thermal insulation of walls and roof, replacement of windows and doors, installation with a heat pump (electrically heated building)	6.2	7.3	9.0	12.1

Source: KAPE calculations.

Table 18. Deep energy renovation simple payback times under conditions of climate neutrality for multi-family buildings [years]

	pre-renovation building condition			
scope of energy renovation for a multi-family building	critical	very poor	poor	average
thermal insulation of walls and roof, replacement of windows and doors (building supplied by a district heating network)	10.9	13.1	16.9	25.0
thermal insulation of walls and roof, replacement of windows and doors (electrically heated building)	3.6	4.3	5.6	8.2
thermal insulation of walls and roof, replacement of windows and doors (building with a heat pump)	7.2	8.6	11.2	16.5
thermal insulation of walls and roof, replacement of windows and doors, installation with a heat pump (electrically heated building)	5.7	6.6	8.2	11.0

Source: KAPE calculations.

Table 19. Deep energy renovation simple payback times under conditions of climate neutrality for commercial and industrial buildings [years]

	pre-renovation building condition			
scope of energy renovation for a commercial/industrial building	critical	very poor	poor	average
thermal insulation of walls and roof, replacement of windows and doors (building supplied by a district heating network)	9.0	10.8	14.0	20.6

thermal insulation of walls and roof, replacement of windows and doors (electrically heated building)	2.1	2.5	3.2	4.7
thermal insulation of walls and roof, replacement of windows and doors (building with a heat pump)	4.1	4.9	6.4	9.4
thermal insulation of walls and roof, replacement of windows and doors, installation with a heat pump (electrically heated building)	4.0	4.6	5.7	7.7

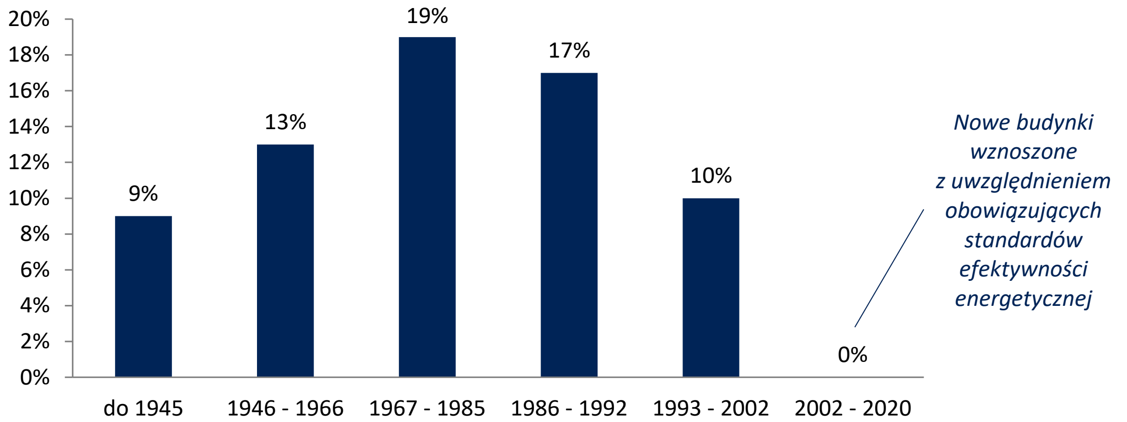
Source: KAPE calculations.

It follows from the calculations that deep energy renovation will be particularly viable in buildings with a poor energy standard and forced to rely on their own zero-emission heat sources under conditions of climate neutrality, due to them being unconnected to a district heating network. In these cases, the simple payback time will be shorter than 10 years. In the case of buildings connected to a district heating network with a poor energy standard, the payback time will be approx. 15-20 years.

3.7. Estimation of the total potential for energy savings and reduction of emissions as a result of viable building renovation

As at the end of 2019, the total area of residential buildings was 1 101 686 000 m^2, while that of non-residential buildings 464 730 000 m^2. The chart below shows the expected share of residential buildings to be renovated by 2020. It is assumed that owners of buildings which have undergone thermomodernisation will not be willing to renovate them again in order to raise energy standards due to the non-viability of such additional renovation effort. The smallest share of buildings which have undergone energy renovation is represented by those erected before 1945, i.e. those with the highest final energy factor. These buildings face many barriers to shallow renovation, including the financial barrier for owners and the protection of historic buildings.

Chart 14. Expected percentages of residential buildings to undergo energy renovation

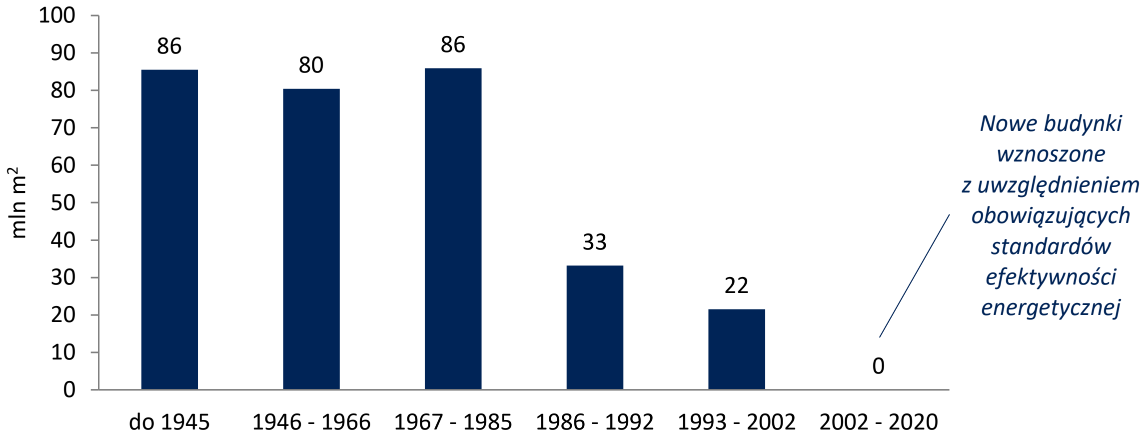


Source: KAPE calculations.

Nowe budynki wznoszone z uwzględnieniem obowiązujących standardów efektywności energetycznej	New buildings erected in compliance with the applicable energy-efficiency standards
do 1945	up to 1945

The next chart shows the usable area of buildings net of buildings which have already undergone an energy retrofit and buildings under conservation protection in 2019.

Chart 15. Area of residential buildings to undergo potential energy renovation



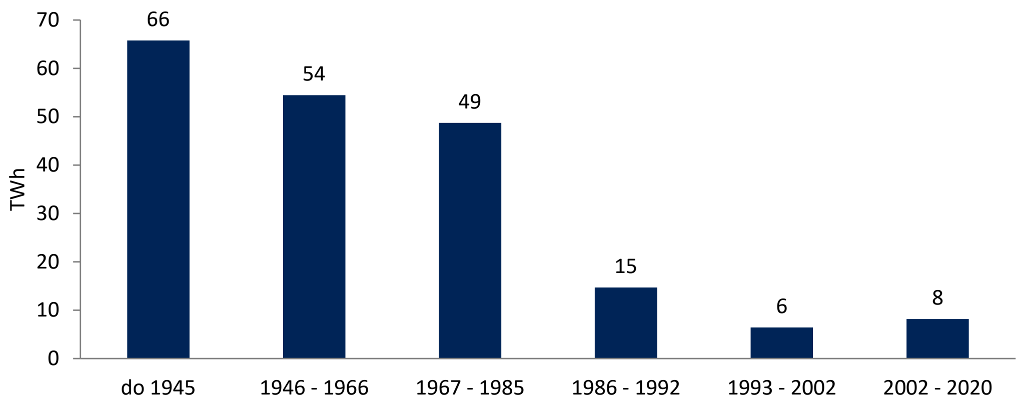
Source: KAPE calculations.

Nowe budynki wznoszone z uwzględnieniem obowiązujących standardów efektywności energetycznej	New buildings erected in compliance with the applicable energy-efficiency standards
mln m^2	million m^2
do 1945	up to 1945

Energy renovation reduces the final energy demand of renovated buildings. The estimated annual final energy demand, by years of construction, is presented in the chart below.

In the case of public buildings, it is estimated that approximately 45% of them underwent energy renovation by 2019. Taking into account projects carried out currently by public institutions and those planned until 2025, the percentage of thermomodernised buildings is estimated to increase to approximately 55-60%.

Chart 16. Estimated annual final energy demand of residential buildings by year built



Source: KAPE calculations.

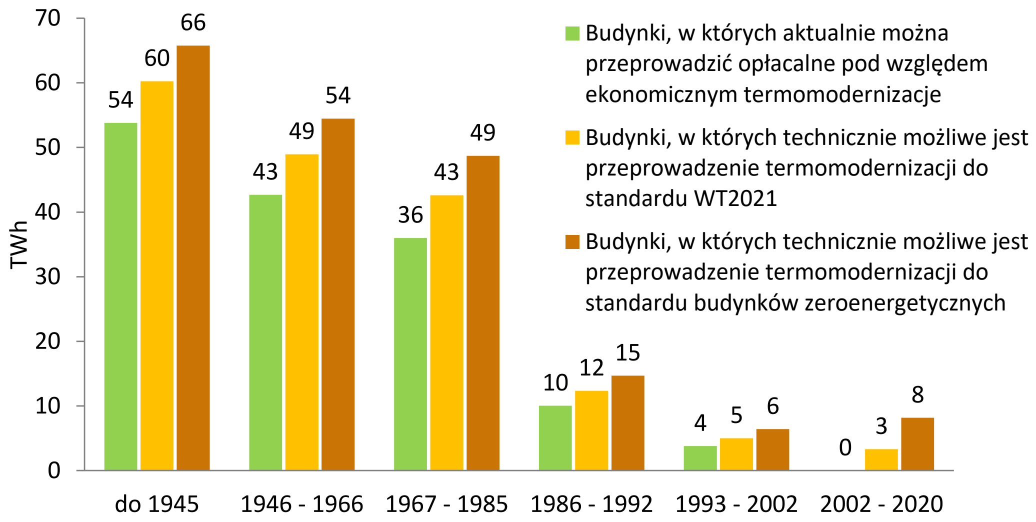
do 1945	up to 1945
TWh	TWh

The chart below shows the results of estimations of the potential for final energy savings in residential buildings where:

- economically viable energy renovations are feasible,
- energy renovation to the WT2021 standard (i.e. that specified in the Technical Conditions Regulation for new buildings constructed as from 31 December 2020) is technically feasible,

- energy renovation to the standard of net zero energy buildings, i.e. buildings with net zero demand for non-renewable primary energy, is technically feasible – these assumptions are adopted for the purposes of this sub-chapter.

Chart 17. Potential for final energy savings in residential buildings



Source: KAPE calculations.

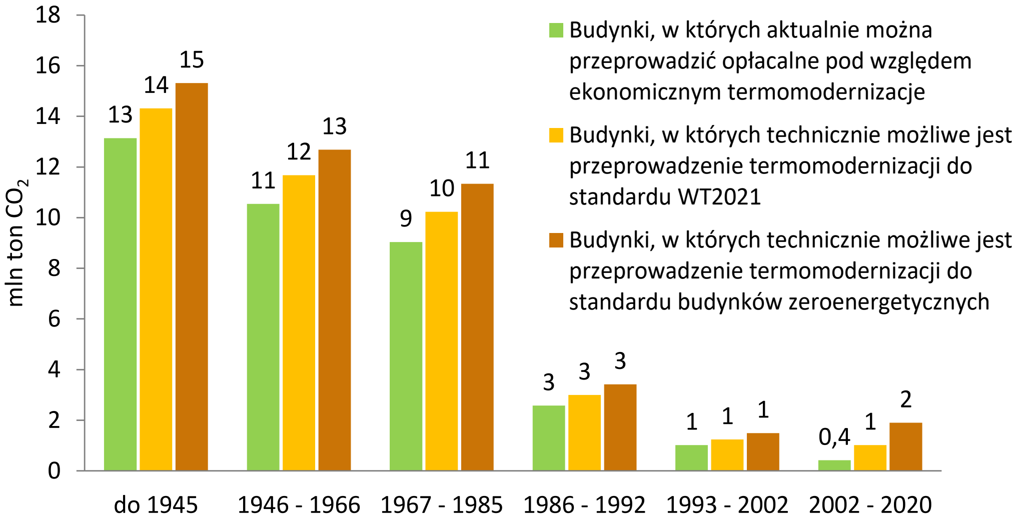
TWh	TWh
Budynki, w których aktualnie można przeprowadzić opłacalne pod względem ekonomicznym termomodernizacje	Buildings in which economically viable energy renovations are currently feasible
Budynki, w których technicznie możliwe jest przeprowadzenie termomodernizacji do standardu WT2021	Buildings in which energy renovation to the WT2021 standard is technically feasible
Budynki, w których technicznie możliwe jest przeprowadzenie termomodernizacji do standardu budynków zeroenergetycznych	Buildings in which energy renovation to the standard of zero energy buildings is technically feasible
do 1945	up to 1945

Overall, economically viable energy renovation has the potential to generate final energy savings in residential buildings of up to **147 TWh**, which amounts to approximately **75%** of their current final energy demand.

The chart below shows the estimated greenhouse gas emission reduction volumes for buildings where:

- economically viable energy renovations are feasible,
- energy renovation to the WT2021 standard is technically feasible,
- energy renovation to the standard of net zero energy buildings is technically feasible.

Chart 18. GHG emission reduction volume for residential buildings



Source: KAPE calculations.

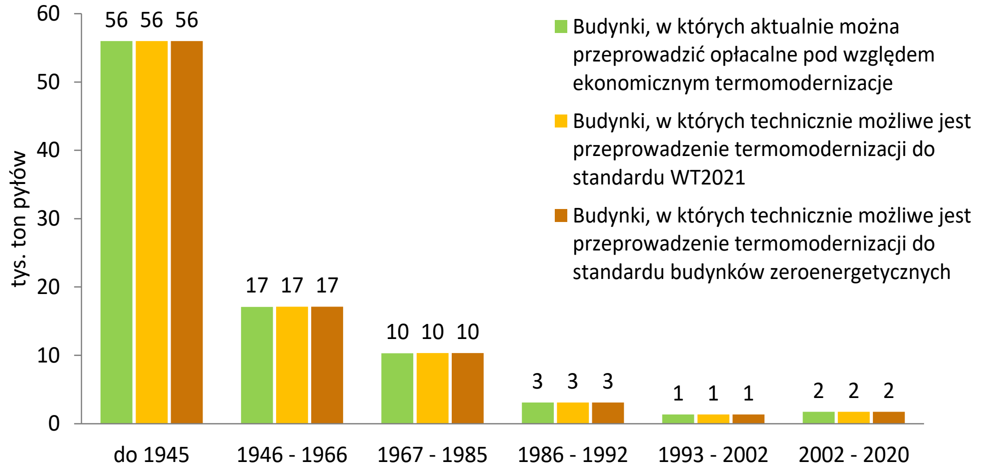
mln ton CO_2	million tonnes of CO_2
Budynki, w których aktualnie można przeprowadzić opłacalne pod względem ekonomicznym termomodernizacje	Buildings in which economically viable energy renovations are currently feasible
Budynki, w których technicznie możliwe jest przeprowadzenie termomodernizacji do standardu WT2021	Buildings in which energy renovation to the WT2021 standard is technically feasible
Budynki, w których technicznie możliwe jest przeprowadzenie termomodernizacji do standardu budynków zeroenergetycznych	Buildings in which energy renovation to the standard of zero energy buildings is technically feasible
do 1945	up to 1945

Overall, economically viable energy renovation has the potential to **reduce CO_2 emissions by over 37 million tonnes per year**, which represents approximately **10% of the total annual greenhouse gas emissions** in Poland.

The chart below shows the estimated particulate matter emission reduction volumes for residential buildings where:

- economically viable energy renovations are feasible,
- energy renovation to the WT2021 standard is technically feasible,
- energy renovation to the standard of net zero energy buildings is technically feasible.

Chart 19. Particulate matter emission reduction volume for residential buildings



Source: KAPE calculations.

tys. ton pyłów	thousand tonnes of dust
Budynki, w których aktualnie można przeprowadzić opłacalne pod względem ekonomicznym termomodernizacje	Buildings in which economically viable energy renovations are currently feasible
Budynki, w których technicznie możliwe jest przeprowadzenie termomodernizacji do standardu WT2021	Buildings in which energy renovation to the WT2021 standard is technically feasible
Budynki, w których technicznie możliwe jest przeprowadzenie termomodernizacji do standardu budynków zeroenergetycznych	Buildings in which energy renovation to the standard of zero energy buildings is technically feasible
do 1945	up to 1945

Overall, economically viable energy renovation has the potential to reduce particulate matter emissions by around **89 000 tonnes per year**, which accounts for about a **quarter of the total PM** emissions in Poland. As regards energy renovation which involves removing asbestos-containing products, mention should also be made of the pollution of air by harmful asbestos fibres released into the air from damaged roof and elevation asbestos-containing materials.

3.8. Selecting and assessing appropriate renovation trigger point in the building's lifecycle

A trigger point in the building's lifecycle is defined as the technical or economically most appropriate moment for renovation activities.

In the light of the above definition, the points in the life cycle of the building opportune for altering it in technical terms have been defined.

Trigger points can be as follows:

- the moment when some building or installation elements lose their durability – individual elements of a building have different useful lives (e.g. about 25-30 years for thermal insulation, 50-100 years for the load-bearing structure),
- the acquisition of a building by an owner who wants to renovate it,
- change of the purpose of the building, such that requires major renovation or conversion,
- repair of damage to the building or its element, e.g. roof, along with removal of asbestos-containing products,

- need to rectify technical defects resulting from technological errors, e.g. insulation falling off the walls,
- retrofit of a production line or implementation of a new technology in an industrial plant or at a service provider's,
- expansion of a building (e.g. adding a superstructure or conversion of the attic to gain more useful floor area).

At the building use stage, various energy renovation projects can be executed. For most of the above trigger points, there is a correlation between energy renovation projects and trigger points at the building use stage. This correlation does not exist only in the case of the trigger points related to:

- the retrofit of a production line or implementation of a new technology in an industrial plant or at a service provider's premises,
- the acquisition of a building by an owner who wants to renovate it,
- change of the purpose of the building, such that requires major renovation or conversion,

Thus, for these trigger points, retrofit activities can be completed in the standard sequence.

However, the sequence of energy renovation actions is usually changed when building damage is to be repaired, e.g. in the case of heavy roof damage, which entails removal of asbestos-containing products, the structure can be reinforced or re-constructed so that thicker thermal insulation can be applied. When the building is expanded upwards, it is necessary to match the thermal insulation of the entire building to the current requirements of the Technical Conditions Regulation and to remove any asbestos-containing products from the building facade.

Changes in the sequence of energy renovation projects, if any, are required in the first place when removal of technical defects and damage is needed. It must be remembered that heating system retrofits should be undertaken once all the work on the building envelope has been completed, unless the heating system has failed or is past its useful life.

Trigger points related to economic and legal considerations include:

- time before the sale of the building – renovation can significantly increase the selling price of the property,
- time after the launch of a building renovation co-funding scheme – acquiring such support will allow some investors to undertake projects for which they previously lacked funds, e.g. removal of asbestos-containing products,
- payment of building insurance compensation,
- surplus funds on the account of an association of flat owners or housing cooperative,
- prohibition on the use of certain fuels or changes to the local zoning plan,
- periodic, legally required technical inspections of the building.

Very often, trigger points related to the technical feasibility of energy renovation in the lifecycle of a building converge with those relevant from the economic and legal perspective, e.g.: the need to carry out a major renovation of the building coincides with the launch of energy renovation support scheme and the ban on the use of solid fuel boilers.

Controlling the initiation of renovation activities in the lifecycle of buildings by central or local governments requires appropriate tools. One of them is the INVESTIMMO computer system, a tool under the 5th European Union Framework Programme supporting decisions regarding long-term investment strategies related to maintenance and energy renovation of buildings.

The INVESTIMMO system is a tool which can be used for analysing the effects of a renovation decision for a group of buildings or structures in a specific area. The INVESTIMMO multimedia software tool is designed for:

- public and municipal construction companies,

- developers,
- individual building owners,
- decision makers,
- banks which collaterise loans,
- insurance companies (insurance risk assessment).

Owners (managers) of medium or large housing stocks can use the software to define quantitatively and qualitatively the desired portfolio of assets (or the desired portfolio changes). The maintenance staff of public or private entities can use the software to plan and rationalise ongoing maintenance and renovation processes. Public authorities wishing to influence building renovation investment policy making can use it when deciding on the use of investment incentives. Financial institutions can use it to control loan collaterals and the long-term effectiveness of the funding of investments.

Trigger points should always be exploited by the building owner or building manager on the owner's behalf. However, potential trigger points should be identified by construction and installation professionals, especially by persons who carry out various types of inspections (building supervision inspectors, chimney sweeps, firefighters, power engineers, heating engineers, gas engineers, etc.).

Trigger points can provide a good opportunity to evaluate issues related to

building safety and vice versa – taking safety measures may be a good moment for taking action to improve the energy efficiency of the building. Regular inspections (especially before renovation) and retrofits undertaken to ensure that the electrical installation complies with the applicable safety standards are particularly important moments in the lifecycle of a building. The relevant entities in charge of safety inspections of electrical, heating and gas installations and equipment should be encouraged to bring energy consumption issues to the attention of building owners upon the necessary renovation of these installations. Prior to renovation, an assessment of the impact of the planned solutions on the fire safety of the building should be carried out.

4. Market barriers and failures which hinder the tapping of potential for cost-effective renovation

Pursuant to Article 2a(1)(d) of Directive 2010/31, strategies should address split-incentive dilemmas and market failures.

Financial barriers

Many a time, energy renovation is an undertaking that requires substantial capital expenditure and is characterised by a long payback time. As a result, often private investors (e.g. ESCOs) do not consider energy renovation to be a viable investment. Meanwhile, sometimes building owners do not have adequate funds to undertake energy renovation actions. People who rent out flats do not carry out energy retrofits, as the funds spent on this purpose will not pay off during the rental period. The lack of long-term, easily available and low-interest loans for energy renovation is also an issue. Additionally, in the case of decisions regarding smaller renovation projects (e.g. limited to insulation of walls), the costs linked to the commencement of activities and finding suitable contractors are disproportionately high.

If the pace of energy renovation investments accelerates suddenly, there is a risk that the market prices for the necessary equipment, materials and services will rise. This effect is bound to lose relevance in the long term as the supply aligns to the increased demand, but it may entail a slowdown in investments in the short term. Counteracting it requires actions both on the demand side (gradual and predictable scaling up of investments such as to balance demand and supply, see chapter 9) and on the supply side (support for technology development and workforce training, see chapters 6 and 7).

Technical barriers

In the case of old buildings, a problem is posed by poor condition of their structures, which makes it impossible for suitable retrofit measures to be taken – e.g. external walls will not support the additional weight of insulation, the roof (e.g. made of asbestos-containing products) does not allow for a PV system or collectors to be installed.

It also happens that inadequate expertise on the part of contractors (construction companies, architects, site managers) leads to errors in the design and execution of renovation activities, which affects the parameters of renovated buildings. Knowledge about the building and the materials of which it is made, as well as an analysis of the technical documentation, will be instrumental for determining whether the building contains asbestos-containing products which should be removed immediately during the planned upgrading works.

Removing asbestos-containing materials may prove impossible for technical, economic and social reasons. This may be the case when asbestos-cement sandwich panels are used for the construction of external walls in multi-family buildings and public buildings, e.g. in hospitals, where finding replacement accommodation for the time when the renovation continues is impossible. In such a case, the only solution is to cover such asbestos-containing panels by other materials so as to prevent the release of asbestos into the air as a result of the destruction of the panels.

Another problem is posed by the excessive thickness of conventional thermal insulation materials (foamed polystyrene, mineral wool) needed to ensure the desired performance of the envelope in the case of deep energy renovation. Modern, innovative thermomodernisation materials (e.g. aerogels) which can significantly reduce the thickness and weight of the insulation are expensive. Another problem is posed by failure by some manufacturers to meet the parameters of insulation materials (e.g. density).

A number of technical challenges are generated by energy renovation of protected historic buildings. It should only involve works which cause minimal damage to historic qualities, as defined by the Historic Monuments Act of 23 July 2003 (Journal of Laws 2021, item 710, as amended), based on solutions acceptable to the conservation services and in accordance with the guidelines of the General Monument Conservator[20]. This may make it impossible for high energy performance of buildings, especially of the envelope, to be attained. In such a case, reducing the demand for non-renewable primary energy will require increasing direct utilisation of renewable energy. If also this impossible due to conservation-related constraints, reduction in non-renewable primary energy consumption will need to be sought over a longer period, indirectly, in line with the transformation of the entire Polish energy sector (replacement of electricity and district heat production technologies, use of low-emission alternatives to natural gas). Energy renovation of historic buildings is also hindered by difficulties in obtaining funds and financial support from cross-sectional national and European energy-efficiency programmes in cases when the required energy performance parameters cannot be achieved.

Information barriers

One major barrier is the insufficient system of information on the benefits of energy renovation and support instruments available. Awareness-raising campaigns on how to save electricity, water and heat in buildings reach only some households.

Split of incentives

Split of incentives is observed primarily in the following areas:

<u>Divergent energy efficiency interests</u> exist where the final consumer is responsible for paying the energy bills, but is not in the position to choose the technology needed to improve the energy performance of the premises and thus has limited possibilities of reducing the energy bills. The landlord-tenant dilemma in the case of flat rental and leasing exemplify such divergent interests. If interests diverge, owners lack incentives to invest in energy efficiency improvement as this will not produce direct and immediate benefits. Furthermore, it is difficult to recover the costs incurred by increasing the rent due to the uncertainty about the impact of increased energy efficiency on the value of the property.

<u>Split of use-related incentives</u> exists when tenants are not responsible for paying the utility bills because the owner pays the costs. As a result, not only are tenants not incentivised to save energy, but they also tend to consume more of it. Such incentive-split occurs, for example, in the hospitality industry.

<u>Split of incentives related to the existence of multiple tenants and owners</u> arise where the responsibility for deciding on whether to improve energy efficiency is distributed among a number of participants and is collective. This requires reaching a consensus, which can be even more difficult if the costs and benefits of improving energy efficiency differ from one user to another. Associations of flat owners, who take decisions collectively, are one way of overcoming such barriers.

<u>Incentive-split related to temporary use</u> occurs when there is a high rotation of property users, which means a high likelihood that the investment in energy efficiency will not pay off. In such a

[20] Guidelines of the General Monument Conservator of 28.02.2020 (ref.: DOZ.070.2.2020.JW) on the protection of the value of cultural heritage in the process of improving energy performance of historic buildings https://samorzad.nid.pl/publikacje/standardy-termomodernizacji-obiektow-zabytkowych/ .

case, improving energy performance, which entails a high initial capital cost, can be viewed as risky.[21]

From the Polish perspective, specific features of the building stock structure are important. Almost half of the country's population live in single-family buildings, and the share of people residing in rented buildings is about twice lower than the EU average. This reduces the impact of split incentive. Poland focuses public intervention on such areas as energy renovation of multi-family blocks of flats, reducing 'low-stack' emissions generated by single-family houses using poor-quality fuels, and counteracting energy poverty. In the case of single-family buildings, energy renovation is often prevented by the unregulated legal status of the property, as a result of which public support instruments cannot be taken advantage of.

The split incentive problems specific for Poland include difficulties in synchronising the demand for and supply of energy carriers, primarily district heat. Energy renovation usually reduces considerably the demand for heat energy, which affects the viability of the supply of district heat to buildings. The problem is mitigated by a number of actions, which include:

- putting local governments under an obligation to prepare the assumptions for 'Plans for the supply of electricity, heat and gaseous fuels'[22]. The purpose of such a document is to develop the concept for the development of the district heating network in a given area and to provide a basis for establishing support tools, if any,
- upgrading district heating networks – heating plants retrofit their assets in order to limit losses and reduce operating costs (which translates into reduced unit cost of supply),
- sourcing heat from cheaper, alternative sources.

Public entities may use PPP-based energy performance contracts in line with the Public-Private Partnership Act of 19 December 2008 (Journal of Laws of 2020, item 711, as amended). The Act lays down detailed rules for cooperation between public authorities and private partners (including ESCOs) on joint projects. Poland also promotes incorporating environmental aspects, including energy efficiency, into public procurement procedures, which is reflected by the 4th National Action Plan for Sustainable Public Procurements for 2017-2020 adopted in 2017[23].

A major challenge to be faced in order to improve the situation lies in coordinating deep energy renovation with the upgrading of the district heating sector so as to optimise the use of existing, retrofitted and new district heating systems in the context of the changing demand for district heat.

[21] L. Castellazzi, P. Bertoldi, M. Economidou, *Overcoming the split incentive barrier in the building sector*, JRC, 2017, p. 3 i 4.

[22] This obligation arises under the Energy Law of 10 April 1997 (Journal of Laws 2021, item 716, as amended).

[23] National Action Plan for Sustainable Public Procurements in 2017-2020 (link).

5. Policies and measures to stimulate renovation of buildings

Pursuant to Article 2a(1)(c), (d) and (e) and paragraph 6 of Directive 2010/31, each Member State is required to propose policies and actions to stimulate cost-effective deep renovation of buildings, including staged deep renovation, and to support targeted cost-effective measures and renovation; an overview of policies and actions to target the worst performing segments of the national building stock, split-incentive dilemmas and market failures, and an outline of relevant national actions that contribute to the alleviation of energy poverty; policies and actions to target all public buildings; annex the details of the implementation of its most recent long-term renovation strategy, including on the planned policies and actions.

5.1. Introduction

This chapter discusses the policies and actions which stimulate or will stimulate cost-effective deep renovation of buildings, including targeted renovation measures such as, for example, actions to combat energy poverty.

It must be stressed that strict energy renovation actions and measures stimulating such renovation fall within the remit of various ministries (Ministry of Infrastructure, Ministry of Development Funds and Regional Policy, Ministry of Climate and Environment, Ministry of Agriculture and Rural Development, Ministry of Development and Technology, Ministry of Culture, National Heritage and Sport), whose energy renovation activities are not currently coordinated. Given the growing importance of energy efficiency and energy renovation for building a zero-emission economy in the coming years, it will be necessary to step up coordination activities in order to continue along the desired policy lines, improve monitoring and avoid unnecessary duplication of activities.

Before the Polish policies and actions supporting deep energy renovation of buildings are presented, it is necessary to provide an insight into the Polish understanding of the key concepts, in particular, those of cost-effectiveness, supporting measures and deep energy renovation.

Cost-effective actions are such that are viable for the investor. Cost-effectiveness should not be confused with economic efficiency, which comprises a broader context – e.g. social, environmental costs, etc. The State can use various tools to incentivise investors into actions which are also beneficial from the perspective of the national economy – e.g. subsidies for renewable energy sources make investments in RES installations viable, in other words cost-effective. Thus, what is non-viable today, may become viable or preferable if suitable tools are employed.

Supporting or stimulating actions are such that build the current or future demand for energy renovation activities, including public campaigns (e.g. social marketing).

Renovation activities have the overarching objective of ensuring cost-effective and socially equitable transformation of the building stock in Poland, such as to improve energy efficiency and eliminate direct use of fossil fuels and achieve climate neutrality in this sector in the long term.

The 2017 long-term renovation strategy attached to the fourth National Energy Efficiency Action Plan for Poland[24] does not explicitly formulate actions to contribute to the achievement of its assumptions. However, this document and the analyses included in it have contributed to the organisation of knowledge and identification of the key areas in need of public intervention and of the necessary improvements in the Polish building stock renovation policy-making. As a result, in

[24] National Energy Efficiency Action Plans are available at:https://www.gov.pl/web/klimat/krajowy-plan-dzialan-dotyczacy-efektywnosci-energetycznej.

2017-2020, a number of actions were taken towards streamlining the system of support for long-term improvement of the energy efficiency of buildings, reduction of greenhouse gas emissions, and improvement of air quality. These actions are described in detail in sub-chapter 5.2. They include:

- adoption of Regulation of the Minister of Energy of 27 September 2018 on the quality requirements for solid fuels (Journal of Laws, item 1890),
- adoption of Regulation of the Minister of Economic Development and Finance of 1 August 2017 on the requirements for solid fuel boilers (Journal of Laws, item 1690, as amended),
- adoption of the Act of 23 January 2020 amending the Act on support for thermomodernisation and renovation (Journal of Laws, item 412),
- adoption of the Act of 28 October 2020 amending the Act on support for thermomodernisation and renovation and certain other acts (Journal of Laws, item 2127);
- adoption of the Act of 10 December 2020 amending certain acts supporting the development of housing (Journal of Laws 2021, item 11),
- introduction of a thermomodernisation allowance to the Polish tax system,
- launch of the 'Clean Air' Priority Programme of the National Fund for Environmental Protection and Water Management, launch of the 'Stop Smog' Government Programme[25],
- commencement of work on the creation of the Central Building Emissivity Inventory.

5.2. Public sources of funding for energy renovation of buildings

Bank Gospodarstwa Krajowego (state budget)

Bank Gospodarstwa Krajowego (BGK) is a state development bank whose mission is to support sustainable socio-economic development of Poland.

BGK, along with other development institutions, plays a key role in delivering the Strategy for Responsible Development, which was adopted by the Cabinet by Resolution No 8 of 14 February 2017 (Polish Official Gazette /Monitor Polski/, item 260) and is a key document defining the medium and long-term economic policy of the Polish state.

BGK is the institution responsible for the operational functioning of the Thermomodernisation and Renovation Fund (FTiR). The FTiR, which is financed by the state budget, pays out bonuses which form part of loans extended for thermomodernisation or renovation projects by commercial banks which have concluded an agreement with BGK. These banks include: Alior Bank S.A., Bank Ochrony Środowiska S.A., Bank Pocztowy S.A., Bank Polskiej Spółdzielczości S.A. along with cooperative banks (Banki Spółdzielcze) associated and cooperating with it, BNP Paribas Bank Polska S.A., Getin Noble Bank S.A., Krakowski Bank Spółdzielczy, Powszechna Kasa Oszczędności Bank Polski S.A., SGB-Bank S.A. along with cooperative banks (Banki Spółdzielcze) associated and cooperating with it, Warmińsko-Mazurski Bank Spółdzielczy.

The Subsidy Fund also supports projects involving the renovation or change of use of existing buildings or premises. As a rule, this aid is dedicated for buildings meant for the poorest people.

The National Fund for Environmental Protection and Water Management (fees and fines) and provincial funds 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, inter alia in the construction sector. The NFOŚiGW operates under the Environmental Protection Law of 27 April 2001 (Journal of Laws 2021, item 1973, as amended). The NFOŚiGW mainly derives its revenues from environmental fees and fines, operating and licence fees, energy sector fees, fees provided for by

[25] 'Stop Smog' Government Programme (link).

the Act of 20 January 2005 on the recycling of end-of-life vehicles (Journal of Laws 2020, item 2056) and from the sale of greenhouse gas emission allowances.

The European Regional Development Fund

The European Regional Development Fund (ERDF) aims to strengthen economic, social and territorial cohesion in the European Union by correcting imbalances between its regions. The ERDF supports, inter alia, activities promoting energy efficiency and the use of RES in enterprises, as well as in the public and housing sectors. The ERDF finances, among other projects, Regional (provincial) Development Programmes, which define priority measures and the associated support schemes.

ERDF budget allocated to building energy renovation projects: approx. EUR 1.7 billion

Duration: 2014-2020

The Cohesion Fund

The aim of the Cohesion Fund (CF) is to reduce economic and social disparities and to promote sustainable development. CF financing supports:

- the development of trans-European transport networks,
- projects related to energy, transport, use of renewable energy as long as they benefit the environment in terms of energy efficiency.

CF budget allocated to building energy renovation projects: 576 million euro

Duration: 2014-2020

The Norway Grants – The Environment, Energy and Climate Change Programme

The EEA Financial Mechanism and the Norwegian Financial Mechanism (so-called EEA and Norway Grants) are a form of non-reimbursable foreign aid provided by Iceland, Norway and Liechtenstein to new EU members, including Poland. The resources of the EEA and Norway Grants are distributed among separate programmes, each of which covers a different priority area.

Funding for energy renovation is available under the Environment, Energy and Climate Change Programme, which aims to mitigate climate change. Funds from the Programme are allocated, inter alia, for renovation of school buildings in order to bring them to a passive standard or for retrofits of individual heat sources.

Programme budget: EUR 164.7 million, including:

- EUR 140 million from the EEA Financial Mechanism
- EUR 24.7 million from the national contribution

Duration of the 3rd edition: 2014-2021

Budgets of local governments

RLGUs may provide targeted subsidies from the budget. Funds from municipal budgets are allocated, inter alia, to actions linked to environmental protection, regeneration, low-carbon economy and combating energy poverty. The amount of local and regional government funds allocated to actions related to energy renovation (including replacement of boilers) is not aggregated.

5.3. Detailed list of national policies and actions to stimulate energy renovation of buildings

Legislation and local law

Energy Efficiency Act

The Energy Efficiency Act of 20 May 2016 (Journal of Laws 2021, item 2166) is the key Polish legislative act related to energy efficiency. It provides, inter alia, for:

- the obligation to draft National Action Plans, which pursuant to the Energy Efficiency Act of 20 May 2016 rests on the minister responsible for climate in consultation with the minister competent for construction, spatial planning and management, and housing, which meets the requirements of Directive 2006/32/EC and Directive 2012/27/EU, which supersedes it, prepares national energy efficiency action plans,improvement of energy efficiency in public buildings,
- a system of energy efficiency certificates, also known as 'white certificates', which are available for projects aimed at improving energy efficiency, in particular through energy renovation of buildings,
- energy efficiency-related tasks of public sector units, which include, inter alia, the obligation to publicise information on the energy efficiency improvement measures used, including information on the delivery of thermomodernisation projects,
- an energy performance contracting framework.

In 2021, the Energy Efficiency Act of 20 May 2016 was revised (Journal of Laws, item 868), as a result of which:

- parties committed under the system of energy efficiency certificates were allowed to fulfil the energy saving commitment in the form of non-reimbursable co-funding schemes for delivery of projects which involve replacement of heating or DHW devices or installations at final consumers' or connection of consumers to a district heating network,
- the provisions on EPC based on the ESCO model were strengthened,
- the requirements for energy efficiency auditors were clarified in order to improve the quality of auditing.

Energy Law

The Energy Law of 10 April 1997 requires municipalities to plan and organise the supply of heat, electricity and gaseous fuels in their area, which includes considering the possibility of applying energy efficiency improvement measures within the meaning of Article 6(2) of the Energy Efficiency Act of 20 May 2016.

The Act defines the principles of the state's energy policy and the rules and conditions for the supply and use of fuels and energy, including heat, and for the operation of energy companies, and names the authorities competent for fuel and energy management.

Environmental Protection Law – air quality programmes and anti-smog resolutions

Pursuant to Article 91 of the Environmental Protection Law of 27 April 2001, if an air quality assessment carried out by the Chief Inspectorate for Environmental Protection has found that air quality standards have been exceeded, the provincial executive board is required to draft an air quality programme, which the provincial assembly is subsequently required to adopt through a resolution.

Given the main source of exceedance of air quality standards in Poland, namely residential buildings using solid fuels for heating purposes, corrective actions foreseen in air quality programmes mainly include replacing solid-fuel heating devices with ecological forms of heating, and improving the energy performance of buildings. Currently (as of March 2021), 31 air quality programmes are being implemented nationwide in all the 16 provinces. They are scheduled to be completed by the end of 2026.

Pursuant to Article 96 of the Environmental Protection Law of 27 April 2001, a provincial assembly may resolve to put in place fuel combustion restrictions or prohibitions within a given area in order to curb directly the use of inefficient heating devices. Anti-smog resolutions are designed to minimise harmful effects of emissions from heating installations. Restrictions on the use of fuels within areas subject to a resolution drives up demand for thermomodernisation activities. Most anti-smog resolutions are to be adopted by 2024, and they will be implemented in the following years.

The first anti-smog resolution was passed by the Małopolskie Province Assembly on 15 January 2016 for the Urban Municipality of Kraków, following which, in January 2017, the same assembly adopted a resolution for the whole province (No XXXII/452/17)[26].

As of March 2021, anti-smog resolutions were in place in 13 provinces.

	Province	**Date of adoption**
1.	Małopolskie	15 January 2016 (Kraków), 23 January 2017
2.	Śląskie	7 April 2017
3.	Opolskie	26 September 2017
4.	Łódzkie	24 October 2017
5.	Mazowieckie	24 October 2017
6.	Dolnośląskie	30 November 2017 (three anti-smog resolutions)
7.	Wielkopolskie	18 December 2017 (three anti-smog resolutions)
8.	Podkarpackie	23 April 2018
9.	Lubuskie	18 June 2018 (three anti-smog resolutions)
10.	Zachodniopomorskie	26 September 2018
11.	Kujawsko-Pomorskie	24 June 2019 (amended on 30 August 2021)
12	Świętokrzyskie	29 June 2020
13.	Pomorskie	24 February 2020 (Sopot), 28 September 2020 (two anti-smog resolutions)
14.	Lubelskie	19 February 2021.

Act on energy performance of buildings and the building's energy performance certificate

The Act of 29 August 2014 on energy performance of buildings (Journal of Laws 2021, item 497) introduced an obligation to have energy certificates drawn up for buildings. An energy performance certificate is a document produced for a building or premises in the case of:

- the disposal of the building or premises under a sale contract,
- the disposal of a cooperative ownership right to premises under a sale contract,
- rental.

The obligation to ensure that a certificate is drawn up rests with the owner or manager of the building or part of the building (where 'part of the building' is often synonymous to 'premises'). The obligation to produce a building energy performance certificate does not apply to buildings which are protected under monument conservation laws.

[26] Resolution No XXXII/452/17 of the Małopolskie Province Assembly of 23 January 2017 imposing restrictions and prohibitions on the use of fuel combustion installations within the Małopolskie Province (link)..

Regulation of the Minister of Infrastructure on the technical conditions to be met by buildings and their siting.

Regulation of the Minister of Infrastructure of 12 April 2002 on the technical conditions to be met by buildings and their siting sets forth the requirements, inter alia, for the U heat penetration coefficient for individual envelope elements and the building's maximum primary energy factors. The current technical conditions took effect on 31 December 2020 and constitute the key reference for the minimum requirements to be met by renovated buildings. The envelope and technical equipment of a renovated building must meet the minimum thermal insulation requirements. In addition, new buildings must meet the minimum conditions applicable to the maximum demand for primary energy for heating, DHW, cooling and lighting, in the case of public, collective accommodation, production, utility and storage buildings – this requirement does not apply to existing buildings undergoing energy renovation.

Regulation of the Minister of Energy on the quality requirements for solid fuels

Regulation of the Minister of Energy of 27 September 2018 on the quality requirements for solid fuels sets limits on the content of ash, sulphur and moisture in solid fuels, i.e. in hard coal, briquettes or pellets containing at least 85% of hard coal, as well as in solid fuels produced through thermal processing of lignite. They were issued on the basis of the authorisation set forth in the Act of 25 August 2006 on the fuel quality monitoring and control system (Journal of Laws 2021, item 133, as amended). The regulation entered into force on 4 November 2018, and the quality requirements for hard coal, briquettes and pellets containing at least 85% of hard coal without admixtures of coal sludge and flotation concentrates (grain size 1 ÷ 31.5 mm: slack grade I, slack grade II, slack grade III) came into force on 1 July 2020.

The regulation also provides that whether specific solid fuel meets the applicable quality requirements is to be assessed by an accredited laboratory. The act which constitutes the legal basis for the regulation provides that a coal marketer is required to issue a fuel quality certificate on the basis of the assessment. This ensures that consumers are provided with information on the parameters of the fuel they buy. The regulation is to be reviewed every two years.

Regulation of the Minister of Economic Development and Finance on the requirements for solid fuel boilers.

Regulation of the Minister of Economic Development and Finance of 1 August 2017 on the requirements for solid fuel boilers entered into force on 1 October 2017, and in February 2019, it was amended. The regulation put in place limit values for CO, particulate matter and OGC (organic gaseous carbon) emissions from boilers and defined the limit values for thermal efficiency of boilers. Thus, it prohibited the sale of high-emission coal-fired boilers, which were characterised by several times higher emissions than modern boilers.

Planning and organisational tools

Establishment of the Central Building Emissivity Inventory (CEEB)

The Central Building Emissivity Inventory (Centralna Ewidencja Emisyjności Budynków – CEEB) will be established on the basis of the Act of 28 October 2020 amending the Act on support for thermomodernisation and renovation and certain other acts. The main objectives of the act, which has been drafted by the Ministry of Climate and Environment, include counteracting smog and energy poverty and improving energy efficiency of buildings. The act is to result in the elimination of 'low-stack' emissions of particulate matter, i.e. emissions by the municipal and domestic sector (mostly households, small, local boiler facilities, service workshops and establishments). The pursuit of these goals is to be supported primarily by the launch of the

Central Building Emissivity Inventory and the streamlining of the operation of the 'Clean Air' and 'Stop Smog' Programmes. The inventory, which is to ultimately cover about 5-6 million buildings, will initially proceed at a pace of 500 thousand buildings per year. The nationwide inventory of buildings will involve the collection of written declarations on heat and combustion sources – by the end of 2021.

CEEB is a computerised tool for inventorying heat and fuel combustion sources in buildings. This system will collect key information on the sources of emissions in the municipal and domestic sector.

It will also be used for collecting data on the energy standard of buildings and information on forms of public aid (subsidies, preferential loans) granted for energy renovation or replacement of boilers in buildings.

A building is registered in the system on the basis of the source capacity criterion, regardless of the legal form of building use. Therefore CEEB will cover not only residential buildings, but also public utility buildings, including small local heating plants or small production plants, provided that the nominal thermal capacity of the fuel combustion source used does not exceed 1 MW.

Heat, electricity and gas fuel supply plans

The Energy Law of 10 April 1997 imposes an obligation to prepare municipal heat, electricity and gas fuel supply plans, the scope of which comprises the development of urban district heating and gas networks, which is directly and evidently related to energy renovation and air protection.

Municipalities carry out this task in line with local zoning plans and in accordance with the air quality programme. In the absence of a local zoning plan, the task is fulfilled in keeping with the municipality development lines defined in the municipal urban development study (studium uwarunkowań i kierunków zagospodarowania przestrzennego gminy).

The draft assumptions for a heat, electricity and gaseous fuels supply plan should be prepared for a period of at least 15 years, and then updated at least every 3 years.

Low carbon economy plans

Low carbon economy plans (LCEPs) are strategic documents setting forth actions which local authorities plan to take to reduce energy consumption, abate carbon dioxide emissions, improve energy efficiency, and use renewable energy within their area. The drafting of an LCEP is not required by law, but is encouraged by preferences in the distribution of EU funds, e.g. for energy renovation.

LCEPs were implemented in response to the adoption of the energy and climate package, i.e. a set of laws implementing the EU's strategy for counteracting climate change, by the European Parliament in 2008. An LCEP is mandatory for municipalities seeking support from EU funds for 2014-2020.

The preparation of LCEPs was financed under Axis IX of the IEOP 2007-2013, with their updating and preparation in subsequent years often financed by municipal budgets.

Nationwide System of Support for Energy Advisers

The project 'Nationwide system of advisory support in the field of energy efficiency and RES for the public, housing and enterprise sectors' is implemented by the NFOŚiGW (Beneficiary, Lead Partner) in cooperation with Partners throughout the country (Provincial Environmental Protection and Water Management Funds and the Marshal Office in Lublin). The project is financed by Priority Axis I 'Reducing the emissivity of the economy' of IEOP 2014-2020. The Concept of the Energy Advice Project was prepared in 2014. The project was included in IEOP

2014-2020. An assessment of the nationwide system of advisory support in the field of energy efficiency and RES for the public, housing and enterprise sectors under Priority Axis I of IEOP 2014-2020[27] has found that energy advisers' services are rendered in a satisfactory way. Advisors, in addition to demonstrating, inter alia, expertise and addressing customers' problems suitably, have significantly improved the quality of LCEPs. They have also consulted investments, mainly related to energy renovation and expansion of buildings and the installation of renewable energy sources. It is estimated that they have supported 13-34% of IEOP PO 1 measures nationwide, inter alia by cooperating intensively with district heating companies.

The Covenant of Mayors

The Covenant of Mayors (Porozumienie Burmistrzów) is an initiative promoted by the European Commission, which brings together representatives of local authorities voluntarily committed to achieving and exceeding EU climate and energy targets. In Poland, the Covenant of Mayors and the drafting of action plans for sustainable energy is promoted by the National Fund for Environmental Protection and Water Management, which acts as the National Coordinator[28]. By November 2020, 79 local governments signed the Covenant in Poland.

Financial tools

Financial support tools are ranked according to the value of the intervention (funds allocated for activities).

'Clean Air' Priority Programme of the NFOŚiGW[29]

Proper climate and energy policy making (including the urgent need to improve air quality), such as to ensure the reduction of greenhouse gas emissions and better working conditions and education, stimulate the use of renewable energy and improve energy efficiency thanks to more energy-efficient buildings, is a major challenge and a requirement following from Poland's membership in the European Union. The Polish Government, striving to respond to the above requirements, has developed the long-term 'Clean Air' Programme, which is based, inter alia, on the following three pillars: emission standards for solid fuel boilers, quality standards for solid fuels and schemes of financial support for energy renovation of buildings and replacement of heat sources available to the public.

Being a flagship scheme of the NFOŚiGW, the programme comprises eliminating high-carbon solid fuel heating sources and energy renovation of single-family buildings.

Its overarching objective is to improve air quality by reducing the emission of PM and other pollutants to the atmosphere and to improve energy efficiency and use renewable energy sources in single-family buildings, as well as to ensure that residents have the widest possible local access to financial support, inter alia with a view to eliminating energy poverty. Natural persons, i.e. owners and co-owners of single-family houses or residential premises in such buildings with a separate land and mortgage register, may apply for co-financing for energy renovation of the building/premises if it will reduce the emission of air pollutants harmful to health and the environment.

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[27] Assessment of the nationwide system of advisory support in the field of energy efficiency and RES for the public, housing and enterprise sectors under Priority Axis I of IEOP 2014-2020, final report for the Ministry of Energy, im app, Warsaw 2018 (link).

[28] Additional information is available on the website: https://www.nfosigw.gov.pl/o-nfosigw/porozumienie-burmistrzow/.

[29] For more information see the website: http://czystepowietrze.gov.pl/.

The programme offers financial support for comprehensive renovation of single-family buildings or separate residential premises in such buildings. It supports replacement of heat sources, improvement of energy efficiency and use of renewable energy sources in single-family residential buildings, in particular through:

- replacement of old generation solid fuel heat sources (solid fuel stoves and boilers), purchase and installation of new heat sources, devices and installations, in particular: high-efficiency solid fuel boilers[30], district heating substations, electric heating systems, oil boilers, gas condensing boilers, heat pumps,
- installation or retrofitting of central heating and domestic hot water systems (including solar collectors, heat pumps for DHW),
- use of renewable energy sources (purchase and installation of photovoltaic microinstallations, solar collectors),
- insulation of the building's envelope,
- replacement of window and door frames,
- purchase and installation of a power ventilation system with heat recovery,
- preparation of the project dossier, including: the building energy audit documentation, design documents for individual disciplines, expert analyses.

PLN 103 billion are planned to be allocated on activities under the scheme. It is assumed that approximately 3 million single-family houses will benefit from the aid and increase their energy efficiency, which will, in turn, significantly improve air quality in Poland. Subsidies under the 'Clean Air' Programme can be combined with the thermomodernisation allowance, which has been available since 1 January 2019, when the Act of 9 November 2018 amending the Act on personal income tax and the Act on flat-rate income tax on certain revenues generated by natural persons (Journal of Laws, item 2246) entered into force. In such a case, the benefits gained by the Beneficiaryunder both these financial mechanisms complement each other.

Duration: 2018-2029, allocation of funds: PLN 103 billion of non-reimbursable support (subsidies): PLN 63.3 billion; of reimbursable support (loans): PLN 39.7 billion.

'My Electricity' Priority Programme of NFOŚiGW

'My Electricity' (Mój Prąd) programme is one of the largest European programmes for co-funding photovoltaic micro-installations for natural persons. Its aim is to reduce CO_2 emissions and enhance the capacity for generation of electricity by home photovoltaic installations.

The programme has been under way since 2019. It offers non-reimbursable support in the form of subsidies for projects involving the construction of a photovoltaic microinstallation with a capacity of 2 to 10 kW to be used for satisfying the energy needs of residential buildings. The maximum amount of support is 50% of the eligible costs of the construction of a microinstallation, but not more than PLN 5 000. The support can only be sought by natural persons who have signed a framework agreement for the supply of produced electricity to the grid. Support is granted if the applicant undertakes to operate the installation for at least 3 years from the date when the co-funding is disbursed.

So far, the programme, which has comprised two calls for proposals – in 2019 and 2020, has co-funded PV installations with a total capacity of 1.2 GW.

In the second half of 2021, another call for proposals is planned, which will involve co-funding of electric car chargers, heat and cold storage devices, and smart building energy management

[30] According to information provided by the Minister for Climate and the Environment, public support for investments in coal-based heat sources will be discontinued under the 'Clean Air' Programme as from 1 January 2022 (link).

systems. Expanding the range of eligible investments will increase the level of self-consumption of electricity by prosumers.

Duration: since 2019, allocation of funds: PLN 1.1 billion of non-reimbursable subsidies (first and second calls)

'Energy-Efficient Construction' Priority Programme of NFOŚiGW. Part (1) 'Reduction of energy consumption in the construction sector'

This programme will involve, inter alia, energy renovation of hospitals, residential care homes, historic buildings, religious buildings and buildings linked to them, student dormitories or buildings designated for culture, religious worship, education, care, upbringing and learning.

The programme awards funds energy renovation work, such as thermal insulation of the building's envelope, replacement of window and door frames, retrofitting of heating systems (including replacement of the heat source, possibly for a renewable one), upgrade of ventilation and air-conditioning systems, replacement of lighting systems with energy-efficient ones, use of building energy management systems and deployment of renewable energy sources.

The main goal of the programme is to improve air quality by reducing energy consumption in buildings (inter alia by increasing renewable production) and abating CO_2 emissions. It is estimated that the programme will reduce primary energy consumption by at least 1 570 000 GJ/year and CO_2 emissions by at least 154 000 Mg/year.

By the end of 2023, PLN 1.65 billion will have been allocated to the programme (in the form of grants and loans). The programme is particularly important for religious and historic buildings, the renovation of which is usually time-consuming and costly. What is more, the scheme does not envisage mere renovation of such buildings, understood as their restoration or refurbishment, but provides for their modernisation and improvement with a view to enhancing their value in use.

Duration: 2019-2023, allocation of funds PLN 1.6 billion

'Clean Air in Schools' Programme of NFOŚiGW

The building energy renovation schemes of NFOŚiGW also include the programme 'Clean Air in Schools' (working title), which is a continuation of activities supporting the improvement of air quality in Poland. As part of the programme, educational establishments have received a questionnaire on the basis of which the most energy inefficient institutions will be identified. The central objective of the scheme will be to improve air quality and reduce energy consumption, which will include enhancing the energy efficiency of buildings of educational establishments. Importantly, the programme will also work towards improving conditions in educational establishments, in particular the quality of air children breathe, which will be beneficial for their health and learning capacities. A guidebook to good practices in energy renovation of educational establishments will be one highlight of the programme. The guidebook is to be a compendium of information on energy efficiency and energy renovation of buildings of educational establishments useful in designing and constructing buildings, as well as in using buildings or their parts. The document will provide insight into relevant legal aspects of such investments and will describe the energy renovation procedure, the associated economic and environmental benefits, and the technological barriers which educational establishments may encounter along with proposed ways of regulating/overcoming them. The primary role of the guidebook is to popularise knowledge on energy efficiency and create a tool supporting thermomodernisation of educational buildings in Poland.

Support for energy renovation is to come from public funds, with the programme assuming that most of the investment will be completed by business operators under the ESCO and PPP formulas. Joint implementation of an undertaking based on the division of tasks and risks between the public and private partners will ensure that educational establishments are provided with technical support in executing the investment and will contribute to achieving its goal.

The attainment of the programme's objective is supported by the implementation of the Environment, Energy and Climate Change Programme, which is co-financed by the EEA Financial Mechanism and is operated by the Minister for Climate and the Environment with the help of the

NFOŚiGW. Within the framework of the Programme, a call for proposals for the ‘Improving energy efficiency in school buildings’ scheme has been announced. The main objective of the call is to improve energy efficiency in school buildings used for educational purposes by supporting comprehensive investment activities which involve deep energy renovation and are undertaken in order to bring school buildings to the ‘passive’ or ‘nearly zero-emission’ standard. The implementation of programme projects should reduce CO_2 emissions, reduce primary energy consumption, increase the share of renewable energy (if the project also involves energy production) and increase public awareness with regard to energy efficiency.

Funding will be available for energy renovation work, the scope of which is so wide that, once it is completed, the energy standard of the school building will come close to the passive or nearly zero-emission standard. Examples of energy renovation activities recommended for a building to achieve an energy standard close to ‘passive’ include the use of power ventilation with heat recovery, insulation of the building’s envelope or proper distribution of glazed surfaces.

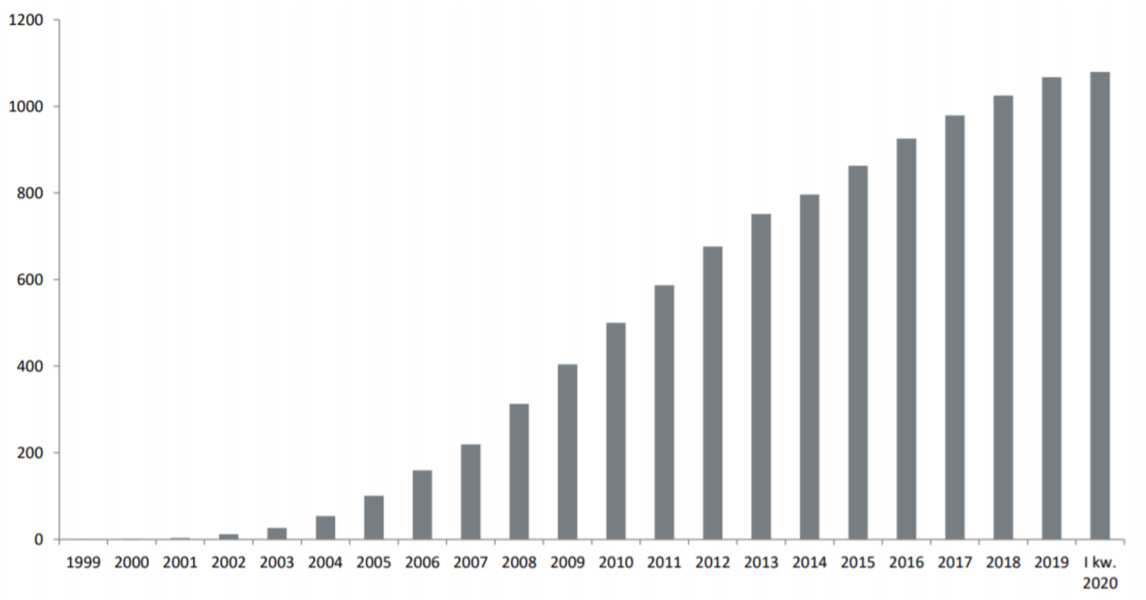
Thermomodernisation and Renovation Fund (FTiR)

The budget of the Thermomodernisation and Renovation Fund (FTiR) is determined every year, and the fund has been functioning on a continuous basis. Having existed uninterruptedly since 1998, FTiR is one of the oldest, continuously functioning tools for supporting energy efficiency in Europe. It was established by the Energy Renovation Support Act of 18 December 1998 (Journal of Laws, item 1121, as amended).

The system of support for thermomodernisation and renovation undertakings (renovation work including energy retrofitting) is financed by domestic funds and is governed by the Act on support for thermomodernisation and renovation of 21 November 2008 and by provisions on the Central Building Emissivity Inventory (Journal of Laws 2021, item 554, as amended). The above regulations set forth the principles for the award of thermomodernisation bonuses, renovation bonuses and compensation bonuses (money paid to owners of buildings with subsidised community dwellings). The responsibility for implementing them rests with Bank Gospodarstwa Krajowego.

From its initiation until 10 September 2019, approximately 32 200 buildings with around 900 000 dwellings underwent thermomodernisation and renovation within the framework of the FTiR. Housing cooperatives and associations of flat owners, which mainly thermomodernised multi-family buildings, were the main beneficiaries of the FTiR. The Fund also supports municipal buildings protected as historic heritage or located within protected sites, but the bonus for such buildings is 60% of the project costs.

Chart 20. Savings produced by support for investments under the FTiR (cumulative savings in PLN million)



Source: Bank Gospodarstwa Krajowego.

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Recent years have seen a decrease in the number of applications for thermomodernisation and renovation bonuses. As is shown by FTiR data, a number of multi-family buildings have already undergone energy renovation so interest in this form of support, although still high, is bound to decline gradually. It can also be observed that the average number of flats in thermomodernised and renovated buildings is decreasing, which may imply that support is channelled to ever smaller housing cooperatives and associations of flat owners. Therefore a decision was taken to amend the Act of 21 November 2008 on support for thermomodernisation and renovation and on the Central Building Emissivity Inventory.

While this document is being drawn up, further modifications to the functioning of the FTiR are being planned.

The Subsidy Fund – Non-Reimbursable Construction Support Programme

The Subsidy Fund, which implements, inter alia, the Non-Reimbursable Construction Support Programme managed by BGK, has existed since 2003, when it was established by the Act of 5 December 2002 on the subsidisation of interest for fixed-interest housing loans (Journal of Laws 2022, item 101), which has governed the operation of the Fund since.

Every year, the Fund receives a subsidy from the state budget. It funds the Non-Reimbursable Construction Support Programme, which aims to increase the stock of residential premises and stock of community premises serving the needs of people with low and average incomes.

The support is available for local government units (districts and municipalities) and public benefit organisations. The programme mainly finances the creation of housing subject to a rent cap, night shelters, homeless shelters and heating shelters. From the point of view of the renovation of buildings, it is important that the funds are also available, inter alia, for renovation or conversion of such buildings. Depending on the beneficiary and type of undertaking, the ratio of support may range from 20% to 60% of its value.

IEOP, Measure 1.3 – supporting energy efficiency in buildings

Under Priority Axis I and Measure 1.3 Supporting energy efficiency in buildings, the NFOŚiGW provides co-funding in the form of subsidies for energy renovation investments in public buildings and in the form of reimbursable aid for energy renovation investments in the housing sector. The support is available for investments involving deep comprehensive energy renovation of buildings, including thermal insulation of the envelope, replacement of window and door frames, replacement of heat sources, retrofits of lighting, central heating and DHW installations. The main goal of the projects is to produce energy savings, reduce CO_2 emissions, achieve a better energy standard in the building and upgrade its technical and utility standard. Once retrofitted, buildings should meet the standards set out in Regulation of the Minister of Infrastructure of 12 April 2002 on the technical conditions to be met by buildings and their siting. In addition, the supported activities work towards the air quality goals defined by air quality programmes, including the elimination of 'low-stack' emissions.

The optimal set of energy-efficiency actions for a given building is identified ex ante on the basis of an energy audit (which is a key element of the project and its eligible cost). In order to verify the achievement of the project goals and effects, an energy audit should also be carried out after the completion of the project (ex post).

A deep comprehensive energy retrofit may comprise thermal insulation of the building and replacement of its furnishings with energy-saving ones, which involves replacement of windows, entrance doors, retrofitting of the indoor heating and DHW installations and replacement of common lighting systems with energy-efficient ones, refurbishment of heating systems (including replacement of the heat source with more energy-efficient and ecological ones, or connection of these systems to the district heating/cooling network or upgrading of such a connection, if the project applicant is the owner of the abovementioned infrastructure), construction/refurbishment of power ventilation systems, remodelling of cooling systems and construction/retrofitting of air-conditioning, provided that this optimises energy consumption leading to reduction of carbon dioxide emissions, possibly through the use of RES and (micro-) trigeneration, installation of renewable energy sources in energy renovated buildings, deployment of energy management systems.

Under IEOP, the energy efficiency of buildings is financed from:

- The Cohesion Fund;
- Domestic funds (public and private).

IEOP, Sub-Measure 1.3.1 – Supporting energy renovation in public buildings

The support is meant for investment projects which involve deep comprehensive energy renovation of public buildings. A public building is defined as a building intended for the needs of public administration, the judiciary, culture, religious worship, education, higher education, scientific research, healthcare, social care and welfare. The support also encompasses activities which involve energy auditing of public buildings and design work forming an integral part of a building energy renovation investment project.

Duration: 2014-2020, allocation of funds EUR 419 388 563

IEOP, Sub-Measure 1.3.2 – Supporting energy renovation in residential buildings

The support is available to housing cooperatives, associations of flat owners from delimited areas, and energy service providers within the meaning of Directive 2012/27/EU. It is designated for projects comprising deep, comprehensive energy renovation of buildings, which includes thermal insulation of the envelope and replacement of the buildings' furnishings and devices with energy-efficient ones. This sub-measure does not fund investments in the Śląskie Province, which benefits from separate Sub-measure 1.7.1.

Duration: 2014-2020, allocation of funds 36 457 352 EUR

IEOP, Sub-Measure 1.7.1 – Supporting energy efficiency of residential buildings in the Śląskie Province

Under Priority Axis I and Sub-Measure 1.7.1. Supporting energy efficiency in residential buildings of the Śląskie Province, WFOŚiGW in Katowice provides co-financing to housing cooperatives, associations of flat owners, local governments and their associations, as well as to commercial companies from the Śląskie Province co-owned by the State Treasury engaged in housing operations and energy service providers within the meaning of Directive 2012/27/EU. Support is envisaged for projects comprising deep, comprehensive energy renovation of multi-family buildings, which includes thermal insulation of the building and replacement of its furnishings and devices with energy-efficient ones.

Duration: 2014-2020, allocation of funds 80 221 539 EUR

IEOP, Measure 1.2 – Promoting energy efficiency and use of renewable energy sources in enterprises

Under Priority Axis I and Measure 1.2 Promoting energy efficiency and use of renewable energy sources in enterprises, the NFOŚiGW provides co-financing in the form of reimbursable aid to large enterprises for deploying solutions which contribute to the optimisation of energy management and enhance energy efficiency, inclusive of the use of RES and deep comprehensive energy renovation of buildings.

The measure is to support the retrofitting or replacement of technological and power devices and installations, lighting systems of the enterprise's buildings, production halls and company premises, elements of (or entire) utility (heat, cold, water, natural gas, compressed air, ventilation air, power) transport/transmission lines, and conveyor systems of production lines, ensuring energy savings in terms of demand for electricity, heat or cooling. Support is also available for automation systems and systems for monitoring energy carriers. In addition, when recommended by the energy audit of the enterprise, support may be provided for deep comprehensive energy renovation of the building and the retrofitting/replacement of local heat sources with energy-efficient ones (e.g. by installation of a renewable energy system). In addition, support can be provided for the utilisation of waste heat energy from industrial installations in enterprises, as defined and described in Directive 2012/27/EU. With regard to renewable energy production, support will be provided (if the energy audit so recommends) to investments which will add to covering the enterprise's needs for heat or for heat and electricity. Putting in place smart energy management systems in the enterprise should be an integral part of the project, provided that this is recommended by the energy audit. The Measure aims towards creating production systems based on the principles of sustainable utilisation of resources in the supported enterprises, and improved energy efficiency is to lead to the creation of better performing production systems in enterprises, thus improving their competitiveness. Improving the security of energy supplies and the company's image will be an additional effect.

The IEOP is financed by:

- The Cohesion Fund;
- Domestic funds (public and private).

Duration: 2014-2020, allocation of funds 39 884 442 EUR

Regional Operational Programmes

As part of the 2014-2020 financial perspective, 16 Regional Operational Programmes (ROPs) are implemented. The ROPs were prepared for the 15 less developed regions and for the Mazowieckie Province, which qualified as a more developed region in the 2014-2020 financial perspective.

ROP funds available for energy renovation of residential buildings are allotted for comprehensive, deep energy renovation of multi-family buildings, with preference given to activities aimed at achieving a 60% energy saving ratio. Deep comprehensive energy retrofits which improve energy efficiency below 25% are not eligible for ROP co-funding. ROP funds may also support buildings registered as historic monuments if they meet the above conditions.

Most of the ROP MAs decided to deploy financial instruments to support energy efficiency of residential buildings (10 ROPs). Support for energy renovation investments in the other provinces is granted through subsidies. EU co-financed projects are selected in an open call organised by provincial executive boards.

At the end of June 2020, a total of 2 715 agreements were signed under ROPs for EU co-funding of PLN 6.5 billion. The following formed the most numerous groups of support seekers: municipalities (1 458 co-financing agreements signed, with EU subsidies of PLN 2.6 billion), followed by cities (365 agreements signed, with EU co-funding of PLN 1.2 billion), then by housing cooperatives and associations of flat owners (301 agreements signed, with PLN 272 million of EU co-financing) and districts (201 co-financing agreements for PLN 542 million worth of EU grants). The least numerous groups of applicants were formed by provincial and district hospitals (61 co-financing agreements for PLN 326 million of EU funding), associations and foundations (40 co-financing agreements for an amount of EU co-funding equal to PLN 72 million) as well as archdioceses, monastic orders and religious associations (58 co-financing agreements PLN 150 million worth of EU grants). Energy renovation of 8 143 buildings is to be one of the effects of activities completed under the 16 ROPs.

Thermomodernisation allowance

The Act of 9 November 2018 amending the Act on personal income tax and the Act on flat-rate income tax on certain revenues generated by natural persons, which was adopted on 1 January 2019, put in place a new personal income tax exemption and the so-called ‘thermomodernisation allowance’.

The thermomodernisation allowance is an instrument addressed to a wide group of taxpayers who own single-family buildings and earn enough for them to be incentivised by such tax deduction. In other words, although this instrument is not likely to alleviate energy poverty, it should stimulate renovation and thermomodernisation expenditure among the Polish middle class.

The allowance is also available where, for example, an installation (e.g. a PV installation) cannot be built in a single-family residential building and will be assembled in another building, e.g. a garage or outbuilding, but supplies the residential building.

The allowance consists of the deduction of single-family building energy renovation costs from the tax base (or from revenues in the case of flat-rate tax).

‘Low-stack’ Emission Reduction Programmes

‘Low-stack’ Emission Reduction Programmes (LSERS) are drafted by municipalities if air quality programmes adopted at the provincial level by resolutions of provincial assemblies under Article 91 of the Environmental Protection Law of 27 April 2001 so require. If an air quality programme does not require that an LSERS be drafted by a municipality, this is voluntary. They are prepared in municipalities where the PM10 and PM2.5 limit values and the benzo(a)pyrene target value are exceeded. The goal of an LSERS is to reduce emissions of harmful substances and improve air quality. LSERSs cover activities involving replacement or elimination of old, ineffective heat sources (i.e. boilers and stoves).

The ‘Stop Smog’ Programme

The ‘Stop Smog’ Programme has the following legal bases:

- Act of 21 November 2008 on support for thermomodernisation and renovation and
- on the Central Building Emissivity Inventory

- Regulation of the Minister for Climate and the Environment of 28 December 2020 on the specimen of the own funds and assets declaration to be filed by applicants
- seeking to conclude a low-stack emission abatement project agreement (Journal of Laws, item 2447).

The ‘Stop Smog’ Programme is targeted at the energy poor living in single-family buildings. It is addressed to all municipalities which are able to demonstrate poor air quality, i.e. concentrations of air pollutants exceeding EU standards, in their territory.

The programme covers the following projects carried out in the abovementioned households:

- replacement of heating devices or systems with devices and systems compliant with low-emission standards,
- removal of heating devices or systems and connection to the district heating, electricity or gas network,
- energy renovation of the building.

Projects are carried out by the municipality for the benefit of the final beneficiary and financed from public funds up to 100% of their value. The municipality is to provide 30% of the applicant’s own contribution (or higher if it has more than 100 000 inhabitants). The remaining part of the programme (70%) is financed from the state budget through the FTiR. The programme is currently planned to run in 2019-2024 and its total budget (comprising the state’s and municipalities’ contribution) amounts to PLN 1.2 billion.

Since the act entered into force, 10 agreements have been signed with municipalities for a total amount of PLN 60.9 million (PLN 42 million – FTiR) for 1 167 buildings (Skawina, Sucha Beskidzka, Pszczyna, Niepołomice, Tuchów, Sosnowiec, Rybnik, Brzesko, Spytkowice, Limanowa).

5.4. Summary of national tools to support renovation of buildings, including directional measures

The building renovation policies and measures presented in this chapter are classified by the following groups and subgroups of buildings they target:

- Multi-family buildings,
- Single-family buildings,
- Public buildings,
- Other non-residential buildings.

In addition, policies and measures in support of renovation of buildings are classified according to the following strategic directions:

- Measures to improve air quality,
- Combating energy poverty,
- Measures for buildings with the poorest energy performance
- Counteracting split of incentives

Table 20. Summary of national tools to support renovation of buildings, including measures for specific target groups

		Building type					Directional measure				Timespan			
		Single-family	Multi-family buildings	Public	Other non-residential	Historic building or building under conservation protection	Measures to improve air quality	Combating energy poverty	Buildings with the poorest energy performance	Counteracting split of incentives	2011-2014	2015-2020	2021-2025	2026-2030
Legislation and local law	Energy Efficiency Act	x	x	x	x	x	x			x	x	x	x	x
	Energy Law	x	x	x	x	x					x	x	x	x
	Environmental Protection Law – air quality programmes and anti-smog resolutions	x	x	x	x	x	x				x	x	x	x
	Act on energy performance of buildings and the building's energy performance certificate	x	x	x	x					x		x	x	x
	Regulation on the quality requirements for solid fuels	x	x	x	x	x	x					x	x	x
	Regulation on the requirements for solid fuel boilers	x	x	x	x	x	x					x	x	x
Planning and organisational tools	Central Building Emissivity Inventory (CEEB)	x	x	x	x	x	x	x	x				x	x
	Heat, electricity and gas fuel supply plans	x	x	x	x	x				x	x	x	x	x
	Low carbon economy plans	x	x	x	x	x	x	x	x	x	x	x	x	x
	Nationwide System of Support for Energy Advisers	x	x	x	x	x	x	x	x	x		x	x	
	The Covenant of Mayors	x	x	x	x	x	x				x	x	x	x
Financial tools	'Clean Air' Programme	x					x	x				x	x	x
	'My Electricity' Programme	x					x						x	x
	'Energy-Efficient Construction' Programme Part (1) 'Reduction of energy consumption in the construction sector'			x	x	x			x				x	
	'Clean Air in Schools' Programme			x			x						x	
	Thermomodernisation and Renovation Fund	x	x	x		x	x	x	x	x	x	x	x	x
	Subsidy Fund		x					x	x	x	x	x	x	x
	IEOP, Sub-Measure 1.3.1			x			x					x		
	IEOP, Sub-Measures 1.3.2 and		x				x	x				x		

	1.7.1													
	IEOP, Measure 1.2				x		x					x		
	Regional Operational Programmes	x	x	x		x	x					x		
	Thermomodernisation allowance	x					x					x	x	x
	‘Low-stack’ Emission Reduction Programmes	x						x	x			x	x	x
	‘Stop Smog’	x						x	x			x	x	

x means that the instrument is available for a specific type of building, implements one of the directional activities and is available in the individual timeframes. The marking is qualitative in nature.

6. Support for development of smart technologies and well-connected buildings and communities.

Pursuant to Article 2a(1)(f) of Directive 2010/31, each Member State is required to provide an overview of national initiatives to promote smart technologies

and well-connected buildings and communities.

6.1. Smart and energy-efficient construction as one of the National Smart Specialisations

The current development policy foresees supporting the strategic sectors included in the **National Smart Specialisations** (NSS) under the financial perspective for 2014-2020. Smart specialisation activities will be continued in the 2021-2027 financial perspective. *NSS 5. Smart and energy-efficient construction* comprises 7 thematic groups:

- Materials and technologies,
- Energy systems of buildings,
- Development of machinery and devices,
- Development of programming applications and environments,
- Integrated design,
- Energy and environmental verification, and
- Processing and re-use of materials.

A detailed list of the areas covered by *NSS 5 Smart and energy-efficient construction* is attached in Annex 4.

The intelligent technologies referred to in Directive 2010/31 fall within the scope of NSS 5 and represent forward-looking and strategic solutions which will bring the Polish building sector closer to climate neutrality. These include energy management systems and smart metering, smart buildings, smart grids and smart cities. The priority research directions are also defined at the provincial level in Regional Innovation Strategies (RISs), which address the provinces' varied R&D potential in individual areas.

In order to monitor and support NSS-related activities and raise knowledge in the field of smart specialisations, the then Ministry of Development launched the **SmartRadar** portal, which is used for visualising and comparing statistical data related to the realisation of the concept of smart specialisations. In each of the analysed thematic areas, including NSS 5, various indicators are available, e.g. the number of implemented projects, the number of supported enterprises, the amount of subsidies under various financing programmes.

6.2. Progress in deployment of smart technologies in Poland

6.2.1. Smart meters and smart grids

Progress made in Poland

Current activities towards the transformation of Poland's power grids into smart ones focus on supporting investments in the construction, retrofitting or remodelling of power grids and substations, connection of renewable power generation units to grids, deployment of smart metering, and grid automation. In 2018, smart meters were installed at approximately 8.4% of consumers' (European average = 34.2%), most of them in northern Poland. In order to accelerate the transformation of the power grid, the Act of 20 May 2021 amending the Energy Law and certain other acts (Journal of Laws, item 1093, as amended) provides that smart meters must be installed by the distribution system operator at final consumers' premises connected to a grid with a voltage of not more than 1 kV within the following timeframes: by the end of 2023 (at least 15% of customers), by 31.12.2025 (at least 35%), by 31.12.2027 (at least 65%), with such installation to be completed for at least 80% of final consumers by the end of 2028. The act also requires that remotely readable meters be installed at MV/LV transformer substations by the end of 2025. The obligation to equip heat meters or heat cost allocators and DHW meters in premises of multi-family buildings with a remote reading feature by 1 January 2027 is imposed on owners or managers of such buildings by the Act of 20 April 2021 amending the Energy Efficiency Act and certain other acts (Journal of Laws, item 868).

Funding instruments

IEOP implemented in 2014-2020:

- Sub-Measure 1.1.2. Supporting projects involving the construction and remodelling of grids such as to allow renewable power generation units to be connected to them
- Sub-Measure 1.4.1. Supporting the construction of pilot and demonstration smart power grids: support was granted for the construction and remodelling of grids to a smart grid standard through the installation of smart metering and grid automation, and upgrading and remodelling of MV and LV lines and stations;
- Measure 7.1. Development of smart energy storage, transmission and distribution systems (projects mainly comprising the construction, retrofitting or remodelling of smart gas and electricity networks and construction of remotely controlled intelligent substations).

ROPs implemented in 2014-2020:

- Measure 4.1. Increasing the use of renewable energy sources (projects comprising the construction and refurbishment of MV and LV power grids, such as to allow renewable power generation units to be connected).

6.2.2. Smart cities

Progress made in Poland

Current activities focus on pilot projects, promoting the smart city idea and deploying innovative solutions in urban spaces in areas of strategic importance for a given city or region, which mainly comprise co-funding the necessary investments. Most of the innovation activities reflecting the smart city concept pertain to road infrastructure management (smart carparks, city lighting, road traffic management, public space monitoring, etc.). The most common energy management technologies implemented in Poland include remotely readable meters or sensors or waste management systems.

Projects and initiatives

The Urban Lab (2019-2022, with the possibility of renewal until 2024) – a pilot tool to improve the quality of life of city residents in keeping with the smart city idea, project coordinated by the Institute for the Development of Cities and Regions, financed by the Ministry of Development Funds and Regional Policy. Its purpose is to support the deployment of innovative solutions in urban spaces by facilitating and promoting joint action between residents, offices, businesses, science and NGOs (events, seminars, conferences).

Academy of Cities of the Future (Akademia Miast Przyszłości) is a programme addressed to staff of public offices of medium-sized cities (between 20 and 100 thousand inhabitants). The aim of the programme is to prepare local government officials and build their competences in managing innovative projects.

PFR for Cities (PFR dla Miast), a programme of Polski Fundusz Rozwoju S.A. addressed to local governments; it aims to support deployment of innovative solutions in cities through education, training and monitoring the implementation of urban innovations with the use of the Innovation Base (Baza Innowacji) and through the award of PFR funds for innovative activities.

International initiatives and projects, e.g.: URBACT, Joint Program European Energy Research Associations Smart Cities.

Funding instruments

'**HUMAN SMART CITIES. Smart Cities Co-Created by Residents**' – a call for proposals addressed to local governments, the main goal of which is to develop the city, by means of smart solutions, as a living space for which residents are co-responsible by taking active part in the management and decision making. Given the pilot nature of the anticipated effects of the competition, the technology solutions and social innovations deployed, it will be equally important to popularise the solutions developed and promote good practices in this area among the various stakeholders and other cities with similar conditions.

The call was announced in 2017 and the results were announced in 2019. Ultimately, support was awarded to 24 cities for projects with a total value of PLN 44.7 million, PLN 39.5 million of which took the form of subsidies. The projects will have been completed by the end of 2022.

Local Development Programme (2019-2021), financed by the 2014-2021 EEA and Norway Grants (continuation of the Human Smart Cities call). The Ministry of Development Funds and Regional Policy (formerly the Ministry of Investment and Development). The programme supports projects dedicated to comprehensive development of a city in environmental, social, economic and institutional terms.

City of the Future 2050 (Konkurs Miasto Przyszłości 2050) – competition for participants of the Academy of Cities of the Future; the winners receive funding for innovative activities from the PFR for Cities programme.

NFOŚiGW – New Energy (Nowa Energia) 2020-2025 Programme, Area (2) Smart Energy Cities, which supports innovative technological solutions optimising energy management and utilisation processes, such that increase the resilience of cities to negative climate change impacts and reduce emissions, e.g. from transport and other sectors, as well as urban regeneration and green space projects.

6.2.3. Smart technologies/innovative technologies

Projects and initiatives

Inno-Lab – the aim of the project is to support the development of the innovation ecosystem in Poland with regard to the preparation and deployment of new technologies, innovative design of services and advisory support for start-ups.

The National Centre for Research and Development is implementing a project entitled '**Raising the level of innovation in the economy through the implementation of research projects under innovative public procurement procedures with a view to delivering the European Green Deal**'. The project foresees 8 undertakings, of which the following are relevant for this Strategy:

- Energy- and process-efficient construction,
- Effective ventilation for schools and houses,
- Energy (heat and cold) storage, storage integrated with heat pumps
- and air-conditioning systems,
- Electricity storage,
- 'Co-Generation Plant of the Future'.

The solutions developed through these projects, such as ventilation systems or heat or cold storage systems, can be utilised directly in the energy renovation of buildings or can be the basis for further research. The development of affordable, quickly scalable, energy and process-efficient solutions in new construction will also contribute indirectly to the streamlining of renovation of the existing building stock. Not only is striving to ensure the best possible energy balance for buildings crucial in the context of climate neutrality, but it also benefits users, who, by utilising renewable energy sources, are not burdened with higher utility bills and can breathe clean air at the same time. In particular, this group includes large families and elderly people, whose needs must be addressed in the housing offer for demographic reasons.

Innovations which make it easier and more cost-effective for gravity ventilation to be replaced with power ventilation with high-efficiency heat recovery will accelerate renovations of existing building stock and improve their efficiency. The use of heat and cold storage will be useful in effective management of renewable energy at times of excess production (which would otherwise be dispersed) and in controlling energy distribution at times of shortage. Surplus energy, also that produced by renewable sources, can be managed (stored) and utilised at times when demand for heat or cold peaks or at power shortage times, which can, at the same time, reduce the demand for electricity for air conditioning, heating or cooling installations. Such activities enhance the economic efficiency of the entire heat or cold supply process, and what is more, the use of heat or cold storage will directly contribute to the reduction of carbon dioxide emissions into the atmosphere on account of the use of energy which ultimately originates from RES. Given the robustness of the Polish heating networks, the effects of the 'Co-generation Plant of the Future' project will play an important role in ensuring that renovated buildings connected to a district heating system are supplied on a zero-carbon basis. The creation of innovative energy storage for the needs of individual and business consumers may help stabilise the power grid and optimise consumption of renewable energy (in particular wind and solar power), the generation of which is less predictable than in the case of conventional sources. In addition, energy storage systems connected to the grid will reduce the peak demand for energy (peak shaving) and reduce capacity contracted by consumers through market-based demand side response (DSR) mechanisms.

Funding instruments

NFOŚiGW – support for innovations conducive to a resource-efficient and low-carbon economy:

Completed:

- Sokół – Falcon (closed in 2017) – deployment of innovative environmental technologies (including high-efficiency, low-carbon and integrated energy generation, storage, transmission and distribution systems, as well as smart and energy-saving construction).

Under preparation:

- Energy-Efficient Lighting Systems.

NFOŚiGW – 'New Energy' priority programme, the aim of which is to boost innovation in the economy by supporting the delivery of modern energy technology projects working towards the development of a carbon-free energy sector and zero-emission industry, as well as of system solutions maximising the efficiency of production, management and utilisation of energy.

The goal of the programme will be pursued in 6 areas:

(1) Plus-energy buildings;

(2) Smart energy cities;

(3) Multi-fuel power units with heat or cold storage;

(4) Production, transport, storage and use of hydrogen;

(5) Stable carbon-free energy sources;

(6) Energy self-sufficient clusters.

SGOP implemented in 2014-2020 – financing research, development and innovation to enhance interaction between business and science. The programme, which is dedicated for enterprises, consortia and research institutions, funds industrial research and/or experimental development aimed at elaborating and implementing innovative products/services/technologies falling within the National Smart Specialisations. As part of the programme (Priority Axis I and III – sectoral programmes, Innovation Voucher, Research for the Market, Protection of Industrial Property, Bridge Alfa), the following were completed:

- Sub-Measure 1.1.1. Industrial research and development work carried out by companies SGOP 2014-2020 'Fast Track' (in progress). Calls (competitions) financed by EU Funds. The list of calls is updated on an ongoing basis. The programme is implemented by the National Centre for Research and Development (Intermediate Body).

  Completed:

  - *Heating Devices* thematic path – co-funding for industrial research, experimental development, and pre-implementation work.

- Sub-Measure 1.1.2 R&D related to the construction of a pilot/demonstration installation (e.g. for the manufacture of innovative polystyrene materials with reduced thermal conductivity).

- Sub-Measure 3.2.1. The programme is implemented by the Polish Agency for Enterprise Development (PARP) (Intermediate Body).

  Completed:

  - 'Research for the Market' (financing the implementation of innovative products and processes) (from 2015 to 2020), support was awarded, inter alia, to projects for: the production of an innovative, energy-efficient prefabricated building system, building of a photovoltaic roof tile manufacturing plant, implementation of innovative construction foamed polystyrene with enhanced performance characteristics, implementation of an innovative low-temperature surface heating and cooling system.

- Sub-Measure 3.2.2 (in progress): The programme is delivered by BGK (Intermediate Body).

  - 'Loan for Technological Innovations' (implemented from 01.06.2020 to 30.12.2020).

ROPs implemented in 2014-2020:

- Sub-Measure 1.2. Research and innovations in enterprises. The programme funded, inter alia, projects for: the development of the design of an elevation panel, research and development towards the development of new biogas-fuelled cogeneration power units, development of highly improved technology for the installation of ventilated facades, development of a hybrid heating system based on air heat pumps and pellet boilers, development of innovative solutions for energy-efficient cooling and air-conditioning systems.

7. Skills and education in the construction and energy efficiency sectors.

Pursuant to Article 2a(1)(f) of Directive 2010/31, each Member State is required to provide an overview of national initiatives to promote skills and education

in the construction and energy efficiency sectors.

Supporting the development of citizens' skills at all stages of life requires developing their existing skills, and also building methods and tools for honing new skills. The 'Integrated Skills Strategy 2030', adopted by the Cabinet, sets a strategic policy framework for the development of skills necessary to build social capital, social inclusion, economic growth, and to achieve a high quality of life. The above document has the nature of a public policy.

7.1. Building renovation qualifications

A number of people of various profiles and qualification levels are engaged in energy renovations of buildings. Three levels of qualifications of people who deal with energy renovation can be distinguished: low-, medium- and high-skilled workers. Low and medium-skilled workers are those who complete the works, while the high-skilled category comprises energy auditors, energy advisors, people who manage construction companies and are responsible for the design documentation.

According to estimates[31], in 2018, out of the 640 508[32] people who worked in the construction industry, approximately 85 000 (13.2%) completed energy renovation work, with acceleration of thermomodernisation likely to create another 100 000 jobs.

In Poland, workers acquire skills to practice their occupation through school and out-of-school education. Occupations are taught in vocational primary schools and secondary technical schools. Vocational schools also enable individuals to acquire additional qualifications useful in their respective occupations, additional professional skills, and market qualifications as part of the Integrated Qualifications System.

The adoption of the RES Act of 20 February 2015 (Journal of Laws 2021, item 610, as amended) have led to the creation of an out-of-school training and certification system for installers of renewable energy sources, which is managed by the Office of Technical Inspection (Urząd Dozoru Technicznego – UDT). Training can be delivered by institutions accredited by the UDT – currently there are 50 of them[33]. By 16.08.2020, the UDT issued 5 657[34] certificates in the following specialties: biomass boilers and stoves, photovoltaic systems, solar heating systems, heat pumps, or shallow geothermal systems.

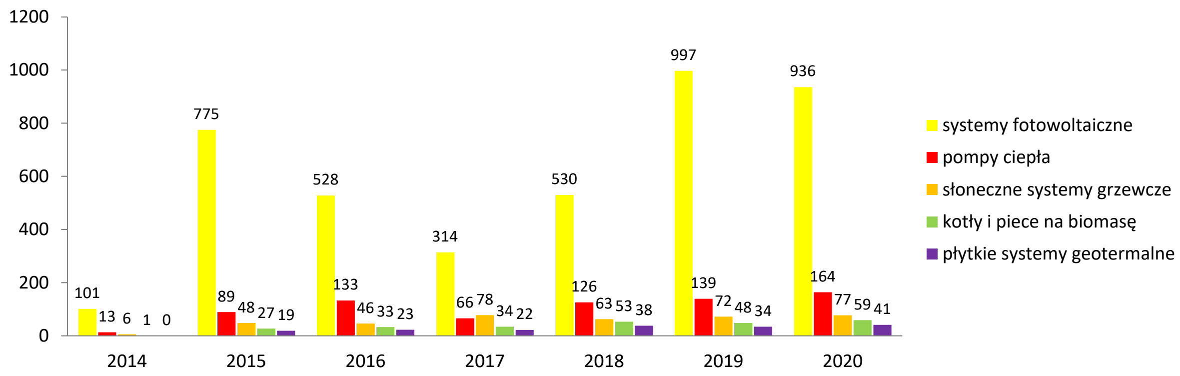
[31] Wpływ termomodernizacji budynków mieszkalnych na rynek pracy w Polsce (The influence of energy renovation of residential buildings on the labour market in Poland), IBS, Warsaw 2018 (link).

[32] GUS data (link).

[33] More information is available on the UDT website (link).

[34] The register is available on the UDT website (link).

Chart 21. Number of certified RES installers (number of certificates issued) in 2014-2020



Source: NAPE's own chart based on UDT data obtained on 11 September 2020

systemy fotowoltaiczne	photovoltaic systems
pompy ciepła	heat pumps
słoneczne systemy grzewcze	solar heating systems
kotły i piece na biomasę	biomass-fired boiler/stove
płytkie systemy geotermalne	shallow geothermal systems

PV system installation certificates account for the largest share of all RES installation certificates issued (73%). Less interest is taken in certification for installation of heat pumps (13%), solar heating systems (7%), biomass boilers and stoves (4%), and shallow geothermal systems (3%).

In parallel, new qualifications have evolved in the tertiary and out-of-school education systems, one of which is the energy auditor, and engineers engaged in renovation processes improve their qualifications on a continuing basis.

The table below presents how human resources are utilised at the main stages of the building energy renovation process which has developed over the course of 25 years, with indication of the qualification level and source.

Table 21. Estimated number of people involved in the building renovation process in Poland by renovation stage and qualification level

No	Stage name	Description of qualifications	Level of qualifications	Source	Estimated cumulative number of people
1.	Preparation of the technical and economic assumptions	Energy auditors (unregulated profession)	High	Courses Post graduate	Approx. 4000*
2.	Verification of the technical and economic assumptions	Energy auditors[35] (unregulated profession)	High	Courses Post graduate	Approx. 4000*
3.	Preparation of the design	Engineers with specific specialisations	High	Tertiary	118 187

[35] Those who have completed an energy audit cannot participate in verifying it.

	documentation	performing independent technical functions in construction, architects		education Qualifications granted by professional self-regulating bodies	(2019 r.)[36] and approx. 13 000 architects (according to information from the Polish Chamber of Architects)
4.	Organisation of the construction site, managing teams of contractors	Technicians/Engineers with concrete specialisations performing independent technical functions in construction	Medium/High	Secondary vocational education	980 700 (2019, including some engineers employed directly in construction)
5.	Direct contractors	Construction workers	Low	Basic vocational education	
6.	RES installers	RES microinstallation installers	Medium/ High	UDT qualification system	5 657
7.	Workmanship control – project supervision by investor	Engineers with concrete specialisations performing independent technical functions in construction	High	Universities Qualifications granted by professional self-regulating bodies	117 222 (2018)
8.	Control of whether the energy effect has been obtained – as-built audit	Energy auditors (unregulated profession)	High	Courses Post graduate	approx. 4000
9.	Process management on behalf of the building owner	Property managers (deregulated profession)	High	Tertiary education, courses	approx. 25 000

Source: NAPE estimates based on interviews with representatives of professions.

Sometimes investors look for additional qualifications if they need to have a grant application prepared or have the project managed by a project supervisor. These services are provided by specialised private or public-private companies, Business Environment Institutions, etc., which employ highly qualified specialists, economists and engineers.

In 2016, encouraged by the European Parliament and the Council[37], Poland started to put in place the Integrated Qualifications System (IQS)[38]. The IQS describes, organises and gathers various qualifications in one, publicly accessible register – the Integrated Qualifications Register. The IQS also defines the rules and standards for acknowledging the qualifications it covers, which

[36] Data of the Polish Chamber of Civil Engineers (link).

[37] More information is available on the IQS website (link).

[38] Integrated Qualifications System Act of 22 December 2015 on the (Journal of Laws 2020, item 226).

guarantees a high quality of the professional certificates issued within the framework of the system. The minister competent for education is in charge of coordinating the IQS.

The following types of qualifications are distinguished:

- qualifications acquired in schools of each level,
- qualifications acquired out of school, awarded under legal provisions,
- market qualifications, i.e. sets of expertise and skills required to carry out specific professional tasks.

Ultimately, all qualifications are to be included in the IQS. In particular, market qualifications must be put in order and described in a more detailed way so that they are adapted to market developments in Poland and Europe. For this purpose, the Sectoral Qualifications Frameworks (SQFs) are being created for the above disciplines. Discipline representatives are involved in their preparation, and the whole process is coordinated by the Educational Research Institute (Instytut Badań Edukacyjnych – IBE). So far, 10 SQFs have been established, and more are under development. As regards building renovation staffing needs, there are 2 SQFs:

- in 2017, the Educational Research Institute published the Construction SQF[39], which put in order the qualifications typical for the construction sector, which help workers plan their career path through acquisition of qualifications and enable employers to evaluate them reliably;
- in June 2020, work began on the creation of the SQF for the real estate sector[40]. On 5.08.2020, the industry received for consultation a draft SQF which included the new competences to be added to the qualification framework, covering inter alia:
    - in terms of expertise: energy efficiency, environmental and climate protection, circular economy, environmental certification,
    - in terms of skills: limiting the impact of the site and building on the environment.

Once established, the framework is expected to incentivise more property managers and administrators involved in the preparation and execution of the building energy renovation process into improving their qualifications.

Ultimately, the activities taken in this area will create conditions for the acquisition of the necessary skills by new workers and for continual improvement and review of the competences of all those employed in the construction and energy efficiency sectors.

7.2. Forecasting workforce needs

Since 2019, the minister in charge of education has announced forecasts of the staffing needs of vocation schools on the nationwide and regional labour markets[41]. Such forecasts are to be issued annually based on research conducted by the Educational Research Institute, public statistics, data from the Social Insurance Institution (ZUS), and the Educational Information System, and after consultation with Sectoral Competence Boards and the Competence Programme Board, as well as with ministers competent for the various vocational jobs. The first part of the forecast identifies the jobs for which, given their importance for Poland's development, special staffing needs are forecast on the domestic labour market, while the second part defines these needs for the individual provinces. If a specific jobs is included in the list of vocational jobs with special staffing needs on the domestic labour market, the corresponding allocation for education from the state budget distributed among regional and local government units for the

[39] Sektorowa Rama Kwalifikacji w Budownictwie (SRK-Bud), Instytut Badań Edukacyjnych, Warsaw 2017 (link).

[40] For more information see the project website.

[41] Forecasts from previous years are available on a dedicated website (link).

next year is increased and the amount of subsidy for the education of a young employee goes up to PLN 10 000 (unlisted occupations receive PLN 8 081). The forecast for 2021 does not include the following jobs: construction technician, refrigeration and air-conditioning technician and appliance and renewable energy system technician, but some provinces are currently reporting such needs.

The need to raise qualifications in the energy-efficient construction and RES sectors was noticed by the EU as early as 2010. This resulted in a pan-European strategic initiative known as Build-Up Skills[42]. As part of the project, each EU Member State has developed an analysis of the educational situation in the above areas and has formulated strategies for improving the qualifications of construction workers in the field of renewable energy technologies and energy-efficiency activities.

As GUS statistics show[43], in 2013, out of the total number of 865 228 people employed in the construction sector in Poland at the end of 2010, 40%, i.e. approx. 317 560, performed work related to the construction and retrofitting of buildings. No data on the educational structure of this group of construction workers was available. It was estimated that in 2011 the total number of installers of renewable energy systems (including solar thermal energy, PV, small biomass boilers, agricultural biogas, heat pumps and small wind farms) in Poland was approx. 4 400, with the largest number of workforce employed in the solar collectors sector, slightly lower in the biomass boiler and heat pump sectors, and the lowest in the PV sector.

The estimated demand for qualified energy efficiency workforce in construction over the 5-year period of 2014-2018 was approx. 20 000 employees per year. Based on statistical data on the state system of vocational education and certain assumptions regarding emigration, the number of school graduates (in occupations most relevant to the needs of the energy-efficient construction and renewable energy labour markets) was estimated at approx. 16 000 people per year.

The demand for qualified energy-efficient construction workforce in 2012-2020 was estimated at 99 000 (Status Quo Analysis), but a training system which takes into account the recommendations should be launched in the autumn of 2014 so that the estimated 2019-2020 market needs are covered in 100%.

Most of those who work in construction are low-skilled workers, most of whom have completed basic vocational education in construction. Currently, school-leavers' careers are monitored by the Ministry of Education and Science on the basis of data contained in databases of the Educational Information System, the Social Insurance Institution, the POL-on Integrated Information Network on Science and Higher Education (Zintegrowana Sieć Informacji o Nauce i Szkolnictwie Wyższym) and of regional examining boards. The career paths of such school-leavers are currently the subject of a joint survey by the Ministry of Education and Science and the Statistics Poland. Based on its results, their further educational and career choices, including the number of leavers employed in construction, will be determined. Moreover, this category of workforce is expected to see increased inflow of miners as a result of the ongoing transition away from coal. By 2050, their number is expected to total 6 000 in the Śląskie Province alone[44]. In parallel, once retrained, coal power industry employees will be able to undertake work related to low- and zero-carbon energy sources.

Leavers of secondary technical schools represent an important group of construction workers. Data from 2010-2018 show that the construction technician job lost in popularity considerably, while interest in the career of a renewable energy equipment and system technician was gradually rising.

[42] More information is available on the project website (link).

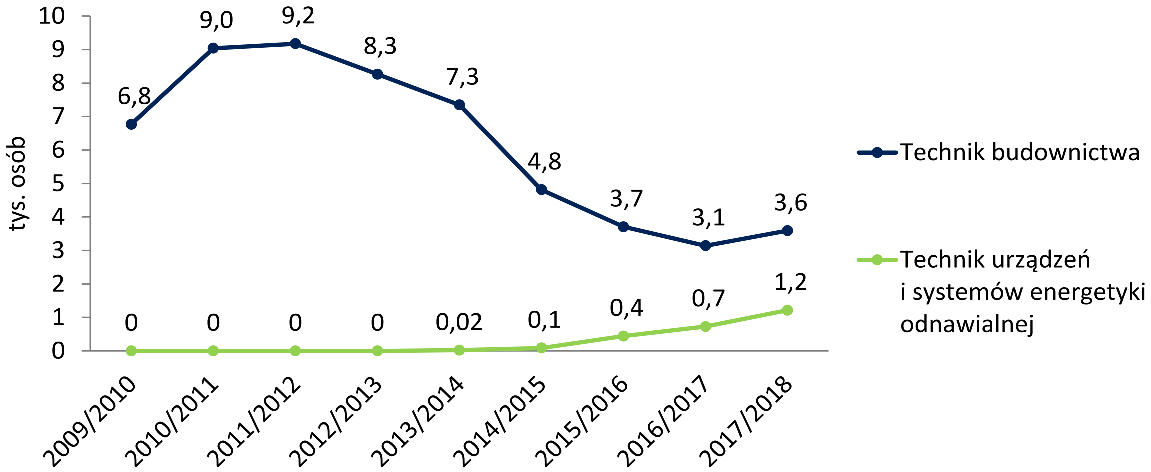
[43] A. Więcka et al., Strategia podnoszenia kwalifikacji pracowników budowlanych w zakresie technologii OZE i działań zwiększających efektywność energetyczną budynków, Warsaw 2013 (link).

[44] Sprawiedliwa transformacja węglowa w regionie śląskim. Implikacje dla rynku pracy (Just transition away from coal in the Silesia region. Implications for the labour market), IBS, Warsaw 2019 (link).

In 2018, the total number of school leavers with these specialisations was 4 706 people. One noteworthy fact was that the inflow of employees with secondary education to the professions in question varied highly from one province to another.

Chart 22. Number of school-leavers with the Construction Technician and

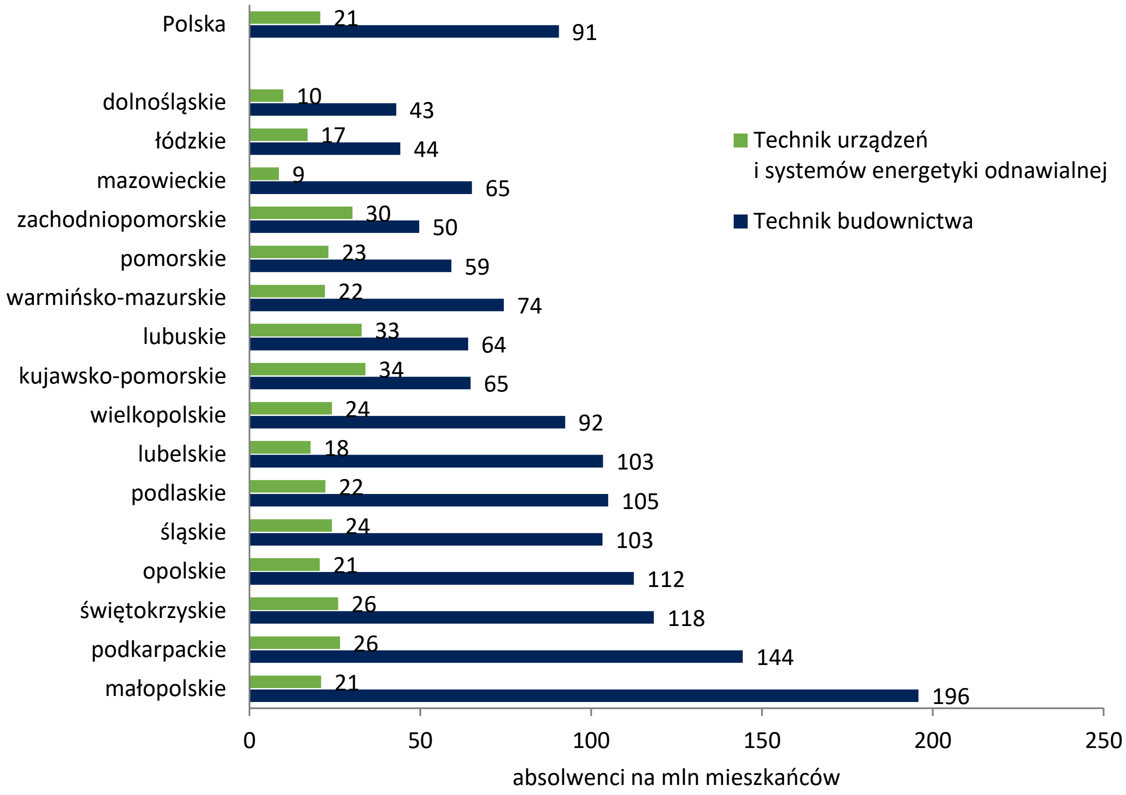
and Renewable Energy System Technician specialisations in Poland in 2010-2018



tys. osób	thousand people
Technik budownictwa	Construction Technician
Technik urządzeń i systemów energetyki odnawialnej	Renewable Energy System Technician

Source: NAPE's own research based on data of the Ministry of National Education acquired on 11.09.2020.

Chart 23. Number of school-leavers with the Construction Technician and and Renewable Energy System Technician specialisations as per million residents in Poland, by provinces, 2016-2018 average



Source: NAPE and WiseEuropa data based on information of the Ministry of National Education acquired on 11.09.2020.

Polska	Poland
dolnośląskie	Dolnośląskie
łódzkie	Łódzkie
mazowieckie	Mazowieckie
zachodniopomorskie	Zachodniopomorskie
pomorskie	Pomorskie
warmińsko-mazurskie	Warmińsko-Mazurskie
lubuskie	Lubuskie
kujawsko-pomorskie	Kujawsko-Pomorskie
wielkopolskie	Wielkopolskie
lubelskie	Lubelskie
podlaskie	Podlaskie
śląskie	Śląskie
opolskie	Opolskie
świętokrzyskie	Świętokrzyskie
podkarpackie	Podkarpackie
małopolskie	Małopolskie
Technik urządzeń i systemów energetyki odnawialnej	Renewable Energy System Technician
Technik budownictwa	Construction Technician
absolwenci na mln mieszkańców	graduates per million of inhabitants

It is essential that the needs for building renovation workforce be balanced with the inflow of employees with various educational backgrounds. This balancing should mainly be made at the regional level and aggregated at the national level, which would facilitate interventions aimed at maintaining the balance between supply and demand for building renovation workers.

In addition, the following are important with regard to construction and RES installation workers:[45]

1. adjustment and supplementation of training programmes for installers,
2. supplementation of existing industry standards with discipline-specific standards for biomass boilers, thermal solar collectors, and ventilation systems with heat recovery, such as to develop harmonised training programmes,
3. creation of a new training system based on modified training programmes, in which every installer seeking certification would be required to take an examination and the training could be provided by open-market operators.

[45] Opinia ekspercka: Program Szkoleń i Certyfikacji Dla Interesariuszy Rynku Usług Instalacyjnych (Expert report: Training and Certification Programme for Stakeholders of the Installation Service Market, MARR i PORT PC, Kraków 2020 (link)).

8. Financing renovation of Polish building stock

Pursuant to Article 2a paragraph 3 of Directive 2010/31, Member States are required to facilitate access to appropriate mechanisms to support the mobilisation of investments into the renovation needed to achieve the goals referred to in paragraph 1.

8.1. Panorama of low-carbon building stock renovation investments mobilised with public funds

This chapter provides an overview of low-carbon investments in the national building stocks, with identification of the sources, policies and methods for the financing, inter alia, of projects which have the purpose of improving energy efficiency and reducing emissions by replacing high-emission heat sources with more energy-efficient and ecological ones or which involve the connection of a building to a district heating network. The analysis includes investments in solar panels when they are part of an integrated investment in energy renovation of a building or in replacement of the heat source. The analysis spans 2014-2019, with the value of investment assigned to the year when it started. All figures are expressed in constant 2019 prices

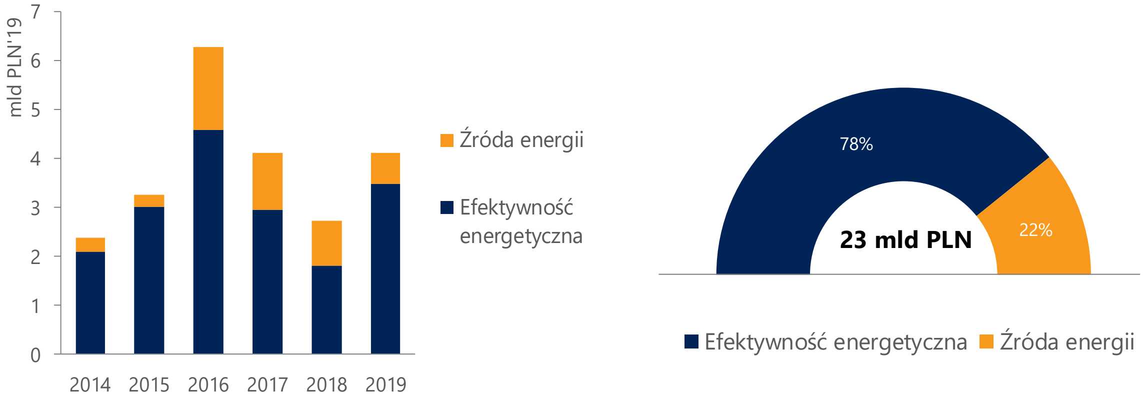
Support programmes included in the analysis[46]:

- EU co-funded projects implemented in Poland under the Multiannual Financial Framework 2014-2020,
- projects delivered in 2013-2019 with support from the EEA Financial Mechanism and the Norwegian Financial Mechanism,
- Thermomodernisation and Renovation Fund,
- thermomodernisation allowance (based on preliminary allowance figures supplemented with the estimated breakdown of investments supported by other support programmes),
- NFOŚiGW's programmes supporting low-carbon investments in construction, including the 'Clean Air' Programme.

The aggregate value of co-funded building renovation investments aimed at reducing emissions executed in 2014-2019 amounted to PLN 23 billion. Over 75% of the funds (PLN 18 billion) were allocated for increasing energy efficiency, while the remaining portion for replacement of heat sources and RES installations. In the period analysed, most investments, i.e. PLN 6.3 billion, were initiated in 2016, following which the scale of funding was decreasing steadily mainly as a result of the pace of EU spending in the 2014-2020 financial perspective. A different dynamics was shown by energy efficiency investments, the volume of which rose substantially in 2019 relative to 2017-2018.

[46] For more information on the analysis methodology see the WiseEuropa report, NCI, I4CE (2020). *Renowacja. Panorama niskoemisyjnych inwestycji w sektorze budynków* (Renovation. A panorama of low-carbon investments in the building sector (link)).

Chart 24. Dynamics of building stock renovation investments (left-hand side) and their aggregate value (right-hand side) in 2014-2019

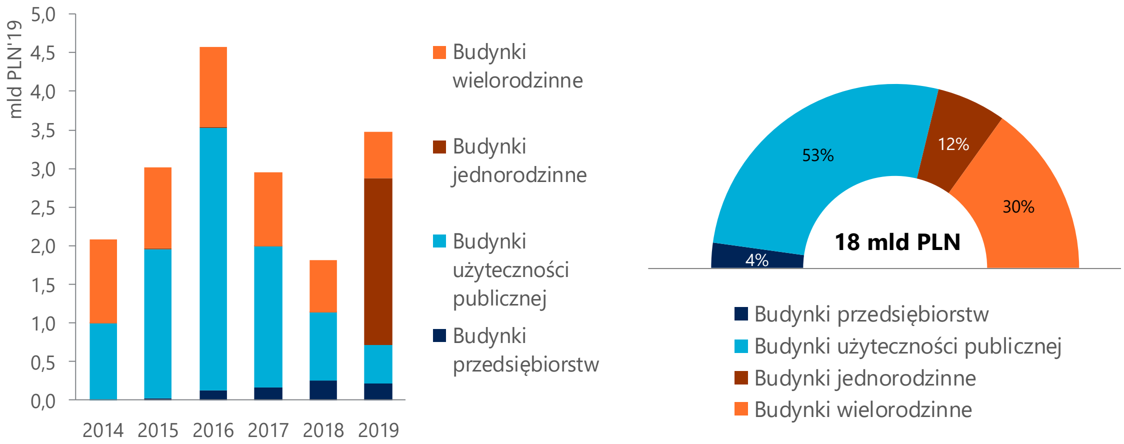


Source: WiseEuropa estimate based on data regarding public support programmes for renovation of building stock in Poland.

mld PLN'19	PLN billion'19
Źróda energii	Energy sources
Efektywność energetyczna	Energy efficiency
23 mld PLN	PLN 23 billion
Efektywność energetyczna	Energy efficiency
Źróda energii	Energy sources

More than half of investments in energy efficiency of buildings supported by public funds in 2014-2019 were expended on public buildings. Most of the investments (worth over PLN 3 billion) were started in 2016. In 2014-2019, investments in energy renovation of residential buildings supported by public policy instruments amounted to approx. PLN 7.6 billion. In 2014-2018, nearly all of the supported projects concerned multi-family buildings, while in 2019 investments in single-family buildings accounted for almost 80% of the co-funded housing investments. This is attributable to the introduction of the thermomodernisation allowance at the time and the early effects of the ‘Clean Air’ Programme, which was adopted in response to the lack of instruments supporting energy renovation of single-family buildings at the time.

Chart 25. Dynamics of investments in energy efficiency of buildings (left-hand side) and their aggregate value (right-hand side) in 2014-2019

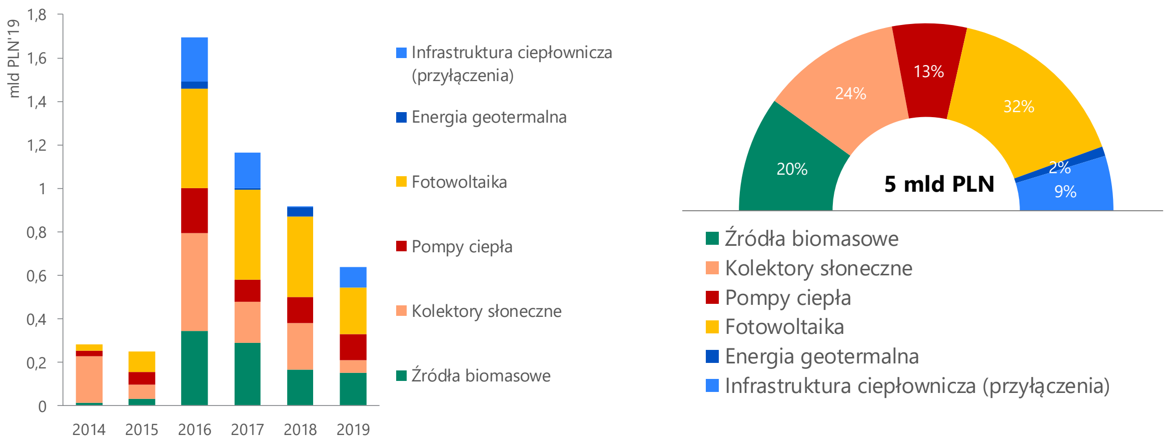


Source: WiseEuropa estimate based on data regarding public support programmes for renovation of building stock in Poland.

mld PLN'19	PLN billion'19
Budynki wielorodzinne	Multi-family buildings
Budynki jednorodzinne	Single-family buildings
Budynki użyteczności publicznej	Public buildings
Budynki przedsiębiorstw	Company buildings
18 mld PLN	PLN 18 billion
Budynki przedsiębiorstw	Company buildings
Budynki użyteczności publicznej	Public buildings
Budynki jednorodzinne	Single-family buildings
Budynki wielorodzinne	Multi-family buildings

In the years 2014-2019, nearly PLN 5 billion was allocated for replacement of energy sources in buildings, almost 1/3 of which was apportioned for solar panels (as part of projects comprising also other renovation spending), and approx. 1/4 for solar collectors. The aggregate estimated value of expenditure on biomass sources did not exceed PLN 1 billion, and a total of approximately PLN 0.6 billion was allotted to investments in heat pumps supported by public funds.

Chart 26. Dynamics of investments in low-carbon energy sources (left-hand side) and their aggregate value (right-hand side) in 2014-2019

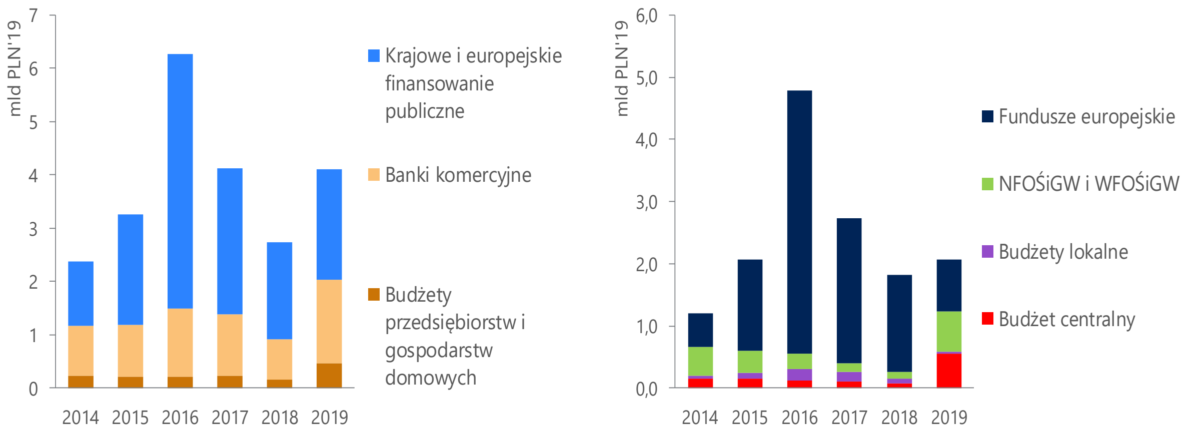


Source: WiseEuropa estimate based on data regarding public support programmes for renovation of building stock in Poland.

mld PLN'19	PLN billion'19
Infrastruktura ciepłownicza (przyłączenia)	Heat supply infrastructure (connections)
Energia geotermalna	Geothermal energy
Fotowoltaika	Photovoltaics
Pompy ciepła	Heat pumps
Kolektory słoneczne	Solar collectors
Źródła biomasowe	Biomass sources
5 mld PLN	PLN 5 billion
Źródła biomasowe	Biomass sources
Kolektory słoneczne	Solar collectors
Pompy ciepła	Heat pumps
Fotowoltaika	Photovoltaics
Energia geotermalna	Geothermal energy
Infrastruktura ciepłownicza (przyłączenia)	Heat supply infrastructure (connections)

EU funds play the leading role in supporting low-carbon investments financed with public funds (75% of all public spending – PLN 11 billion). Notably, in 2014-2019, over 70% of the EU funds (PLN 9 billion) were utilised by the public sector of the national, regional and local levels. In 2015-2018, the value of EU funds exceeded the value of domestic public funding over five times. From 2016, the share of EU funds in the funding structure was systematically decreasing, which resulted directly from the timing of the calls under the 2014-2020 financial perspective. The decreasing share of EU funds over that period was not, however, compensated by an increase in domestic funding. In 2019, the picture changed radically following a high increase in the share of financing from the central budget (thermomodernisation allowance) and from the NFOŚiGW ('Clean Air' Programme) in the breakdown of building renovation funding in Poland.

Chart 27. Dynamics of building renovation investments (left-hand side) and their aggregate value (right-hand side) by key sources of funding in 2014-2019



Source: WiseEuropa estimate based on data regarding public support programmes for renovation of building stock in Poland.

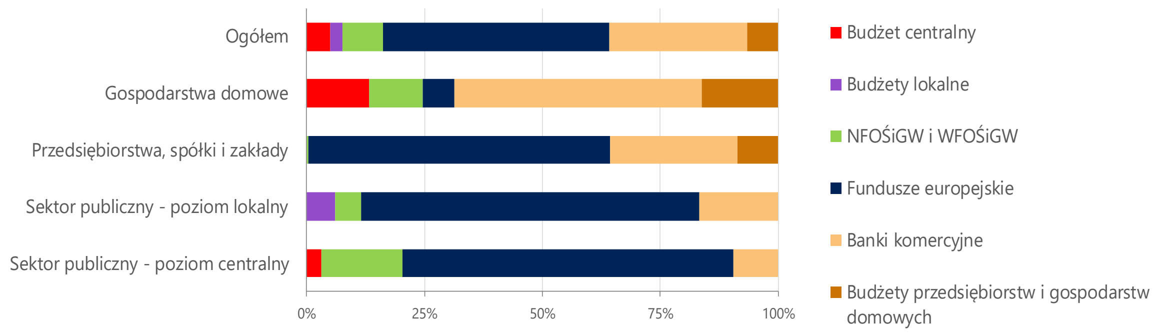
mld PLN'19	PLN billion'19
Krajowe i europejskie finansowanie publiczne	National and European public financing
Banki komercyjne	Commercial banks
Budżety przedsiębiorstw i gospodarstw domowych	Enterprise and household budgets
Fundusze europejskie	European funds
NFOŚiGW i WFOŚiGW	National Fund for Environmental Protection and Water Management (NFOŚiGW) and Provincial Fund for Environmental Protection and Water Management (WFOŚiGW)
Budżety lokalne	Local budgets
Budżet centralny	Central budget

In the period under analysis, funds allocated by the NFOŚiGW for energy renovation and replacement of low-carbon energy sources in buildings amounted to just under PLN 2 billion, with most of the funds apportioned in 2019. Own funds from local government budgets (excluding loans and subsidies) accounted for approx. 3% of the public funds allotted to low-emission investments in the renovation of buildings.

In 2019, financing from budgets of enterprises, households and commercial banks amounted to almost 50% of all investments, while in 2014-2018, the rate of private sector funding was much lower and did not exceed 40%. On average, commercial banks funded 30% of investments.

Most of the funding for public sector investments, primarily for energy renovation of public buildings and residential buildings in public ownership, was sourced from EU funds (over 70% of public sector investors relied on them). Low-carbon investments in the building sector carried out by public administration were also possible thanks to funds provided by the NFOŚiGW – those pursued at the central level were more dependent on NFOŚiGW than those implemented by regional and local governments (the share of NFOŚiGW funds accounted for 17% and 6% of all investments carried out by these groups of investors, respectively).

Chart 28. Aggregate share of sources of funding for low-carbon technologies, by groups of investors in 2014-2019.

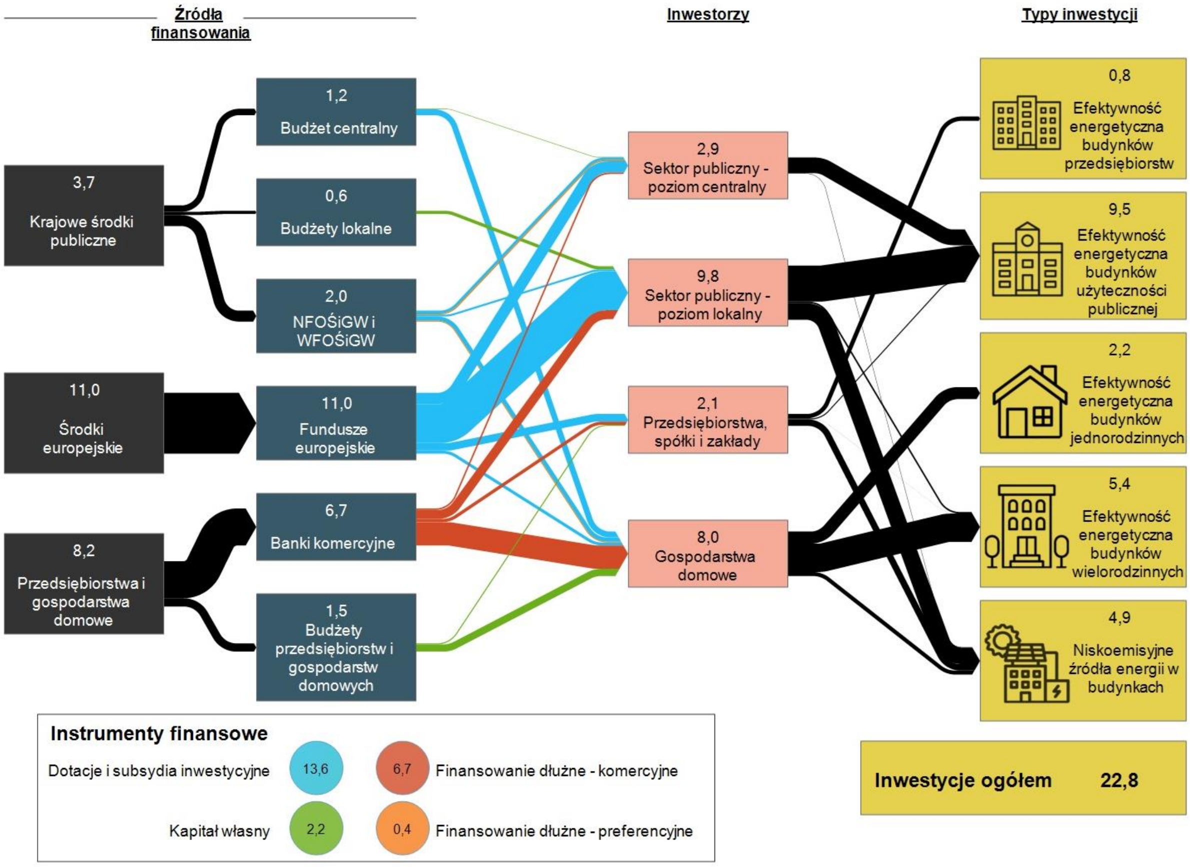


Source: WiseEuropa estimate based on data regarding public support programmes for renovation of building stock in Poland.

Ogółem	Total
Gospodarstwa domowe	Households
Przedsiębiorstwa, spółki i zakłady	Enterprises, companies and plants
Sektor publiczny - poziom lokalny	Public sector - local level
Sektor publiczny - poziom centralny	Public sector - central level
Budżet centralny	Central budget
Budżety lokalne	Local budgets
NFOŚiGW i WFOŚiGW	National Fund for Environmental Protection and Water Management (NFOŚiGW) and Provincial Fund for Environmental Protection and Water Management (WFOŚiGW)
Fundusze europejskie	European funds
Banki komercyjne	Commercial banks
Budżety przedsiębiorstw i gospodarstw domowych	Enterprise and household budgets

As is shown by the model of funding of low-carbon building investments by households (both natural persons, associations of flat owners and housing cooperatives), this group of investors primarily relied on capital acquired from commercial banks and on their own funds. The remaining portion was mobilised from the central budget (through the FTiR and thermomodernisation allowance) and from the NFOŚiGW. Only 7% of the projects executed by this group of investors benefited from EU funds. Investments by enterprises were co-funded for the most part by EU funds with a high intensity of the support. However, under IEOP 2014-2020, energy efficiency investments delivered by large enterprises were supported by reimbursable aid with an investment premium for effects. The rest of the funds was sourced on commercial terms from banks or covered by the company’s own contribution.

Chart 29. Panorama of low-carbon building stock renovation investments mobilised with public funds (PLN billion total for 2014-2019)



Source: WiseEuropa and I4CE study based on data regarding public support programmes for renovation of building stock in Poland.

Źródła finansowania	Sources of financing
Krajowe środki publiczne	National public funds
Środki europejskie	European funds
Przedsiębiorstwa i gospodarstwa domowe	Enterprises and households
Budżet centralny	Central budget
Budżety lokalne	Local budgets
NFOŚiGW i WFOŚiGW	National Fund for Environmental Protection and Water Management (NFOŚiGW) and Provincial Fund for Environmental Protection and Water Management (WFOŚiGW)
Fundusze europejskie	European funds
Banki komercyjne	Commercial banks
Budżety przedsiębiorstw i gospodarstw domowych	Enterprise and household budgets
Inwestorzy	Investors
Sektor publiczny -poziom centralny	Public sector - central level
Sektor publiczny -poziom lokalny	Public sector - local level
Przedsiębiorstwa, spółki i zakłady	Enterprises, companies and plants
Gospodarstwa domowe	Households
Typy inwestycji	Investment types
Efektywność energetyczna budynków przedsiębiorstw	Energy-efficiency of company buildings
Efektywność energetyczna budynków użyteczności publicznej	Energy-efficiency of public buildings

Efektywność energetyczna budynków jednorodzinnych	Energy-efficiency of single-family buildings
Efektywność energetyczna budynków wielorodzinnych	Energy-efficiency of multi-family buildings
Niskoemisyjne źródła energii w budynkach	Low-carbon energy sources in buildings
Inwestycje ogółem	Total investments
Instrumenty finansowe	Financial instruments
Dotacje i subsydia inwestycyjne	Investment grants and subsidies
Kapitał własny	Own capital
Finansowanie dłużne - komercyjne	Debt financing - commercial
Finansowanie dłużne - preferencyjne	Debt financing - preferential

8.2. Building renovation funding tools

This chapter looks at how existing financing tools for building renovation are targeted depending on the building renovation stage and building type. The need for harmonisation of individual funding instruments in terms of intensity of intervention and eligible costs for the same types of buildings is highlighted. The chapter also proposes improvements to these instruments and policies towards development of organisational and financial forms aimed at enhancing support for beneficiaries at the various building renovation stages.

8.2.1. Complexity of the building renovation process and the financial needs of the investor

By deciding to start a renovation, the owner initiates the investment process, which comprises the following three main stages:

- Preparation of investment,
- Execution of investment,
- As-built actions.

The division of tasks **across the stages of the investment**[47] is presented below:

	Stage name	Task name
I.	**Preparation of investment**	
1.		Analysis of the needs and possibilities – multiple-variant energy audit
2.		Feasibility Analysis – Feasibility Study
3.		Formation of project execution team
4.		Mobilisation of funding
5.		Creating detailed implementation plans
6.		Selection of contractors
II.	**Execution of investment**	
1.		Establishment of the work management and supervision set-up
2.		Timely completion of energy renovation activities
3.		Acceptance of renovation work and operational implementation
III.	**As-built actions**	
1.		Implementation audit
2.		Settlement with the implementation teams
3.		Implementation of operational monitoring of the systems implemented

[47] Presentation: 'Example of an energy efficiency project implemented in a local government unit in Poland on a nearly 'one-stop-shop' basis; general findings', FPE 2018 (link).

Existing building renovation funding instruments comprise components which enable investors to reduce the costs of the individual investment stages.

As regards the funding of the **preparatory stage**, two types of support can be distinguished:

1. Dedicated support not related directly to the financing of successive project stages, provided as technical assistance from the EU's ELENA facility[48], which offers reimbursement of up to 90% of the costs necessary to prepare an investment project for the completion state. ELENA funds for the renovation of multi-family buildings are available in combination with an offer of low-interest ROP-supported loans extended by Alior Bank S.A. in the Podlaskie, Łódzkie, Dolnośląskie and Małopolskie Provinces, by Getin Noble Bank S.A. in the Kujawsko-Pomorskie, Pomorskie and Warmińsko-Mazurskie Provinces, while across Poland they are offered by Alior Bank S.A. and BNP Paribas S.A.
2. in combination with a loan with a thermomodernisation or renovation bonus.
3. Eligible support, i.e. investment preparation costs qualify as investment costs which can be co-funded and are widely recognised as such by institutions financing renovation of buildings.

The **investment execution** stage is funded by means of a number of financial instruments targeted at specific types of building. The sources of funding are presented in Chapter 5.

Typically, the costs of **as-built stage** tasks are eligible if the execution of these tasks (e.g. ex-post energy audit) is required by the manager of the financial instrument.

The range of building renovation fund sources and forms presented above is supplemented by municipal initiatives such as Kraków's and Warsaw's 'low-stack' emission reduction programmes, as well as provincial schemes of low-interest loans granted, inter alia, for building renovation purposes, including loans for regeneration projects/Jessica2 (under regional operational programmes) in the Wielkopolskie, Pomorskie, Śląskie, Małopolskie and Mazowieckie Provinces extended by BGK (directly or indirectly).[49]

8.2.2. Features of efficient public building renovation funding programmes

The 2014-2020 financial perspective saw the development of a number of new support programmes, some of which emerged in parallel to the existing programmes. Based on an analysis of their effects and the way they function[50], a list their good qualities can be proposed.

Adequate intensity of support

With the exception of public sector buildings (including municipal buildings owned by RLGUs), the intensity of support should be much lower than 90-100% of eligible costs. Depending on the quality and ambition of the renovation project, support of 30-70% is usually sufficient for renovation to be completed and, at the same time, for those responsible to be incentivised to manage and expend funds efficiently. Such rates of support also ensure that private funds are expended on public welfare, for example through: EPCs, inter alia on the basis of PPPs, ESCOs[51] or financial instruments.

Facilitating the combination of other financial instruments with grants

[48] For more information see the EIB website (link).

[49] For more information see BGK's website (link).

[50] More effective use of the 2021-2027 Cohesion Funds for energy security of the Visegrad, Buildings for the Visegrad Future project report (link).

[51] ESCO – Energy Service Company, i.e. a provider of energy efficiency services investing its own or mobilised funds in order to implement energy-efficient solutions guaranteeing energy savings.

Combining financial instruments with subsidies lies in the public interest. The deployment of financial instruments means that private funds work towards public goals, which highly boosts the efficiency of public spending. In order for financial instruments to be integrated efficiently with public support programmes for renovation, the rules governing them must ensure that the same sets of costs are eligible under both financial instruments and grants, and the grant and instrument application processes should be harmonised.

Ensuring that financial support promotes more ambitious construction and renovation projects

Programme and call rules should incentivise owners of buildings to improve their energy performance, adapt them to climate change, use building materials responsibly, and ensure suitable indoor environmental quality. The rates of non-reimbursable financial aid should be made dependent on the use of the above measures.

Preference for long-term support programmes with stable conditions

Usually, hasty preparation of a project, which is typically caused by tight co-funding application timeframe, reduces the quality of renovation. The stability of support conditions builds trust and enables building owners to plan their activities in line with their own needs and possibilities (e.g. financial, time- and construction-related ones).

Preventing competition between programmes

Efforts should be made to eliminate the existence of multiple programmes which support the same renovation activities, but are subject to different conditions. For a given building type, there should be one renovation scheme or renovation activities should be supported on equal terms across the programmes, with the same requirements applicable to energy efficiency, climate effect and other building characteristics, and with the same set of eligible costs.

Effective monitoring through standardised reporting and effective system for the flow of information regarding the size, structure and effects of expenditure

Given the large number of different support instruments for the renovation of buildings managed by various institutions, getting a full picture of the level, structure and effectiveness of public financing in this area will be difficult if no harmonised approach to reporting and improving the flow of data in this regard is implemented.

8.2.3. Actions to improve the efficiency of public funds expended in support of renovation of buildings

An analysis of the utilisation of Cohesion Fund resources for renovation of buildings in the Visegrad countries in the financial perspective 2014-2020[52] highlights the following actions likely to boost the effectiveness of the mobilisation of private funds by public instruments.

Use of continuous calls

The ‘start-stop' system of calls reduces the quality of projects. A beneficiary-focused approach should be put in place, such as to take into account the fact that a long time horizon and stability of the conditions behind support help build the trust of building owners and allows the latter to plan in line with their own preferences and needs (e.g. financial, time- and construction-related

[52] More efficient use of the 2021-2027 Cohesion Funds for energy security of the Visegrad, Buildings for the Visegrad Future project report (link).

ones). Usually, hasty preparation of a project translates into lower quality renovation. Applicants and building owners should make their own decisions based on when their buildings really need renovation or when they want to commit their resources as they see fit rather than as required by the call timelines set by the implementing body.

Providing technical assistance to municipalities and building owners

There is a need for networks of one-stop shops or OSSs (preferably at the level of provinces) to help building owners prepare and execute renovation projects and mobilise financial support. OSSs should serve not only managers of public buildings, but also owners of residential buildings, and the OSS programme should comprise, inter alia, support for the preparation of public procurements, if necessary for a project. In the case of buildings protected by a conservator, the OSSs should help prepare public procurements and the necessary conservation documents required for the provincial monument conservator to approve the project. OSSs can also apply for funding from the EIB's ELENA facility or other EU programmes for the co-financing of the preparation of energy efficiency projects in buildings.

Raising awareness on energy saving

In general, renovation of buildings reduces energy costs, which many building owners do not see as a benefit. Therefore, financing should be complemented by information campaigns highlighting the specific opportunities and benefits for building owners. It is also essential that local communities be involved in the preparation and implementation of climate change mitigation plans so as to raise public awareness on how to counteract climate change. There is a need for developing information campaigns targeting different groups of energy users, to be financed by the budgets of each of the programmes.

Promoting comprehensiveness and quality, not just improvement of energy efficiency

In addition to promoting energy savings in buildings, it is important that owners be encouraged to improve the quality of their buildings. Actions to improve the indoor environmental quality or adaptation of the building to climate change should also constitute eligible project costs. Improving the energy efficiency of buildings should produce other construction-related benefits, such as ensuring a sufficient supply of fresh air, appropriate lighting, sound comfort, and improved safety of users, e.g. through the retrofitting or replacement of obsolete electrical installations and use of a combi boiler for DHW preparation instead of a bathroom gas heater, as well as through the removal of dangerous substances, such as asbestos. Asbestos-cement tiles should be removed from renovated buildings and replaced with other material in the course of renovation, with the use of funding envisaged for this purpose by the Polish asbestos abatement programme.

During construction works, the project investor is required to ensure that the environment in the area where work is carried out is protected.

More financial support for project preparation

Proper preparation of an application for financing requires a thorough energy audit, a feasibility study, a renovation schedule, etc. Deep energy renovation projects are multidisciplinary undertakings which require a wide range of skills from contractors, much wider than for typical renovation projects. The cost of preparing such projects is relatively higher than the awarded budget, as it should cover the cost of an integrator of services rendered in various areas of specialisation. In Poland, some banks which extend preferential lending or loans for energy renovation and retrofitting of multi-family buildings have already been provided assess to the EU's ELENA budget, which funds professional technical and economic assistance for associations of flat owners, housing cooperatives, and local governments.

8.2.4. Recommended approaches helping investors to undertake and complete renovation of buildings

Building renovation projects increasingly require interdisciplinary and specialised technical, architectural, conservation, economic and legal expertise. The selection of appropriate competences to supervise the subsequent renovation stages is a key precondition for achieving the expected effect.

It is important to enhance the intensity of support provided to investors, in particular at the investment preparation stage, the quality of which determines the quality of construction works. Support in this area takes the form of information activities as part of the NFOŚiGW's energy advice system (Chapter 5) and reimbursement of the costs of technical preparation of a project (energy audit, design documentation, tendering procedures and other necessary expert reports) under the EU ELENA facility.

One-stop-shops (OSSs)

One-stop-shops provide services in one place to facilitate the preparation and execution of a task/project in a comprehensive way. From investors' point of view, this should mean them being able to have everything handled, i.e. select and purchase all the products they need and acquire information and support on how to use them, in the same place. Importantly, municipality residents, investors, building owners, etc. should somehow 'find their way' to a one-stop-shop thanks to appropriate information and publicity.[53]

The OSS concept assumes setting up an appropriate structure to help all types of public or private stakeholders engaged in a renovation process. OSSs act on behalf of public bodies as intermediaries supporting the implementation of energy saving measures, which can take the form of energy effect contracting (including maintenance services, such as construction works, deliveries or energy retrofit services) or other form of contracting. The benefits of OSSs include simplification of procedures, assistance in the preparation of the required documents, and reduction of investment time compared to that needed for analogous activities to be handled by public institutions[54].

In Poland, the OSS service is mainly provided by property managers to owners of multi-family buildings[55]. It should be supplemented by the monitoring of the energy and economic effect in order for additional potential for reducing heat energy and electricity consumption to be identified. In addition to heat consumption, the use of electricity in these buildings and enhanced use of renewable energy, including photovoltaics, should be addressed.

As it seems, the OSS concept would be most appropriate for the implementation of a scheme for improving energy efficiency in single-family houses owned by both low- and higher-income families. Such activities should be coordinated by regional and local government units together with public, private or mixed OSSs based on the rules applicable to current support for this type of buildings.

The scope of OSS services should be adapted to the local needs and structure of the investment project.

An OSS should have the following characteristics and meet the following requirements:

- Have proven competence to render the following scope of services:
    - preparation and delivery of investment projects, raising external funds, settling expenditure, and checking project outcomes,

[53] Report from the Second Round Table on the financing of energy efficiency in Poland, Warsaw 2018 (link).

[54] Round Table on the financing of energy efficiency in Poland. The background of the meeting, Warsaw 2018 (link).

[55] Report from the Round Table on the financing of energy efficiency in Poland, Warsaw 2018 (link).

    - guaranteeing the energy effect assumed at the preparation stage, both for simple and comprehensive investment projects.

- Inspire confidence among investors, financing institutions and contractors.
- Be neutral vis-a-vis/independent of suppliers of goods and services for the purposes of investment implementation.
- Have the ability and experience to solve problems which come up during investment processes.
- Have financial and human resources to assume the responsibility for executing the investment and achieving the anticipated effects within a reasonable timeframe after the completion/commissioning of the project.

OSS services may be offered by:

- Organisations and entities which have participated in comprehensive energy renovations of buildings, including:
    - Managers of non-public and public real estate (local government units),
    - Energy agencies,
    - Professional energy auditors,
    - Business Environment Institutions,
    - Energy Service Companies (ESCOs).

  Each of the above could undertake investments as an OSS independently or in collaboration with the other types of organisations.
- An important role in the development of the market for OSSs may be played by Energy Advisers of the NFOŚiGW
- under the 'support for investment' measure as coordinators of larger-scale regional projects and independent verifiers of project assumptions. Them being attached to Provincial Funds for Environmental Protection and Water Management – WFOŚiGW (institutions which have their own funds and manage EU funds) would streamline the creation of energy efficiency programmes for buildings of different owners: collective accommodation buildings (associations of flat owners and housing cooperatives) owned by individuals, local government units, SMEs, at least in terms of financial engineering. The activity of NFOŚiGW's Energy Advisors should not compete with the work of energy auditors and other specialists dealing specifically with the preparation and delivery of investments.

In the next EU financial perspective, Commission and EIB support will be available for the development of institutions providing one-stop-shop services at the national, regional and local levels[56].

The delivery of investments through energy performance contracting by a specialised ESCO based on the PPP model is an alternative or specialised form of one-stop-shop services.

ESCO/PPP

Notably, apart from such advantages as cost savings and improved use comfort, one important aspect related to economic benefits lies in ensuring that the energy effect assumed before the investment is feasible, and then, in confirming that, once the project is completed, it is durable. The durability of the effect means that it produces the assumed benefits each year until the next investment project in the building (usually 7-15 years or more).

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[56] European Commission (2020), Renovation Wave for Europe – greening our buildings, creating jobs, improving lives (COM(2020) 662 final, str. 16.)

In order to guarantee the durability of the energy effect, it is necessary to employ an approach where the overall responsibility for achieving the effect rests on a specialised entity dealing with energy management systems on a daily basis, and not on the building user. EPC is the most effective form of cooperation in this area. EPC means that the contractor will receive its payment if the planned energy performance is actually achieved in the individual years after the completion of the works.

EPC may be based on two cooperation formulas: PPP and ESCO, but it must be noted that as per the Energy Efficiency Act of 20 May 2016, as amended, EPC will be treated as a special type of a PPP arrangement. The differences between the two models are discussed in section 4.3. In both cases, a private party undertakes to achieve an actual energy effect over a long period of the functioning of the building. The above conditions make the PPP/ESCO model highly recommendable for energy efficiency projects for public buildings. The PPP/ESCO model guarantees the achievement of actual effects, high-quality services, optimisation of costs and protection of public funds if design or workmanship errors occur. It must be borne in mind that the scale of possible benefits on the public side will be the greater, the greater the capex on a single project. Therefore, individual investment needs should be pooled into larger investment packages.

The deployment of the PPP/ESCO formula for the delivery of the above projects aligns with the Strategy for Responsible Development, the Energy Policy of Poland until 2040 (PEP 2040), and the Government Policy for the Development of PPPs, adopted by Cabinet Resolution of 26 July 2017.

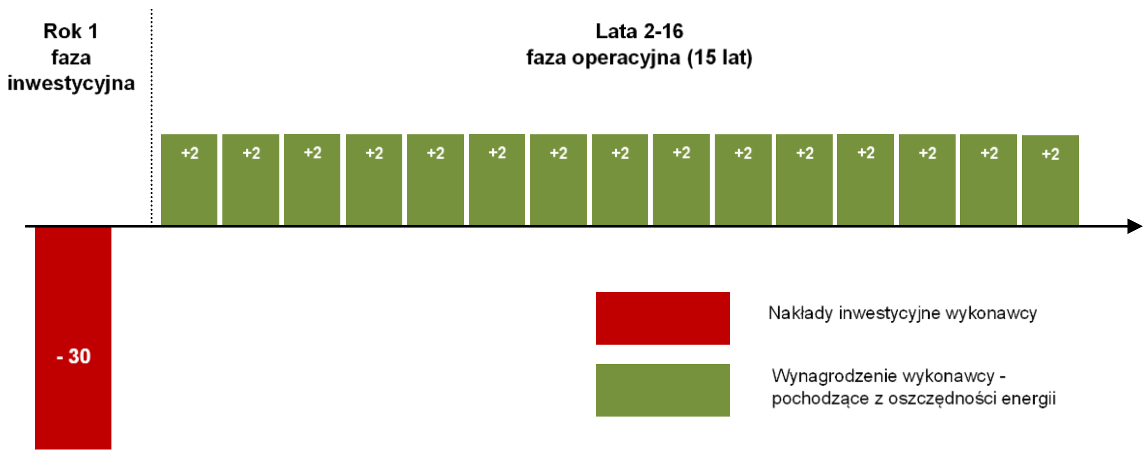
The main assumption behind this formula is that the energy cost savings generated by a project will guarantee return on the expenditure made. At the investment stage, a specialised contractor (the private partner) designs, executes and possibly finances the works to improve the energy performance of the building. In the operational phase, the contractor manages the building's energy system in return for remuneration. The user of the building benefits from cost savings. The contractor's remuneration (in its entirety or in part) is sourced from the savings. The level of remuneration depends on the level of savings, i.e. the durability of the energy effect.

The sections below present three models maximising the effectiveness of energy-efficiency investments: ESCO, PPP, and a hybrid model. In each of them, the contractor is responsible for the design and execution of the investment, the financing of (at least a portion of) the capex, and the management of the building's energy system so as to maintain the energy effect.

Model 1. ESCO

The investment solely covers work necessary to increase the energy efficiency of the building, with no additional tasks included. The return on investment is covered exclusively by the energy cost savings achieved. The remuneration depends on the attainment of the energy effect.

Diagram 2. Financial flows in an ESCO project (values in PLN million)



Source: Data of the Ministry of Development Funds and Regional Development.

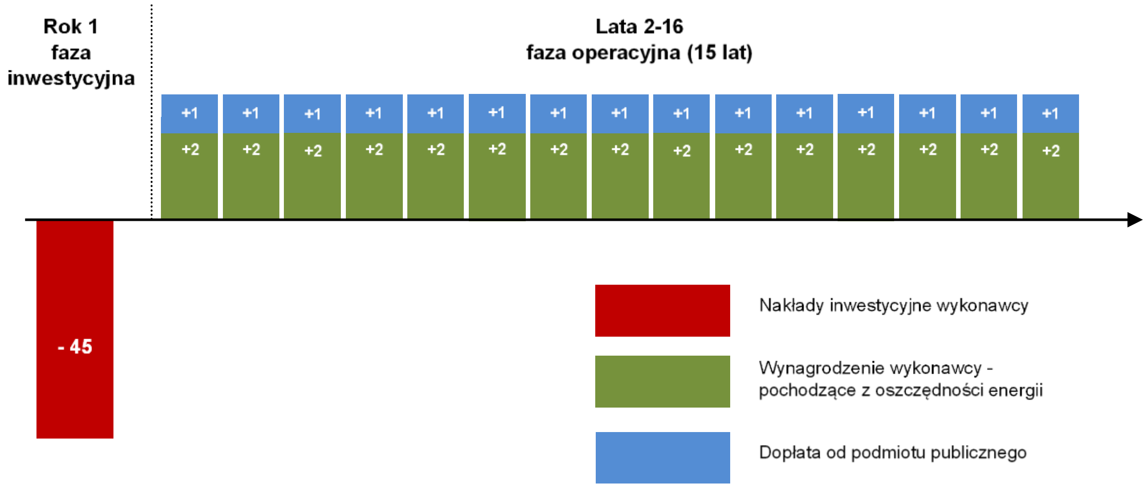
Rok 1 faza inwestycyjna	Year 1 investment stage
Lata 2-16 faza operacyjna (15 lat)	Years 2-16 operational stage (15 years)
Nakłady inwestycyjne wykonawcy	Contractor's capex
Wynagrodzenie wykonawcy -pochodzące z oszczędności energii	Contractor's fee - deriving from energy savings

Model 2. Public-private partnership (PPP)

The investment covers a wide range of work necessary to increase the energy efficiency of the building, which translates into higher capex. As a consequence, the contractor's remuneration is financed by the energy savings generated and an additional fee from the public partner. All the tasks are carried out by the private partner, which receives remuneration depending on the energy effect attained.

Diagram 3. Financial flows in an ESCO project

including a PPP (values in PLN million)



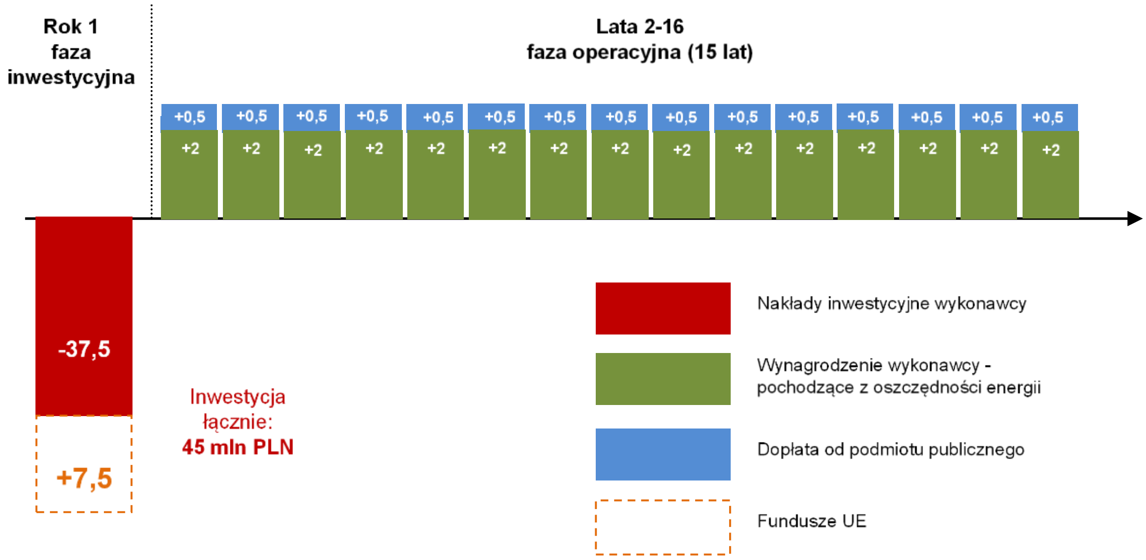
Source: Data of the Ministry of Development Funds and Regional Development.

Rok 1 faza inwestycyjna	Year 1 investment stage
Lata 2-16 faza operacyjna (15 lat)	Years 2-16 operational stage (15 years)
Nakłady inwestycyjne wykonawcy	Contractor's capex
Wynagrodzenie wykonawcy -pochodzące z oszczędności energii	Contractor's fee - deriving from energy savings
Dopłata od podmiotu publicznego	Subsidy from a public entity

Model 3. PPP project with EU co-funding (a hybrid project)

The investment covers a wide range of work necessary to increase the energy efficiency of the building. All the tasks are executed by the private partner, whose remuneration is financed by the energy savings and an additional fee paid by the public partner. Moreover, the additional fees for the contractor can be reduced by EU subsidies.

Diagram 4. Financial flows in an ESCO project including a PPP and EU co-funding (values in PLN million)



Source: Data of the Ministry of Development Funds and Regional Development.

Rok 1 faza inwestycyjna	Year 1 investment stage
Lata 2-16 faza operacyjna (15 lat)	Years 2-16 operational stage (15 years)
Nakłady inwestycyjne wykonawcy	Contractor's capex
Wynagrodzenie wykonawcy -pochodzące z oszczędności energii	Contractor's fee - deriving from energy savings
Dopłata od podmiotu publicznego	Subsidy from a public entity
Fundusze UE	EU Funds
Inwestycja łącznie: 45 mln PLN	Investments in aggregate: PLN 45 million

In order for the ESCO formula to be furthered, a targeted programme for the development of ESCO-based investments must be put in place. The following actions popularising the development of this market are recommended: (1) setting up dedicated funds to support the use of the ESCO formula in financing programmes, (2) the need for the central administration to adopt formal solutions for ESCO activities, (3) creation of a knowledge platform, (4) drafting and dissemination of model documents, in particular energy performance contracts, and preparation of the criteria for selecting ESCOs in tendering procedures.[57]

As has been agreed by the stakeholders of Roundtables on Energy Efficiency Finance[58], work has been undertaken and continued to develop the market for such undertakings through the establishment of a guarantee facility for the forfeiting of energy performance contracts in the field of renovation of public buildings, multi-family buildings, and enterprises with the use of EU and Polish funds.

It is also important that an approach be deployed whereby municipalities' EPC commitments would be treated as extra-budgetary ones, which will considerably improve the economic environment for ESCOs. A power is delegated under statutes to the competent minister to enact a

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[57] Badanie „Możliwości wdrażania instrumentu ESCO w ramach I priorytetu Programu Infrastruktura i Środowisko 2014-2020" (Study 'Possibilities of implementing the ESCO instrument under Priority I of the Infrastructure and Environment Operational Programme 2014-2020', Kreatus upon the commission of the Ministry of Energy, Bielsko-Biała 2017 (link)).

[58] More information is available on the Commission's website dedicated to Roundtables (link 1), (link 2), (link 3).

regulation governing the methodology of the impact of EPC commitments on the state's public debt.

Aggregation of projects

In the case of public buildings, aggregation (grouping) of projects should be promoted under support programmes so that more beneficial financing can be obtained from Polish and EU financial institutions. This formula has already been tested in the case of energy renovation of municipal public buildings financed by EEA funds. Such programmes can be combined with partially free-of-charge technical assistance to facilitate their preparation (e.g. ELENA). Buildings with the same or different purpose, which belong to different owners, can be pooled into investment packages, since the economies of scale may lower unit investment costs. Such packages could be organised by regional-level public institutions using specialised companies and institutions, for example regional development agencies or regional development funds set up to support larger projects implemented by multiple investors from the province. Grouped projects become more attractive for private partners with whom PPP arrangements can be made, which has worked well in a number of cases in Poland.

9. Recommended renovation scenario – 2050 roadmap

Pursuant to Article 2a(2) of Directive 2010/31, in its long-term renovation strategy, each Member State is required to set out a roadmap with measures and domestically established measurable progress indicators, with a view to the long-term 2050 goal of reducing greenhouse gas emissions in the Union by 80-95% compared to 1990, in order to ensure a highly energy efficient and decarbonised national building stock and in order to facilitate the cost-effective transformation of existing buildings into nearly zero-energy buildings. The roadmap is required to include indicative milestones for 2030, 2040 and 2050, and specify how they contribute to achieving the Union's energy efficiency targets in accordance with Directive 2012/27/EU.

9.1. Assumptions of the scenario analysis

In order to arrive at the recommended renovation scenario to be included in the 2050 roadmap, consideration has been given to three building energy renovation scenarios in Poland in the perspective of 2021-2050, with the assumption that Polish construction attains climate neutrality by 2050.

The scenario analysis is based on the estimated distribution of energy efficiency of residential buildings and the average costs of investments in improving energy efficiency (repositioning of the building within the distribution). The analysis is based on the primary energy factor [kWh/(m²·year)] as the most synthetic measure of energy efficiency of buildings. Importantly, the scenario analysis does not constitute a detailed roadmap for the energy renovation of all types of buildings in Poland, but instead defines a strategic approach to the transformation of existing building stock into nearly zero-energy buildings in the long term, including the indicative 2030, 2040 and 2050 milestones. Therefore it includes a number of simplifying assumptions (e.g. analysis of the distribution of buildings by PEF, averaged 'typical' energy renovation investments), which, however, do not affect the key findings and decisions arising from the recommended scenario. In particular, the above applies to the overall pace of energy renovation, the choice between deep and staged energy renovation, as well as to the indicators (number of energy renovation projects, including deep renovation undertakings) of the indicative scale of activities necessary to realise the assumptions of the recommended scenario in the upcoming decades.

Since there are no energy efficiency classes in Polish legislation, for the purposes of the scenario analysis, energy efficiency brackets are defined for buildings based on the PEF [kWh/(m²·year)]:

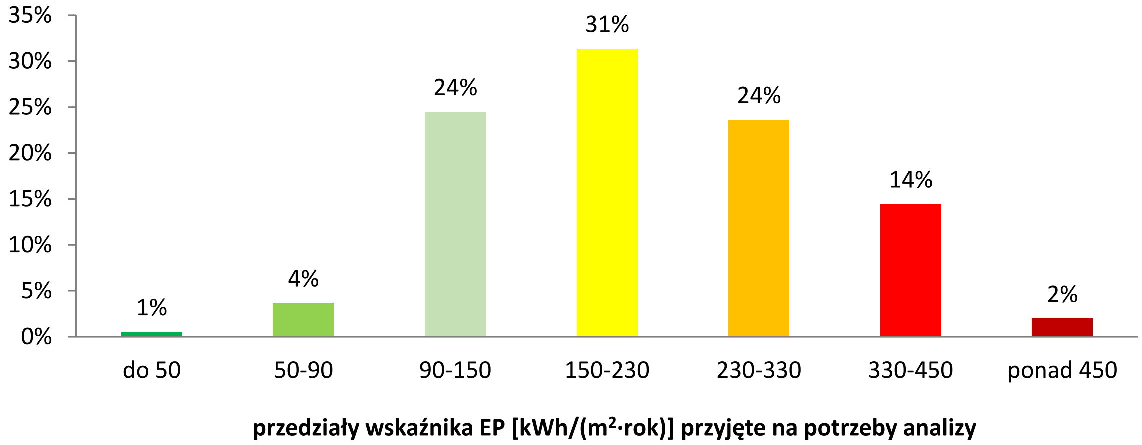
Table 22. Building energy efficiency brackets by PEF [kWh/(m²·year)] adopted in the scenario analysis

up to 50	50-90	90-150	150-230	230-330	330-450	more than 450

Source: KAPE assumptions.

Subsequently, the distribution of residential and public buildings by energy efficiency brackets was estimated for 2020.

Chart 30. Estimated distribution of residential and public buildings by energy efficiency brackets



Source: KAPE estimates based on a database of audited buildings.

do 50	up to 50
ponad 450	more than 450
przedziały wskaźnika EP [kWh/(m2•rok)] przyjęte na potrzeby analizy	EP ratio brackets [kWh/(m**2**·year)] adopted in the analysis

The estimation shows that over 70% of these building stocks have a PEF higher than 150 kWh/(m²·year), which is considered energy inefficient, of which over 15% fall within the two poorest efficiency brackets. They are mainly old, non-upgraded single-family buildings and hospitals, which are characterised by a high demand for energy (utilised largely for DHW).

Buildings considered as those with PEF<90 kWh/(m²·year) account for more than 4% of all the stocks under consideration. Buildings with PEF<50 kWh/(m²·year) represent only half a percent of the building stock, which is due to the fact that energy-efficient construction began to develop in Poland relatively recently.

If the majority of buildings in Poland are to achieve the assumed high energy-efficiency levels by 2050, large-scale energy renovation measures are needed. This includes, inter alia, deep energy renovation, the scale of which – by reference to the above brackets – is estimated as the sum of energy renovations whereby a building reaches a PEF of up to 50 kWh/(m²·year) and half of energy renovations whereby a building attains a PEF which falls within the 50-90 kWh/(m²·year) bracket. The estimate includes most types of buildings for which the PEF specified in the Technical Conditions Regulation is up to 70 kWh/(m²·year) (including not higher than 70 kWh/(m²·year) for single-family buildings, 65 kWh/(m²·year) for multi-family buildings, 75 kWh/(m²·year) for collective accommodation buildings). It must be stressed that for some types of buildings with higher energy needs the PEF specified in the Technical Conditions Regulation is much higher (190 kWh/(m²·year) for healthcare buildings). Thus, the number of necessary deep energy renovations is underestimated. However, owing to the low share of such cases in the total number of buildings analysed (public buildings, including hospitals, account for less than 3% of the number of buildings surveyed), this does not affect substantially the aggregate indicator defining the 2030, 2040 and 2050 milestones for the number of deep renovations.

The scenario analysis also assumes a shift in the distribution of the effects of deep energy renovation over time: along with technological progress, the popularisation of energy-efficient solutions on the market and the anticipated rise in the prices of energy carriers, all the scenarios entail a growth in investments leading to the achievement of PEFs surpassing the minimum requirements of the Technical Conditions Regulation.

9.2. Quick and deep energy renovation

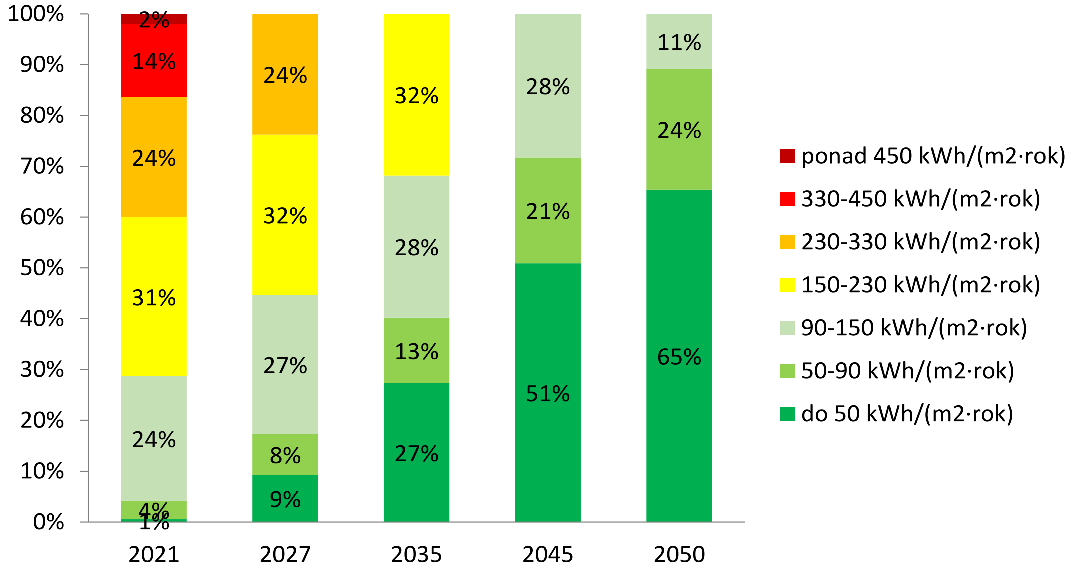
The first scenario assumes broad-ranging, deep energy renovation of the building stock, which will start with buildings with the lowest energy efficiency. It is the most ambitious and most economically viable plan.

This scenario assumes that by 2027 all buildings with a PEF greater than 330 kWh/(m²·year), and by 2035, all buildings with a PEF higher than 230 kWh/(m²·year) will have undergone energy renovation. In 2045, all buildings will have a PEF of not more than 150 kWh/(m²·year).

According to this scenario, by 2050, 65% of the building stock will have a PEF under 50 kWh/(m²·year), and 24% from 50 to 90 kWh/(m²·year). The remaining 11% of the buildings, which cannot undergo a deep retrofit for technical reasons, will have achieved a PEF between 90-150 kWh/(m²·year).

Under this scenario, the average annual renovation rate is around 3%. The impact of the energy renovation scenario on the distribution of energy efficiency of the building stock in Poland is presented below. The graph reveals a rapid decline in the share of buildings with the poorest energy efficiency, which are to undergo energy renovation first. In parallel, there is a steep growth in the share of buildings with a PEF below 50 kWh/(m²·year), which continues in the following years. Since no staged energy renovation is deployed, there is no significant increase in the share of buildings from the middle of the current energy efficiency range (PEFs between 150 and 230 kWh/(m²·year)) at any time point of the scenario. In addition, the share of buildings with PEFs between 90 and 150 kWh/(m ²·year) remains stable until 2045, following which some of them will undergo deep renovation in the last five years before 2050.

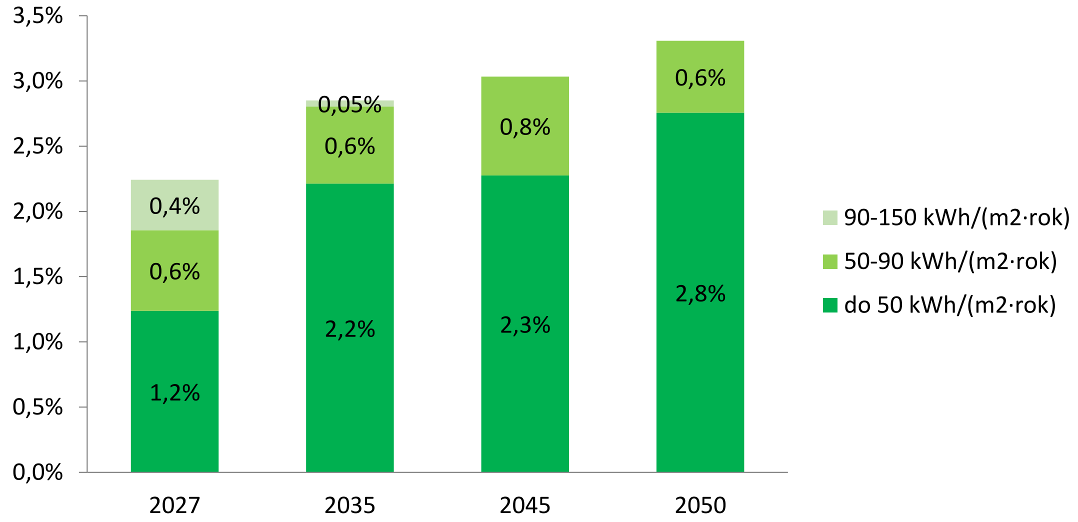
Chart 31. PEF-based distribution of residential and public buildings across the periods [quick and deep energy renovation scenario]



Source: KAPE and WiseEuropa calculations.

ponad 450 kWh/(m2·rok)	over 450 kWh/(m2·year)
330-450 kWh/(m2·rok)	330-450 kWh/(m2·year)
230-330 kWh/(m2·rok)	230-330 kWh/(m2·year)
150-230 kWh/(m2·rok)	150-230 kWh/(m2·year)
90-150 kWh/(m2·rok)	90-150 kWh/(m2·year)
50-90 kWh/(m2·rok)	50-90 kWh/(m2·year)
do 50 kWh/(m2·rok)	up to 50 kWh/(m2·year)

Chart 32. Annual energy renovation rates by the targeted PEF brackets [quick and deep energy renovation scenario]



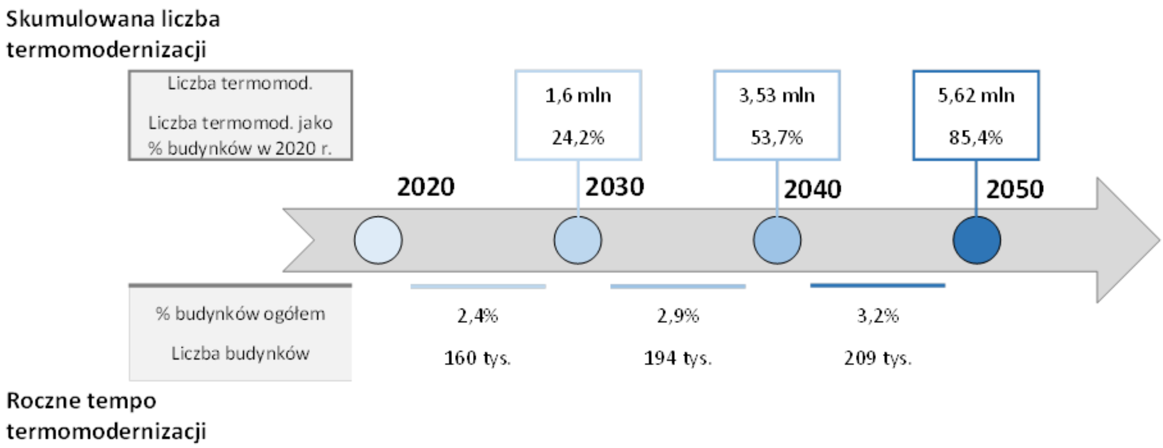
Source: KAPE and WiseEuropa calculations.

90-150 kWh/(m2·rok)	90-150 kWh/(m2·year)
50-90 kWh/(m2·rok)	50-90 kWh/(m2·year)
do 50 kWh/(m2·rok)	up to 50 kWh/(m2·year)

The quick and deep energy renovation scenario produces the target effect with the lowest number of energy renovation undertakings of all the scenarios considered, since it avoids the need for repeated investments as part of staged thermomodernisation. This also translates into a lower overall rate of energy renovation, which is not bound to exceed 3% until the second half of the 2040s. However, it must be emphasised that this rate is mainly made up of complex and capital-intensive investments producing PEFs of up to 50 kWh/(m^2·year).

However, the realisation of this scenario may be difficult since, often, owners of buildings in poor condition lack financial resources to carry out deep energy renovation. At the same time, this scenario involves delayed mobilisation of funds among other building owners, including those who already have a high level of awareness and are willing to undertake energy retrofits, provided that they receive support in this regard.

Diagram 5. 2030-2040-2050 renovation pace in the quick and deep energy renovation scenario



Source: KAPE and WiseEuropa calculations.

Skumulowana liczba termomodernizacji	Cumulative number of energy renovations
Liczba termomod.	Number of energy renov.
Liczba termomod. jako % budynków w 2020 r.	Number of energy renov. as % of buildings in 2020
% budynków ogółem	% of total buildings
Liczba budynków	Number of buildings
Roczne tempo termomodernizacji	Annual energy renovation rate
1,6 mln	1.6 million
3,53 mln	3.53 million
5,62 mln	5.62 million
160 tys.	160 thousand
194 tys.	194 thousand
209 tys.	209 thousand

9.3. Staged energy renovation

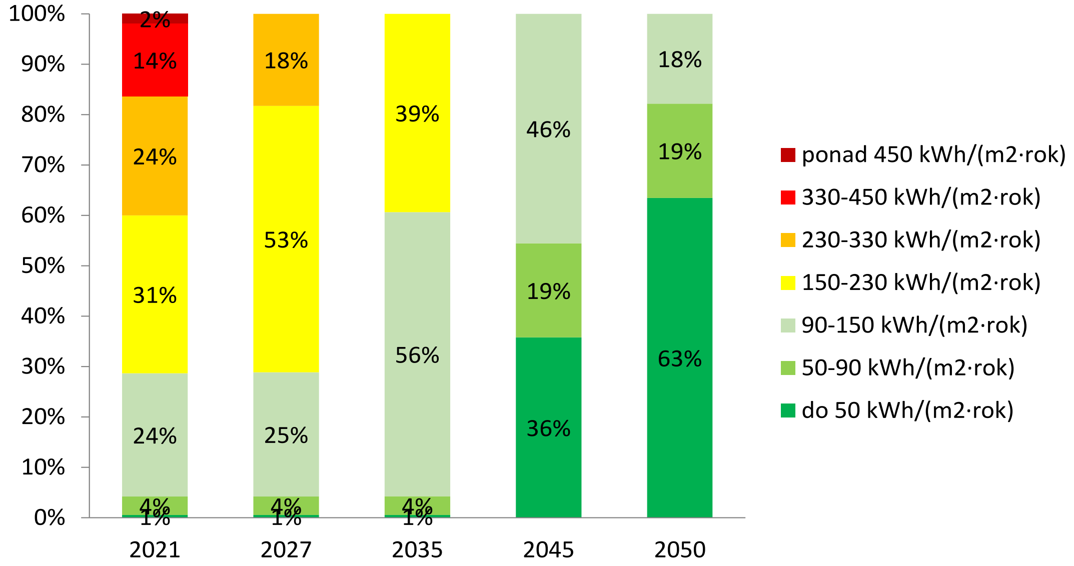
The second scenario assumes extensive energy renovation of building stocks, where buildings in the poorest condition will be retrofitted in stages until the best energy efficiency brackets are attained. The individual stages of renovation comprise only portions of the full scope of energy renovation work, which makes it possible for the target energy performance to be attained in steps and for the cumulation of spendings and aggregate demand for the goods and services necessary to carry out the investment to be avoided. Importantly, from the very start, the process is planned with a view to the end result, so as to ensure consistency between the various stages and avoid duplication or mutual blocking of activities in the successive stages.

This scenario assumes that by 2027 all buildings with a PEF greater than 330 kWh/(m^2·year), and by 2035, all buildings with a PEF higher than 230 kWh/(m^2·year) will have undergone energy renovation. In 2045, all buildings will have a PEF of not more than 150 kWh/(m^2·year). Thus, the pace at which the poorest performance brackets are eliminated remains the same as in the first scenario, but buildings start to be retrofitted to a PEF below 90 kWh/(m^2·year) only after 2035.

In the staged energy renovation scenario, by 2050, 63% of the building stock will have achieved a PEF of less than 50 kWh/(m^2·year) and 19% from 50 to 90 kWh/(m^2·year). The remaining 18% of the building stock, which cannot undergo deep thermomodernisation for technical or economic reasons, will have attained the PEF bracket of 90-150 kWh/(m^2·year). Therefore, the final outcome of this scenario is worse than in the case of quick and deep energy renovation, which is due to the lower cost and technical efficiency of staged activities.

The impact of the energy renovation scenario on the distribution of energy efficiency of the building stock in Poland is presented below. The fall in the share of buildings with the lowest energy efficiency is faster than in the deep energy renovation scenario, but there is no parallel emergence of buildings with low PEFs. Instead, there is transitory increase in the share of the successive in-between PEF brackets: between 150 and 230 kWh/(m²·year) in the 2020s and between 90 and 150 kWh/(m²·year) in the 2030s. The last energy renovation stage, in which the share of buildings with PEFs below 90 kWh/(m²·year) rises, starts only after 2035.

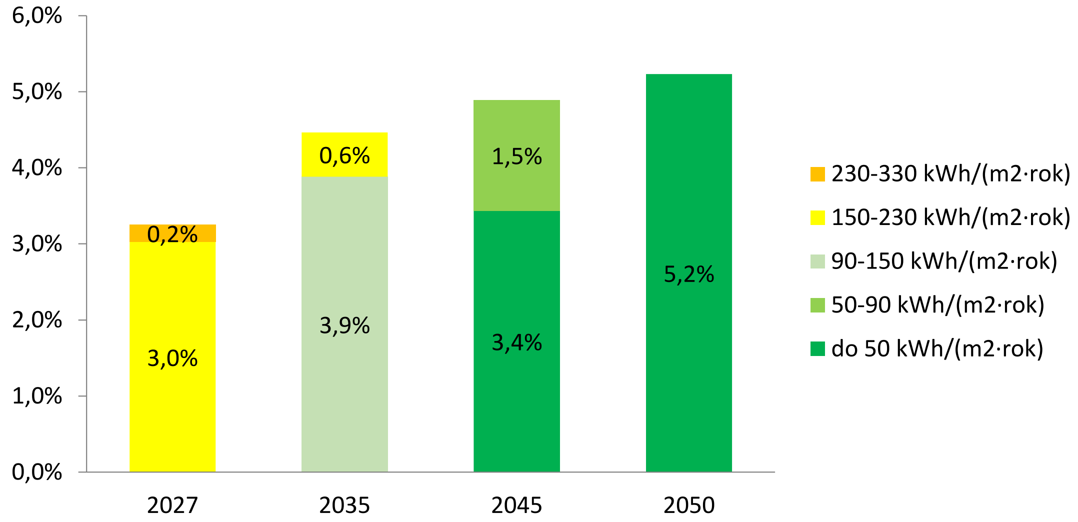
Chart 33. PEF-based distribution of residential and public buildings across the periods [staged energy renovation scenario]



Source: KAPE and WiseEuropa calculations.

ponad 450 kWh/(m2·rok)	over 450 kWh/(m2·year)
330-450 kWh/(m2·rok)	330-450 kWh/(m2·year)
230-330 kWh/(m2·rok)	230-330 kWh/(m2·year)
150-230 kWh/(m2·rok)	150-230 kWh/(m2·year)
90-150 kWh/(m2·rok)	90-150 kWh/(m2·year)
50-90 kWh/(m2·rok)	50-90 kWh/(m2·year)
do 50 kWh/(m2·rok)	up to 50 kWh/(m2·year)

Chart 34. Annual energy renovation rate by the target building energy efficiency brackets [staged energy renovation scenario]



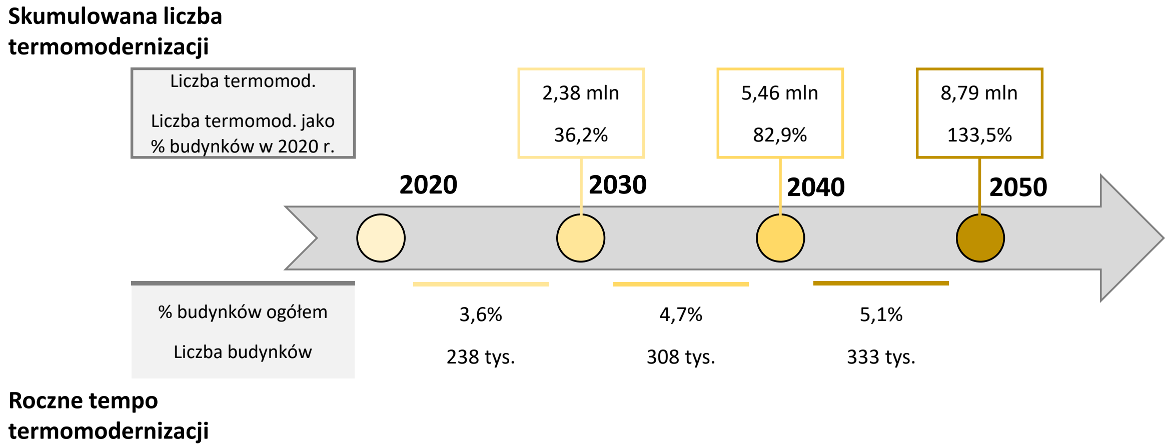
Source: KAPE and WiseEuropa calculations.

230-330 kWh/(m2·rok)	230-330 kWh/(m2·year)
150-230 kWh/(m2·rok)	150-230 kWh/(m2·year)
90-150 kWh/(m2·rok)	90-150 kWh/(m2·year)
50-90 kWh/(m2·rok)	50-90 kWh/(m2·year)
do 50 kWh/(m2·rok)	up to 50 kWh/(m2·year)

In the staged energy renovation scenario, the average annual renovation pace is high and amounts to approx. 4%. This stems from the fact that staged energy renovation entails the need to complete several investments over the period 2021-2050. The pace of thermomodernisation grows fast to reach a very high level towards the end of the period analysed.

The delivery of the staged energy renovation scenario will be simpler, but at the same time less efficient in economic terms. It will be hampered considerably by the scale of necessary investments since the implementation of the plan would require a renovation rate of 5-6% per year.

Diagram 6. 2030-2040-2050 renovation pace in the staged renovation scenario



Source: KAPE and WiseEuropa calculations.

Skumulowana liczba termomodernizacji	Cumulative number of energy renovations
Liczba termomod.	Number of energy renov.
Liczba termomod. jako % budynków w 2020 r.	Number of energy renov. as % of buildings in 2020
% budynków ogółem	% of total buildings
Liczba budynków	Number of buildings
Roczne tempo termomodernizacji	Annual energy renovation rate
2,38 mln	2.38 million
5,46 mln	5.46 million
8,79 mln	8.79 million
238 tys.	238 thousand
308 tys.	308 thousand
333 tys.	333 thousand

9.4. Recommended scenario

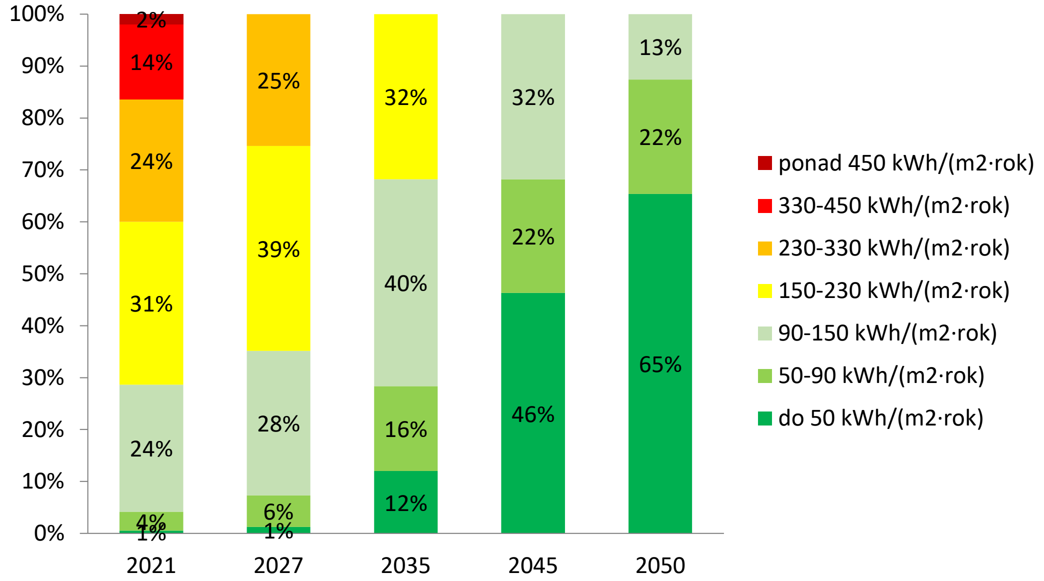
The recommended scenario assumes an approach which combines the advantages of the two above scenarios. It consists of quick execution of the first stage of energy renovation of buildings from the poorest energy efficiency brackets combined with popularisation of deep energy retrofits in the nearest years, and then market-wide popularisation of high-standard renovations.

This scenario assumes that by 2027 all buildings with a PEF greater than 330 kWh/(m^2·year), and by 2035, all buildings with a PEF higher than 230 kWh/(m^2·year) will have undergone energy renovation. In 2045, all buildings will have a PEF of not more than 150 kWh/(m^2·year).

In the recommended scenario, by 2050, 65% of the buildings will have achieved a PEF of less than 50 kWh/(m^2·year) and 22% from 50 to 90 kWh/(m^2·year). The remaining 13% of the building stock, which cannot undergo deep thermomodernisation for technical or economic reasons, will have attained the 90-150 kWh/(m^2·year) bracket. Therefore, the end result of this scenario is comparable to that obtained in the quick and deep energy renovation scenario. This results from the early launch of the scaling up of deep energy renovation investments and reduction in the number of subsequent renovation stages, which improves the economic and technical efficiency of activities compared to the multi-stage retrofitting scenario.

The impact of the energy renovation scenario on the distribution of energy efficiency of the building stock in Poland is presented below. The recommended scenario entails processes observable both in the staged energy renovation scenario (rapid drop in the share of buildings with the poorest energy efficiency) and in the quick and deep energy renovation scenario (gradual increase in the share of buildings with PEFs below 90 kWh/(m^2·year)), except that they have a more balanced nature than in the other variants. Overall, the recommended scenario leads to a gradual shift of the building stock in the distribution towards the target low PEFs.

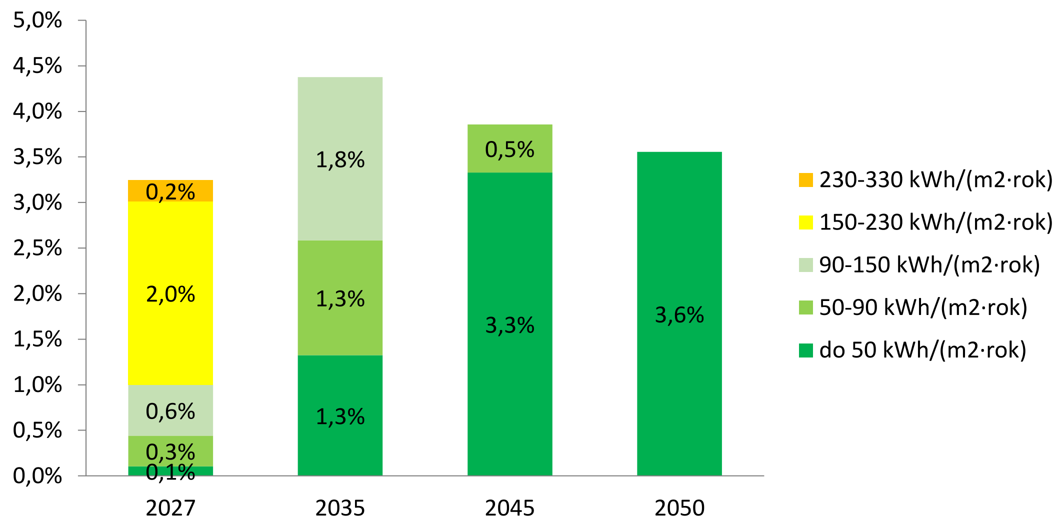
Chart 35. PEF-based distribution of residential and public buildings across the periods [recommended scenario]



Source: KAPE and WiseEuropa calculations.

ponad 450 kWh/(m2·rok)	over 450 kWh/(m2·year)
330-450 kWh/(m2·rok)	330-450 kWh/(m2·year)
230-330 kWh/(m2·rok)	230-330 kWh/(m2·year)
150-230 kWh/(m2·rok)	150-230 kWh/(m2·year)
90-150 kWh/(m2·rok)	90-150 kWh/(m2·year)
50-90 kWh/(m2·rok)	50-90 kWh/(m2·year)
do 50 kWh/(m2·rok)	up to 50 kWh/(m2·year)

Chart 36. Annual pace of energy renovation by target PEF brackets [recommended scenario]



Source: KAPE and WiseEuropa calculations.

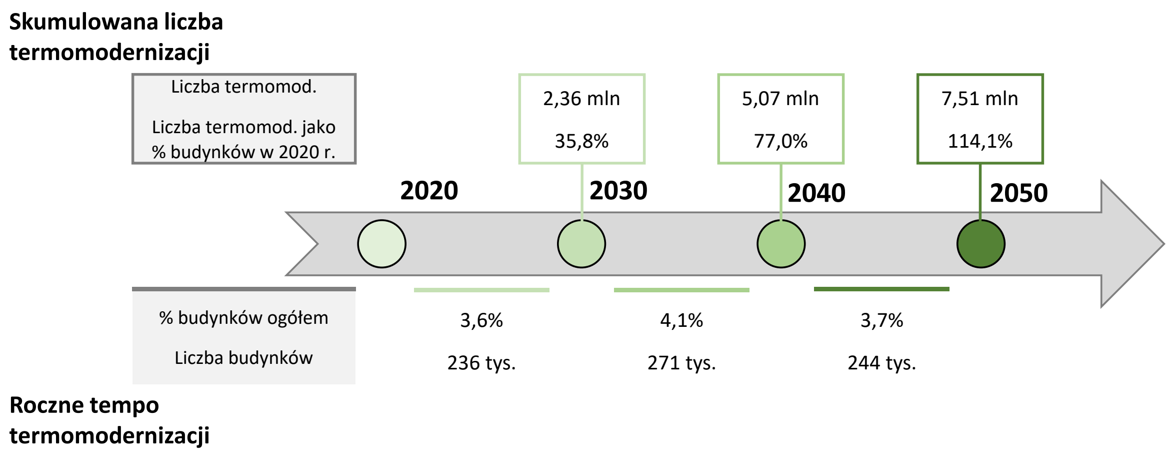
230-330 kWh/(m2·rok)	230-330 kWh/(m2·year)

150-230 kWh/(m2·rok)	150-230 kWh/(m2·year)
90-150 kWh/(m2·rok)	90-150 kWh/(m2·year)
50-90 kWh/(m2·rok)	50-90 kWh/(m2·year)
do 50 kWh/(m2·rok)	up to 50 kWh/(m2·year)

In this scenario, the average annual rate of energy renovation is approx. 3.8%, but renovation to a PEF of up to 50 kWh/(m^2·year) starts to be prevail only after 2035, which means that there will be sufficient time for building suitable competence and potential among providers of the necessary technological solutions. The individual renovation stages are presented below.

The initial shallow energy renovation will be more readily available in buildings in the poorest condition, the owners of which do not usually have the resources to carry out deep retrofitting. At the same time, promoting deep energy renovation as early as from 2021 will allow high energy performance standard to be attained faster.

Diagram 7. 2030-2040-2050 renovation pace in the recommended scenario



Source: KAPE and WiseEuropa calculations.

Skumulowana liczba termomodernizacji	Cumulative number of energy renovations
Liczba termomod.	Number of energy renov.
Liczba termomod. jako % budynków w 2020 r.	Number of energy renov. as % of buildings in 2020
% budynków ogółem	% of total buildings
Liczba budynków	Number of buildings
Roczne tempo termomodernizacji	Annual energy renovation rate
2,36 mln	2.36 million
5,07 mln	5.07 million
7,51 mln	7.51 million
236 tys.	236 thousand
271 tys.	271 thousand
244 tys.	244 thousand

Therefore, an economically effective and technically feasible process of ensuring climate neutrality of the building stock in Poland will proceed in stages both with regard to individual buildings and to groups of buildings of specific type and purpose. Regardless of what energy renovation work is completed, the structures should be designed and constructed so that they can be easily refurbished in the future, when the relation of the prices of zero-emission energy carriers to the costs of construction works of suitable quality encourages renovation to zero- and plus-energy building standards. The sequence of thermomodernisation activities should be such as to produce the greatest possible effects in terms of reduced energy consumption and costs relative to engaged funding.

The table below presents the 2030, 2040 and 2050 milestones in the recommended building stock renovation scenario in Poland. The total number of completed energy renovation projects indicator specifies the necessary scale of activities, while the number of completed deep energy renovation actions measures synthetically the final effect of the executed investments (contribution to the adaptation of buildings in Poland to the conditions of a climate-neutral economy). The indicators are estimated on the basis of the results of the scenario analysis.

Table 23Summary of the recommended building stock renovation scenario – indicative 2030, 2040 and 2050 milestones

	Total number of energy renovations to be completed in a given period (million units)	Number of deep energy renovations to be completed in a given period (million units)
2021-2030	2.4	0.5
2031-2040	2.7	1.8
2041-2050	2.4	2.4
2021-2050	**7.5**	**4.7**

Note: the 'total number of energy renovations' indicator includes staged energy renovation, which means that more than one energy retrofit may be carried out in one building. Meanwhile, 'the number of deep energy renovation projects completed' corresponds to the number of buildings to undergo deep energy renovation, with no further activity planned once the building attains the performance corresponding to the requirements set forth by the Technical Conditions Regulation.

Source: KAPE and WiseEuropa calculations.

It is important that the staged process towards climate neutrality be free from mistakes such that would block energy renovation for many years. An essential role in the management of this processes will be played by a review of legislation related to the broad energy efficiency of buildings, which may reveal a need for deployment of tools to facilitate making investment decisions, a system of energy classes and/or solutions based on the concept of 'building energy passport', i.e. the recording in a single document or electronic database of information about all energy renovation actions carried out and planned at the space of a dozen or so years. This is expected to lead to the high energy efficiency standard defined at the beginning of the planning, and widespread use of such tools under Polish conditions could ensure that energy renovation stages completed at intervals of even several years can be controlled.

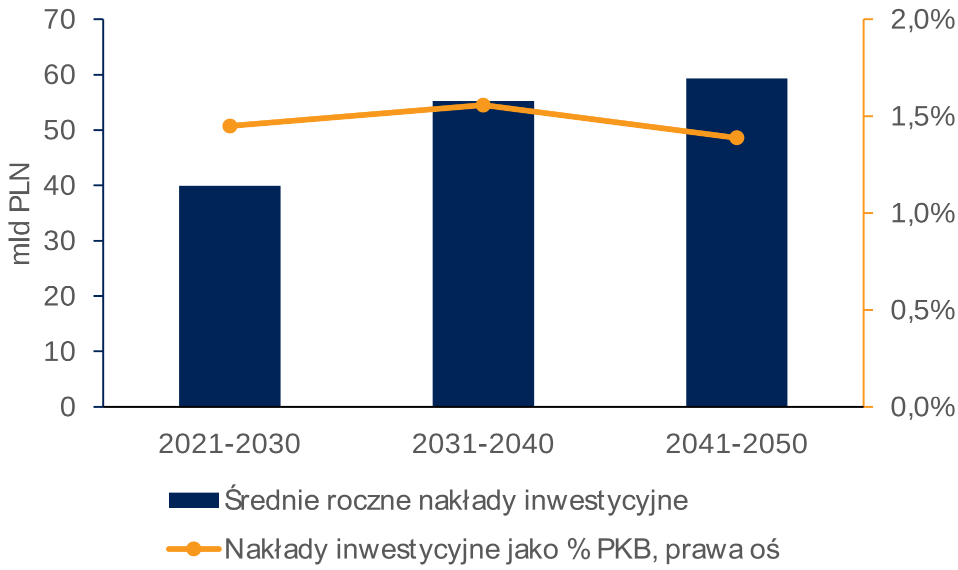
The implementation of the recommended scenario will require mobilising both private and public funds on a large scale. The total capex on renovation of building stocks (energy retrofitting and heat source replacement) in 2021-2050 will amount to approximately PLN 1.54 trillion[59]. Assuming that the renovation of the main categories of buildings (one- and multi-family buildings, public buildings) proceeds at an even pace, these outlays will amount to approx. PLN 400 billion in 2021-2030, with 3/4 of this amount spent on residential buildings. The proportions of capital expenditure between residential buildings and public buildings will remain unchanged in the years 2031-2050, but average annual spending in 2041-2050 is bound to increase from PLN 55 billion in 2031-2040 to PLN 59 billion. Assuming that the 2014-2019 intensity of support for energy renovation of the individual types of buildings is maintained[60], public funding of nearly PLN 120 billion will need to be mobilised in 2021-2030. This may include direct subsidies from domestic and EU funds, as well as tax allowances and funding of projects in the public sector with public

[59] The detailed assumptions regarding the estimated scale of the necessary financing for the recommended scenario are presented in Annex 5.

[60] Public co-funding at 31% of the total capital expenditure for the housing stock and 23% for public buildings (including 85% for public sector buildings and maintaining the 8:1 ratio for financing channelled to the public and private sectors). Detailed data on the structure of funding for investments in energy renovation and heat source replacement for 2014-2019 is presented in Chapter 8.1.

institutions' own resources. The above amount corresponds to the planned budget of the 'Clean Air' Programme until 2030 (approx. PLN 100 billion), increased by the estimated funds to be available under the FTiR (approx. PLN 4 billion by 2030) and by the average public financing for energy renovation of public buildings supported by EU funds spent previously (approx. PLN 16 billion until 2030, assuming that the 2014-2019 average level of support is maintained).

Chart 37. Estimated average building renovation capex in the recommended scenario, 2021-2050



Source: WiseEuropa and KAPE calculations. The detailed assumptions are presented in Annex 5.

mld PLN	PLN billion
Średnie roczne nakłady inwestycyjne	Average annual capex
Nakłady inwestycyjne jako % PKB, prawa oś	Capex as % of GDP, right axis

Notably, the above amounts are estimates. Both the total amount of spending and the rate at which renovation will be co-funded with public funds will be influenced by:

- the effectiveness of staged energy renovation (avoiding duplicated costs of activities in successive stages, which will influence post-2030 spending levels),
- the degree of market development and availability of qualified workforce (competitive prices and high quality of the goods and services needed in energy renovation of buildings will reduce the total costs of the realisation of this scenario),
- technological progress and availability of innovative solutions,
- the effectiveness of public support instruments and combining them with solutions which make it easier for investors to undertake and carry through renovation of buildings (including one-stop-shops, ESCO/PPP, project aggregation),
- trends in prices of energy carriers, which influence the viability of investments in deep energy renovation and replacement of heat sources.

The key potential sources of public funding for renovation of buildings in the medium term (until 2030) include:

- The Modernisation Fund: approx. EUR 4 billion in 2021-2030, assuming the sale of 135 million emission allowances at an average price of EUR 30/t,
- The Recovery and Resilience Facility (RRF funds under the National Recovery Plan): EUR 23.857 billion of subsidies and EUR 11.507 billion of loans in the first stage, with climate expenditure to reach 42.7% (39.4% = RRF grants, 49.5% = RRF loans),

- The European Regional Development Fund and the Cohesion Fund: a total of EUR 21 billion allocated to Objective 2 (Greener, low-carbon Europe) in 2021-2027, in line with the draft Partnership Agreement,
- The Just Transition Fund: EUR 4.234 billion in 2021-2027, as per the draft Partnership Agreement.

The final scope and form of EU support will depend on the legislative package for the Cohesion Policy 2021-2027, the results of the final negotiations with the European Commission, ex-ante analyses regarding the use of financial instruments, as well as on decisions of the institutions in charge of operational programmes, including monitoring committees.

From the perspective of the private sector, for the recommended scenario to be realised, investment in renovation of buildings must grow by 1% of GDP in 2021-2030, with 0.8 pp to be apportioned for investment in residential buildings. For comparison, in 2016-2019, total investment in residential buildings (renovations and new projects) in Poland amounted to an average of 2.1% of GDP, and overall in construction projects to 9.1% of GDP. These ratios are much lower than the EU-27 average (5.1% and 10.1% of GDP, respectively). This implies that there is considerable potential for scaling up investments in renovation of buildings without going beyond the scale of typical investment efforts observable in other European economies.

In addition, accelerated renovation of the national building stock in line with the recommended scenario will add considerably to the delivery of the Strategy for Responsible Development (SRD) towards increasing the rate of investments to 25% of GDP and maintaining it at this level until 2030. In 2019, the investment rate was 18.5%. Considering the private and public capex to be mobilised, the investment impulse generated by the implementation of the renovation strategy in 2021-2030 will total approx. 1.4% of the GDP, which roughly corresponds to the 1/5 of the current gap in the SRD target.

The actions and guidance presented in this Strategy will translate into the delivery of the recommended renovation scenario in such a way as to maximise the effectiveness of the utilisation of public and private funds allocated to investments in energy renovation and replacement of heat sources in Polish buildings.

The recommended renovation scenario will reduce primary and final energy consumption, adding to the achievement by Poland of the energy savings envisaged by the National Energy and Climate Plan (NECP), which will, in turn, contribute to the Union's energy efficiency goals set out by Directive 2012/27/EU. In particular, the implementation of the actions foreseen in the Strategy until 2030 in line with the recommended renovation scenario will help reduce the annual final energy consumption by 7.0 Mtoe.

9.5. Performance indicators

The key performance indicators for the delivery of the Strategy include both measures of the scale and pace of energy renovation of buildings as per the recommended renovation scenario, the contribution of building-related activities to the achievement of energy and climate goals for the entire economy in keeping with the National Energy and Climate Plan (NECP), and the phasing out of direct use of hard coal by households in line with the Energy Policy of Poland until 2040 (PEP 2040).

Table 24. Strategy performance indicators

Name of indicator	Measurement unit	Baseline	Target	Source
Buildings which undergo energy renovation overall	million units	0 (2020)	2.4 (2030)	MRiT/Ministry of Climate and Environment/ Ministry of Development Funds and Regional Development/Ministry of Finance[61]
Buildings to undergo deep energy renovation	million units	0 (2020)	0.5 (2030)	MRiT/Ministry of Climate and Environment/ Ministry of Development Funds and Regional Development[62]
Final consumption of energy carriers in the household and service sectors	Mtoe	27 (2018)	≤26 (2030)	Ministry of Climate and Environment/GUS
CO_2 emissions from the burning of fossil fuels in housing, services and stationary sources in agriculture (category 1.A.4)	$MtCO_2$	52 (2018)	≤35 (2030)	Ministry of Climate and Environment/GUS
Percentage of urban households using (individually) hard coal for space heating	%	20 (2018)	0 (2030)	Ministry of Climate and Environment/GUS
Percentage of rural households using (individually) hard coal for space heating	%	71.3 (2018)	0 (2040)	Ministry of Climate and Environment/GUS

Source: GUS, NECP, EPP2040 data, KAPE and WiseEuropa calculations.

In addition, it is foreseen that the minister in charge of construction, land use planning, spatial development and housing will monitor progress in the implementation of the national policy

and measures to support the renovation of buildings, as well as the availability and degree of commitment of public funding in this area.

[61] Based on: data on the FTiR, 'Clean Air' Programme, other building energy renovation programmes of the NFOŚiGW, EU Funds, the thermomodernisation allowance, central building energy performance register. Ultimately, data will also be retrieved from the CEEB as an additional and key source of data.

[62] See above

Annex 1. Overview of building stock renovation solutions

Building stock renovation solutions available depending on the type of building

The energy efficiency of a building is influenced by multiple factors, notably by its structure and the systems and installations used – everything that is relevant for the amount of energy consumed for the functioning of the building and ensuring the comfort of its use.

The building's structure and technical condition are highly relevant for the cost-effectiveness of energy renovation.

The main structural elements form the basic building structure and are divided into:

- load-bearing elements, which support any loads acting on the building and transfer them directly or through other elements to the ground,
- separating elements (the envelope and partitions), which are designed to shield spaces inside the building from external influences, or to divide the interior into individual usable spaces.

Some building elements function as both load-bearing and partitioning components.

According to the type of load-bearing structure materials, the following building types are distinguished:

- wooden,
- brick-and mortar,
- monolithic reinforced concrete,
- prefabricated reinforced concrete,
- steel,
- mixed (hybrid),
- buildings with atypical construction (e.g. rammed earth construction, composite materials).

The type of load-bearing structure determines the costs of energy renovation of the building, so it is worth analysing the features of buildings erected with the use of specific technologies.

When choosing energy renovation solutions, consideration should be given to the requirements for maintaining the character and form of the building envisaged by the designer, appropriate for the specific function and location, notably the functional and structural-material solutions for the interior and the exterior: preserving the features of buildings (including architectural detail) characteristic of the region or immediate surroundings, preserving the divisions and rhythm of the facade, glazing, proportions and forms of woodwork, window and door openings, selection of finishing materials and colours. It is also necessary to harmonise changes to the external character of the building with its surroundings.

Energy renovation of historic buildings should minimise the damage to the historic qualities and be based on solutions recommended by conservation services and in line with guidance of the General Monument Conservator[63]. In the event that high energy efficiency performance of a building, in particular of its envelope, cannot be ensured, the demand for non-renewable primary energy should be reduced in the longer term in line with the transformation of the Polish energy sector (change of electricity and district heat production technologies, use of low-carbon alternatives for natural gas). Owing to the large variety of occupancy functions of buildings, the set of energy renovation actions should be defined on an individual basis. This process may be

[63] Guidelines of the General Monument Conservator of 28.02.2020 (ref.: DOZ.070.2.2020.JW) on the protection of the value of cultural heritage in the process of improving energy performance of historic buildings (link).

aided considerably by continuous expansion of knowledge of good practices in energy renovation of historic buildings released in publicly available domestic[64] and European publications[65].

Wooden buildings

Wooden-structure buildings can be divided into buildings made of logs, glued laminated or cross laminated timber, and timber frame buildings (based on traditional and light or Canadian frame systems).

In the case of wooden structures of all types, the technical condition of the building, especially in terms of microbial degradation, is crucial for the level of energy renovation costs. Structural elements colonised by fungi or infested with insects must be replaced, and the entire visible structure should be re-protected with appropriate chemicals, which, of course, highly increases the costs of renovation. In some cases, demolishing the structure (if it is not a historic building) will be a more technically and economically viable option. In the case of a wooden structure, it is absolutely necessary to check whether its load-bearing capacity is sufficient to support the materials and devices to be used in the energy renovation process. When walls of wooden buildings are insulated, use is usually made of light dry cladding technologies. It must then be remembered for appropriate vapour barrier membrane and wind barrier to be used in order to protect the wooden structure against dampness. Moisture, no sunlight and wall temperature of around 20˚C are ideal conditions for the growth of microbes and degradation of wood. It is also recommended that thermal insulation with relatively high vapour permeability and ventilation gaps be used in the wall structure, which allows moisture in the insulation, if any, to evaporate. In the case of log buildings, often, given the need to preserve the architectural character of the building, use is made of interior wall insulation and covering timber boards imitating logs. In this case, proper temperature and humidity conditions in the partition must also be ensured.

In the case of frame buildings where use is made of the light wet insulation method (insulation is plastered onto OSBs), the same thermal and humidity conditions as in the case of renovation of log buildings must be ensured. This results from the fact that fungus can grow at the interface between the OSB and the insulation.

In wooden buildings, it is relatively easy to insulate the floor with boards on joists based on brick or concrete posts. If the dismantling of joists does not change the statics of the floor structure, this can be done with no major problems. Following this, a new floor may be constructed over the air gap, or a concrete base, a layer of waterproofing, thermal insulation (most often of extruded polystyrene) and a levelling layer for any finishing work may be laid. This will also provide an opportunity for installation of underfloor heating.

The refurbishment solutions for wooden buildings outlined above are usually cost effective. However, the selection of energy renovation actions must always be preceded by an energy audit.

Brick and mortar buildings

Most buildings in Poland are brick and mortar structures. Often, the walls in these buildings are oversized. If they are dry and in good technical condition, walls will usually transfer the additional

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[64] Np.Kaliszuk-Wietecka A. i in. (2019), Opracowanie dotyczące możliwości termomodernizacji budynków zabytkowych ze szczególnym uwzględnieniem docieplenia przegród pionowych /Study on the possibility of energy renovation of historic buildings with a focus on thermal insulation of vertical partitions/ (link).

[65] E.g. the *Violet – preserVe tradItiOnal buiLdings through Energy reducTion* project (https://www.interregeurope.eu/violet/), the *RIBuild – Robust Internal Thermal Insulation of Historic Buildings* project (https://www.ribuild.eu/), the *SHC Task 59 – Renovating Historic Buildings Towards Zero Energy* project (https://task59.iea-shc.org/).

loads produced by materials and elements used in the energy renovation process to the ground. However, if walls are wet, they should be dried and protected against moisture before they are insulated thermally. The costs of these protections and replacement of damaged elements are an additional financial burden.

In the case of brick and mortar buildings, light wet methods are most often opted for to insulate walls. Proper preparation of the base for the insulation layer, i.e. filling any gaps in the plaster, degreasing it and impregnating the wall, is key here. Some brick and mortar buildings have external three-layer walls with an air gap. Filling the gap with insulating material (most often polyurethane foam) is not sufficient to meet the currently required U-values. It is necessary to apply additional insulation on the elevation layer and to check the load-bearing capacity of this layer of the wall.

In the case of buildings with a basement, it is important for the thermal insulation of external walls to reach underground, down to the footings (at least to the freezing depth – i.e. about 120 cm below the ground surface) and for the ceiling above the basement to be insulated.

In brick and mortar buildings, it is possible to employ virtually all the cost-effective technologies presented in the previous chapters and carry out staged energy renovation as prescribed for specific types of buildings.

Monolithic reinforced concrete buildings

Being durable as they are, properly designed monolithic reinforced concrete buildings are usually suitable for the installation of additional devices and materials used in the energy renovation process.

Most reinforced concrete constructions are slab-column and slab-slab structures. The way the envelope of such buildings is designed is crucial from the perspective of the cost-effectiveness of the energy renovation of such buildings. Usually, their external walls are made using masonry techniques of elements such as bricks, blocks or hollow bricks, which, provided that the envelope is in good technical condition, allows for typical insulation technologies (most often light wet methods) to be employed. Glass elevations in high-rise office buildings may pose a problem. In monolithic reinforced concrete buildings, it is possible to employ virtually all the cost-effective energy retrofit technologies presented in the previous chapters and carry out staged energy renovation as prescribed for specific types of buildings.

A challenge is posed by insulation of balcony slabs, which form a thermal bridge at the interface with the ceiling slab. Protecting a balcony slab with a layer of thermal insulation from above and below reduces this problem, but affects the visual qualities of the building's elevation, which may be unacceptable. The challenge also occurs in the case of prefabricated buildings.

Buildings with a prefabricated reinforced concrete structure

Prefabricated buildings erected in the second half of the twentieth century still represent a large group of residential buildings in Poland. Also in their case, it must be remembered that the energy renovation costs will depend on the technical condition of the building and the necessary scope of work. First of all, it is necessary to take into account the fact that some types of renovation work will need to be performed for the sole purpose of preserving the good technical condition of the building. In the group of prefab buildings, notably those made using large-panel technologies, consideration should also be given to the durability of the elements joining the various structural elements. The main disadvantage of large-panel technologies are as follows: cracks and fractures in wall and ceiling elements, leaks in the places where balconies and loggias are joined with the building's wall, moisture, mould, rusty weeps on reinforced concrete surfaces, loss of concrete, degradation of the roofing and of the drainage system.

In order for the thickness of the thermal insulation of external walls to be selected properly, the load-bearing capacity of the anchors with which the cladding is attached to the structural layer needs to be assessed. Sometimes it is necessary to reinforce these joints with additional anchors, which generates costs affecting the viability of energy renovation. One major and frequent error is made when energy renovation is not preceded by a thorough technical assessment of façade anchors in sandwich panels and of how to reinforce them. Once the building is refurbished, the possibility of inspecting the technical condition of three-layer panels is limited, and the additional (compared to the original design assumptions) loads may cause redistribution of stresses in the panel. Where the technical condition of a building has not been assessed properly and no reinforcements have been made prior to thermal insulation, cracking occurs in the thermal cladding, especially if light wet technologies have been used.

One positive aspect of thermal insulation of the envelope of large-panel buildings is their increased thermal stability. This is ensured by the property whereby fluctuations in the heat stream which flows through the envelope as a result of change in outside temperatures are dampened. The additional layer of thermal insulation improves thermal comfort in the building – there is no significant cooling of flats in winter and no excessive heating in summer.

The diameters of ventilation ducts in legacy buildings constructed with the use of industrial technologies were not designed in line with the position and size of rooms. The ventilation of flats through the kitchen and the bathroom causes large spaces inside such flats not to be ventilated in line with their purpose. With insufficient exchange of air through windows and ventilation ducts, moisture condenses on inner surfaces of external walls, causing growth of mould. This necessitates ventilation system retrofitting.

Steel-structure buildings

The steel structure of a building consists of columns and horizontal beams (spandrel beams). In this technology, ceilings are usually made of reinforced concrete often with the use of permanent trapezoidal sheet formwork. The steel frame technology is used in industrial buildings, public buildings (sports halls, shops) and high-rise buildings. External walls of such facilities can be made of virtually any building material. Therefore, insulating them thermally does not pose any significant technical problems. However, when thermal insulation is provided for industrial and service buildings with curtain walls made of sandwich panels, replacing the entire panels with such that have a much thicker insulation layer may be necessary, which entails additional costs affecting the viability of the entire project.

At this point, the construction of sandwich panel walls with the use of asbestos must be mentioned. In the early 1960s, a product called 'layered panels' (sandwich or composite panels) made of pressed flat asbestos-cement cladding stretched on a wooden or steel frame with a filling (foamed polystyrene or mineral wool core) was developed. Number '3' in the PW3/A symbol, which designates the product, stands for cladding made of asbestos-cement sandwich panels. In the mid-1970s, the product was developed into corrugated panels designated as PŻW3/A/S (joint PW3/A panels) or PŻ3/W and PŻ2/3W with a mineral wool core. The products also comprised a product named PW3/B, which was made of asbestos-cement cladding and polyurethane foam core. The sandwich panels gave rise to the so-called 'Integrated Construction System' (Zintegrowany System Budownictwa – ZSBO), which was based on the typification of products (including sandwich panels) and applications: depending the building size and function. <u>This led to widespread use of sandwich walls based on typified composite elements containing asbestos-cement panels.</u> They included three-layer wall elements, window jambs, wall elements with windows. Roof coverings with the use of these products were also developed (most often for industrial buildings).

In wall elements and roof coverings (referred to as 'lightweight partitions'), ventilated and non-ventilated elements were distinguished. Based on these elements, lightweight sandwich-panel curtain walls used in industrial construction, sports halls, housing, retail and service buildings, buildings of healthcare establishments and other public utility buildings such as schools, offices, etc., were developed. PW3/A panels remained in use until 1975. Later, corrugated panels prevailed in residential buildings, initially those rising to a height of up to 30 m and then to 50 m.

In addition, steel elements of steel-framed buildings must be protected against corrosion and corroded elements must be replaced. It should also be checked whether the structural elements will support the additional load produced by the installation of the thermal insulation.

In steel-framed buildings, it is possible to employ nearly all the cost-effective energy retrofit technologies presented in the previous chapters and carry out staged energy renovation as prescribed for specific types of buildings (mainly public buildings and industrial buildings) depending on the type of envelope.

Mixed structure (hybrid) buildings

Mixed structure (hybrid) buildings combine the technologies described above. There are buildings with a steel-reinforced concrete structure, a steel-wooden structure, a reinforced concrete-wooden structure, etc. A hybrid building is subject to all the conditions of the energy renovation process and of its costs which apply to the main technology.

Buildings with atypical construction

As regards buildings constructed of atypical (in Polish conditions) materials (e.g. rammed earth), no general conclusions can be drawn regarding the viability of energy renovation and the possibility of using specific technologies on the basis of the completed analyses. Such structures should be analysed on a case-by-case basis.

Technical equipment of a building

Technical equipment of buildings relevant for thermomodernisation includes:

- heating systems,
- domestic hot water installations,
- ventilation and air conditioning installations,
- light systems and lighting fittings,
- energy and building management systems.

Heating systems

A heating system is a set of devices and elements of installation used for sourcing and distributing heat in a building. It consists of a heat source and a heat distribution system, i.e. internal heating installations and automation which ensures optimal operation of the whole system. In terms of heat source type, buildings' heating systems can be based on:

- gas,
- oil,
- coal,

- electricity (including electric resistance heating systems, induction systems, and electrically driven heat pump systems),
- district heat,
- renewable sources – biomass, sun, wind, geothermal and ground energy, air and water used as lower energy sources in heat pump technologies.

As regards the method and mechanism for distribution of heat in a building, the following systems of indoor heating installations are distinguished:

- water,
- air,
- electric (resistance),
- steam.

In practice, heating systems found in buildings are a combination of the heat sources and heat distribution methods listed above.

In the case of deep renovation, the heat source is almost always replaced. Reduction of the building’s demand for usable energy makes using electricity-based heating devices (heat pumps, heaters, radiators and underfloor heating mats), solar energy, or air heating more viable. One option is to equip the building with a heat pump compatible with underfloor or wall heating.

Undoubtedly, the future belongs to heating installations based on renewable energy sources.

A heating system can be retrofitted through the installation of a relatively inexpensive air source heat pump, which in addition to supplying the heating system will produce heat for the preparation of DHW (and can also produce cold in summer). A heat pump can be powered by a photovoltaic installation or a home wind turbine. Distributed energy sources can also power directly an electric heater which heats ventilated air, or heating can be integrated with it by means of heating cables and mats, while domestic hot water can be prepared by a system of solar collectors or photovoltaic thermal collectors. It is also possible to use solar collectors as the primary heat source under certain conditions and provided that heat storage is used. Therefore, prior to a heating system retrofit, consideration must be given to cost-efficiency and user comfort aspects. From the perspective of the latter, electric devices seems to be the most suitable solution. In addition to ensuring thermal comfort and it operating automatically, such a heating system is characterised by a low investment cost and is easy to control (e.g. based on smart building systems). Use can also be made of systems based on heating cables or mats, which do not require a separate space for the heating device. However, account must be taken of the current level and the anticipated future dynamics of electricity prices, which may be driven by the need for investments in the electricity sector and by Poland’s international commitments. Therefore electric heating will be attractive in cost terms in houses with high energy efficiency and where the electricity for heating is produced by distributed sources (e.g. a photovoltaic installation) integrated with the building. If there is a district heating network nearby, connecting to it may be worthwhile, since this is usually cost effective.

In detached houses, solid fuel, natural gas, liquid gas and fuel oil boilers are the most common heat sources. In the last dozen or so years, the efficiency of heating boilers has increased by 10-15% – such savings can be achieved by replacing the old boiler with a high-efficiency boiler. However, it must be remembered that when purchasing modern low-temperature condensing boilers, it may be necessary to replace the radiators, as well as to install a chimney insert made of non-flammable materials to protect the chimney against damage by condensation.

Notably, each replacement of a heat source entails the obligation to install automatic temperature control devices in each room. The use of thermostatic radiator valves and heads and of automation to control underfloor heating can highly improve the operation of the whole system, since it allows additional natural energy gains and waste heat produced during the use of spaces to be utilised. Another advantage is the possibility of controlling temperatures in different rooms separately depending on their purpose and the way they are used.

In the case of multi-family and public buildings, a heating system retrofit could also involve the deployment of a device for automatic hydraulic balancing of the installation, which ensures that heat is distributed evenly throughout the building regardless of how far a given room is distanced from the heat source.

Domestic hot water installations

How the domestic hot water system is to be retrofitted depends on the times of the day when warm water is needed. For example, in single-family houses, domestic hot water (DHW) is used over a short time, following which it can be re-heated in an instantaneous heater or storage tank. Instantaneous domestic hot water heating makes sense when the length of piping from the heater to the outlet does not exceed 6 m. In houses with large areas and an extensive DHW system, a DWH heating system with a storage tank might be a better option since it provides greater comfort of warm water use.

In public buildings, DHW is mainly needed at times when they are open for work. When the building is connected to a district heating network, domestic hot water is supplied by a dual-purpose substation. By contrast, when the heat source is located inside the building, cogeneration or a solar collector installation might be a reasonable option. When planning a solar collector installation, attention should be paid to whether the demand for hot water will exist at highest solar radiation times. For example, solar collectors will be ineffective in schools, where hot water production will peak during summer holidays. By contrast, such an installation can prove viable for hospitals.

The efficiency of a domestic hot water system can be improved by:

- switching to another hot water preparation method (heat pump, solar collectors, condensing boiler with a storage tank),
- insulating the water supply piping and the circulation pipe,
- using a timer to control the circulator,
- using tap aerators, water outflow control, modern taps with various sensors and settings,
- using heat recovery from grey water,
- using heaters powered by electricity produced by the building's PV or cogeneration installations,
- using thermal balancing valves and temperature controls,
- using solenoid shut-off valves to prevent water loss and flooding,
- choosing a shower rather than a bath in residential houses (a bath uses up to 100 litres of water, while a shower consumes only 8 l/min.).

In residential buildings, the energy demand for the preparation of domestic hot water is about 24 kWh/(m^2·year). In the case of buildings with high thermal energy consumption (approx. 300 kWh/(m^2·year)), this figure is a small fraction of the total energy needs. It is only in buildings with better standards that consumption of heat for domestic hot water preparation starts to account for a significant percentage of the total heat demand. Therefore, the viability of DHW system retrofitting projects depends largely on the standard of the building before the energy renovation.

For the sake of users' safety, effort should be taken to replace bathroom gas water heaters with a different hot water supply system. When preparing the renovation of a building, the technical condition of the bathroom gas heater should be assessed. If it is in a bad technical condition or there is no proper supply of fresh air or exhaust removal (air tightness and draught in the chimney), the gas heater should be removed and possibly replaced with an electric instantaneous water heater.

Ventilation and air conditioning installations

Ventilation is the process of removing used air from interior spaces and supplying fresh air to replace it. Ventilation is necessary because the air in all rooms is being constantly polluted.

The following types of ventilation are distinguished:

- Natural or gravity ventilation, which works on the basis of the difference in air temperatures inside and outside the building and action of the wind. Air enters the building through leaks in windows and doors or through special air inlet vents and comes out through ventilation grilles and ducts. The efficiency of natural ventilation depends on weather conditions, which means that it is highly variable during the year.
- Hybrid – gravity ventilation is supported by a low-power fan installed at the end of exhaust air ducts.
- Power or mechanical ventilation – forced air flow is achieved through the use of a fan. The air exchange is independent of any weather conditions.
- Power supply-exhaust ventilation (very often with heat recovery), where both air supply and removal is made possible by the use of a fan.

The energy renovation process may involve change of the type of ventilation system, usually from gravity ventilation to power ventilation with heat recovery or to hybrid ventilation.

Power ventilation with heat recovery is an effective way to ensure that the air exchange in the building is independent of the weather. However, constructing such an installation requires substantial alterations in the building, namely installation large diameter ventilation ducts and finding space for an air handling unit. An air handling unit for power ventilation in a detached house (up to 150 m^2) is relatively small (it takes up more or less the same space as a kitchen cupboard). By contrast, in other buildings, it is necessary to find space for one large air handling unit or several dozen smaller units. When installing a power ventilation system with heat recovery in a renovated building, it should be remembered that, in practice, the savings will depend on the energy standard of the building, its air tightness, consumption of electricity by the recuperator fans, the price of the energy carrier utilised for heating (electricity, LPG and fuel oil are the most expensive ones), and the way the interiors are used. Consumables such as filters and maintenance services (e.g. installation cleaning) generate additional cost. The behaviour of building users, who may unseal the building, e.g. by opening windows, can significantly reduce the effectiveness of mechanical ventilation with heat recovery. The annual heat demand of a building with properly designed, constructed and operated power ventilation with heat recovery can be reduced by up to 25%. However, the deployment such ventilation in renovated buildings generates high costs of additional work, i.e. of installation and masking of ventilation ducts (which may sometimes make energy renovation unviable). This means that also here financial support systems for investments will be required in order for the potential for deep energy renovation to be tapped to the maximum.

Air-conditioning

Air conditioning is the process of cooling and humidifying the air in a room aimed at maintaining the desired indoor climate, i.e. the appropriate range of air temperature and humidity, ensuring comfortable work and living environment or optimal conditions for a specific technological process.

An upgrade of the air-conditioning system in the process of energy renovation of a building usually comprises insulating the air supply vents, replacing the drives in large air conditioning units with energy-efficient ones, deploying new, more efficient split conditioners (which can also support heating by reducing direct consumption of fuels for heating purposes), and using free cooling. The economic efficiency of such investments depends on the initial condition of the installation and the scope of project. Therefore, it is recommended that such retrofits be completed past the technical lifetime of old units.

Light systems and lighting fittings

In public buildings, energy renovation involves replacement of light systems with modern ones based on fittings with LED light sources. Additionally, various lighting control systems, e.g. motion sensors, twilight sensors or timeclocks, are installed, producing energy savings of even over 60%, which renders the investment highly efficient (short payback times).

Electrical installations in buildings erected more than 30 years ago are not fit for the current number of devices connected to them, and the aluminium cables used in them have aged. Such installations endanger the safety of their users and devices connected to the sockets, which may present a risk of electric shock or fire, and therefore must be replaced or retrofitted. Pre-renovation audits must assess the current condition of the electrical system and find whether replacement or retrofitting is required.

Energy and building management systems

Automatic computer systems controlling all the installations and processes are a key component of modern construction projects. Lighting, ventilation, heating, cooling, domestic hot water, etc. can be controlled in a smart and automatic way. If properly designed and operated, processes and installations will produce appreciable electricity, water and fuel savings, and will minimise waste, while ensuring the comfort of use of the building and reducing its negative environmental impacts.

Until recently, individual installations were not integrated and although they did fulfil their function, they did not allow for the entire building to be managed comprehensively. Today, BMS technologies make it possible for existing and designed systems to be integrated so that they form a smart building. Such systems generate final energy savings of up to 30%. The use of wireless technologies in BMSs has considerably lowered the costs of such installations in energy renovated buildings, making thermomodernisation highly energy efficient.

Assessment of the potential for development and application of innovative building technologies

The analyses of energy renovation of buildings with various structural design and technical equipment described above are based on current knowledge. However, technological progress is bound to lead in the near future to wide use of construction technologies which are currently being researched or applied on a small scale, or which are not yet cost-effective. The increase in unit prices of energy carriers renders many new construction technologies more economically viable. It is worth following the trends in the area of the new technologies which can soon be employed in energy renovation processes, and the lists of activities, devices and solutions suggested above should not be treated as exhaustive.

Building envelope insulation technologies

Currently, mineral wool and foamed polystyrene are the most widespread building envelope insulation materials in Poland. Using them for deep renovation of existing buildings poses multiple challenges.

First, their thickness on external walls exceeds 20 cm. Although the price of such standard insulation material is about 20% of the total wall insulation cost and increasing its thickness will translate into only slightly higher overall project spending, high thickness of insulation materials (more than 20 cm) will cause technology problems. In the case of the light wet method, plaster cracks may occur, while the light dry method may entail complications related to the fixing of the wood framing to the wall.

Secondly, if a building must be insulated from the inside, thick insulation will highly reduce the usable area of the renovated space.

On balance, it must be emphasised that the above insulation materials have a number of advantages, notably a lower price compared to alternative solutions, ease and flexibility of use at the construction site and wide experience among contractors.

Vacuum insulation

This category comprises modern insulating materials utilising the good insulation performance of a vacuum. In construction, they are used in the form of vacuum insulation panels (VIP). VIP consists of two elements: micro-/nano-porous material, also known as 'core', and a gas-tight envelope is sealed under vacuum, known as 'foil'. The core is typically made of: glass fibres, open-cell polyurethane foam, open-cell polystyrene foam, pyrogenic silica, and nanogel. A typical VIP envelope consists of three layers: the outer protective layer (e.g. polyethylene terephthalate), the middle barrier layer (e.g. aluminium foil) and the inner sealing layer (e.g. polyethylene).

The benefits of VIPs are as follows:

- highly reduced thickness of the insulation layer,
- high thermal resistance,
- low specific weight,
- very low thermal conductivity (λ value), and thus very good thermal insulation properties.

The disadvantages include:

- high price compared to typical insulation,
- installation requiring a trained team,
- shorter lifetime compared to traditional insulating materials,
- the panels cannot be machined on the construction site – a very precise installation plan is required before the material is ordered,
- easy to damage during installation.

Smart insulation

The thermal conductivity of smart insulation varies depending on external conditions. Smart insulation is based primarily on VIPs filled with glass fibres or powders which enables mechanical loads acting on the insulation to be transferred. By changing the gas pressure in the pores, heat conductivity values adapted to the external conditions are obtained. Such insulation has the same advantages and disadvantages as vacuum insulation.

Aerogels

Aerogels are formed through the removal of the liquid from gel and replacing it with gas. This makes the substance become ultra-light because it consists of air in 90%. The rest of the weight is the material that forms the aerogel structure – most often silica. Aerogels are currently the lightest solid substances, not much denser than air. Aerogel insulating materials are characterised by very low thermal conductivity oscillating around 0.014 W/(m*K). The main advantage that distinguishes aerogels from other insulating materials is their high tensile and compressive strength. The disadvantages include high brittleness and low shear, twisting and impact resistance. The popularisation of aerogels is also largely hindered by the price of the material, which is several times higher than the most commonly used insulation materials. Modern aerogels are insulating products manufactured in nanotechnological processes. Aerogels are used wherever very good insulation with top performance and minimum thickness is needed, such as to ensure time and space savings. The thermal conductivity of aerogel, which is three times lower than that of the most common present-day insulation materials, means that deep energy renovation can be ensured with the use of material which is only several cm thick.

Smart windows

Transparent elements, mainly windows, are among the crucial envelope elements. Windows in energy renovated buildings should have parameters consistent with applicable technical requirements, above all the best possible heat penetration coefficient. For the windows which are to meet the requirements as from 31 December 2020, the U-factor should not exceed 0.9 [W/($m^2 \cdot K$)]. However, it should be highlighted that the choice of the solution in this respect should take into account the cumulative influence of windows on the energy consumption of the building, including both heat losses and heat gains from sunlight.

When replacing windows, the so-called ‘warm three-layer installation’ should be used. If the old windows are in such bad condition that they need to be replaced, it is worth considering whether any of the new windows may be of the non-openable type. Such windows are not only cheaper, but also offer better thermal performance and have smaller cross-sections of the frame, which provides more light with the same size of the opening needed for the installation of the window. They prove their worth not only on the ground floor, but also wherever windows can be accessed easily from the outside (e.g. from the balcony or terrace) so that they can be cleaned and maintained.

Heat losses through windows can be reduced by installation of external roller shutters, which also provide anti-burglary protection and protection against excessive sunlight in summer. External roller shutters closed at night can reduce loss of heat through windows by up to 30%, so it is worth installing them on all windows, provided that they are actually closed every evening. This requires that their closure and opening be controlled electronically, which involves additional costs of at least PLN 600 per window.

It should also be remembered that once windows are replaced with much tighter ones, top-efficiency (i.e. mechanical, supply-exhaust) ventilation will need to be provided (which will increase the investment costs) or air inlet vents, preferably humidity-controlled, installed.

Modern windows are no longer simple elements of the building’s envelope, but have become complex devices with:

- multi-chamber frames filled with innovative insulation materials,
- self-cleaning glass,
- a warm spacer frame, reinforced with glass fibre, covered on the outside with thin, state-of-the-art foil,
- intelligent window panes, reinforced with PVB foils, which not only protect against burglary, but also prevent cuts when the glass is broken, and suppress noise
- and filter out most of the UV rays,
- shading elements such as blinds or roller shutters integrated with the window.

The design of windows is evolving towards the use of electrochromic technologies which control the amount of light (heat) entering the building through the windows by dimming or brightening them. In winter, such windows become brighter, increasing the amount of heat supplied to the room and thus reducing the demand for thermal power. In summer, they darken and block the light, reducing the amount of heat and thus the need for room cooling. Windows lighten or darken as a result of chemical reactions triggered by low voltage applied to them. The thin layer of solar cell made of a nickel-magnesium alloy can repeatedly switch from the transparent to opaque state.

In many historic buildings, replacing windows with new ones, offering higher insulation performance is not allowed. In such cases, consideration should be given to alternative solutions such as internal sashes or conservation of antique woodwork. This will improve the building's energy efficiency without affecting its historic value.

Lighting systems

As mentioned above, most modern lighting systems are based on LED technologies.

The innovative lighting solutions to be used in the near future include:

- OLED technologies,
- daylighting systems,
- dynamic lighting systems, which change the colour and intensity of light depending on the user's needs,
- optical fibres, dimming systems and occupancy sensing,
- the use of integrated smart building control systems.

In a smart building, lighting is controlled through adjustment of the light brightness level to the presence of users and through even several programmable lighting scenes. The light goes off automatically every time the sensors stop to detect user presence, while dimmers adjust the intensity to the user's preferences preset in a given lighting scene.

In addition to generating considerable energy savings, intelligent lighting systems allow building users or managers to optimise the way the building is used based on anonymised data about the actual energy needs they collect. This produces savings not only in terms of lighting, but also air conditioning, and in the case of office buildings, also in terms of building maintenance and use costs.

Modern heating, ventilation and air conditioning systems

Nowadays, many interesting innovative heating technologies which could be applied for the production of heat and cooling in Polish buildings are being implemented worldwide.

They include:

- reverse cycle heat pumps,
- pulse gas-condensing boilers,
- cogeneration, trigeneration, polygeneration devices,
- heat piping,
- infrared heating panels,
- solar collectors and photovoltaic thermal collectors dedicated to heating buildings,
- heat storage.

Smart heating and cooling control systems

As regards heating and/or cooling of buildings, a smart energy management system measures the temperatures in individual rooms and controls the heating and/or cooling system in such a way as to maintain the temperatures at the levels preset by the users. Thanks to controlling devices installed in every room, temperatures can vary from one room to another depending on how the individual spaces are used and what users' preferences are. Once users leave the building, the system switches to the energy-saving mode, and it lowers the temperature to values which suit users when operating in the night mode. Using remote control, the user can set the temperatures in different rooms with a phone app, also when staying outside the building. Opening the window in a room switches off the heating/cooling. Independent temperature control in each room produces electricity savings of up to 30%. As regards ventilation and air-conditioning, energy management systems control roller shutters and blinds to reduce room overheating, control the process of natural cooling of the building at night and use occupancy sensing to ensure climate comfort in different zones of the building. Based on data from multiple sources, the system optimises the operation of the heating and/or cooling installation, while its actuating elements ensure optimal energy distribution and efficient operation of the system without the need for external monitoring or interference by the user or maintenance staff.

Annex 2. Overview of achievable savings as illustrated by examples of real buildings

Examples of estimated savings resulting from renovation work are presented below.

Table Z2.1. Estimated savings achievable in buildings heated with a fuel oil boiler (calorific value of fuel: 36.12 MJ/l, fuel price: PLN 3.20/l)

SAVINGS PRODUCED BY ADDITIONAL THERMAL INSULATION OF EXISTING ENVELOPE ELEMENT				
Location:	Poland			
The nearest meteorological station:	Warsaw			
Outdoor temperature [°C]	-20			
Indoor temperature [°C]	22		23	
Building standard	single-family, erected before 1990, not renovated		multi-family buildings, erected in 1990-2000, not renovated	
Type of thermally retrofitted envelope element	external wall	roof	external wall	roof
Surface area of insulated envelope element [m²]	300	150	1 000	400
Type of additional insulation material:	foamed polystyrene	mineral wool	foamed polystyrene	mineral wool
Insulation layer thickness [cm]	15			
Reduction of energy losses [GJ/year]	88.2	28.5	147.7	45.5
Annual cost savings	PLN 7 816	PLN 2 526	PLN 13 087	PLN 4 027

Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

Table Z2.2. Estimated savings achievable in a building heated with a coal-fired boiler (calorific value of fuel: 26 MJ/kg, fuel price: PLN 800/t)

SAVINGS PRODUCED BY ADDITIONAL THERMAL INSULATION OF EXISTING ENVELOPE ELEMENT	
Location:	Poland
The nearest meteorological station:	Warsaw
Outdoor temperature [°C]	-20
Indoor temperature [°C]	20
Building standard	single-family, built in 2000-2014, not renovated
Type of thermally retrofitted envelope element	external wall
Surface area of insulated envelope element [m²]	400
Type of additional insulation material:	foamed polystyrene
Insulation layer thickness [cm]	15
Reduction of energy losses [GJ/year]	30.6
Annual cost savings	PLN 940

Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

Table Z2.3. Estimated savings achievable as a result of the refurbishment of a DHW system supplied by a light fuel oil boiler (fuel calorific value: 36.12 MJ/l, fuel price: PLN 3.20/l)

SAVINGS PRODUCED BY THE REFURBISHMENT OF A DOMESTIC HOT WATER SYSTEM:		
	BEFORE REFURBISHMENT	AFTER REFURBISHMENT
Heat source	Compact district heating substation without housing, with a rated capacity of up to 100kW, **efficiency 91%**	Compact district heating substation with housing, with a rated capacity of up to 100kW, **efficiency 98%**
Type of heating installation	Central water heating – systems with circulation, with uninsulated risers and insulated distribution piping – number of distribution points 30-100, **efficiency 50%**	Central water heating – systems with circulation and limitation of operating time, with risers and insulated distribution piping – number of distribution points 30-100, **efficiency 70%**

Annual demand for final energy [GJ]	361.2	239.6
Average annual heating cost	PLN 32 000	PLN 21 224
Annual cost savings	PLN 10 776	

Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

Table Z2.4 Estimated savings achievable as a result of the refurbishment of electric heating

SAVINGS PRODUCED BY THE REFURBISHMENT OF A HEATING SYSTEM		
Heat source	BEFORE REFURBISHMENT	AFTER REFURBISHMENT
	Direct electric radiators, **efficiency 99%**	Gas condensing boilers (55/45) with a rated capacity of up to 50kW **efficiency 94%**
Type of heating installation	Direct electric radiators with proportional P-controller, direct electric radiators with proportional P-controller, **efficiency 91%**	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, **efficiency 88%**
Unit price of electricity/fuel:	0.65 PLN/kWh	PLN 1.90/m^3
Annual demand for final energy [GJ]	32.4	35.3
Average annual heating cost	PLN 5 850	PLN 1 862
Annual cost savings	PLN 3 988	

Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

The tables below show the results of the energy efficiency and economic efficiency analysis for real single-family and office buildings.

The analysis covers two types of energy renovation (deep and shallow), as defined for the purposes of this Strategy (see: overview of key terms at the beginning of the document). Additionally, in the case of shallow energy renovation, consideration is given to sets of activities providing the greatest cost-effectiveness (for a given building), such as to generate final energy savings of at least 25% of the baseline final energy consumption. Such an approach can be used for comparing similar projects: comprehensive investments involving multiple actions aimed at material improvement of energy efficiency. The key difference between them lies in the fact that shallow energy renovation focuses on maximising the economic effect (selecting the most cost-effective activities), while deep energy renovation, on maximising the energy effect (achieving performance consistent with the requirements of the Technical Conditions Regulation).

Table Z2.5. Analysis of capex depending on savings for a single-family building with fuel change (useful floor area = 167 m^2)

Residential building	Fuel	Final energy consumption (heating + DHW) [kWh/year]	Final energy factor [kWh/(m^2·year)]	Energy savings [kWh]	Annual cost of heating and DHW	Annual savings
Currently	coal	59 126	354	-	PLN 8 278	**-**
Shallow energy renovation	gas	37 013	222	22 113	PLN 5 552	**PLN 2 726**

Deep energy renovation	gas	18 680	112	40 446	PLN 2 802	**PLN 5 476**

Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

Table Z2.6. Analysis of capex depending on the savings for a single-family building with fuel change (useful floor area = 187 m²)

Residential building	Fuel	Final energy consumption (heating + DHW) [kWh/year]	Final energy factor [kWh/(m²·year)]	Energy savings [kWh]	Annual cost of heating and DHW	Annual savings
Currently	coal	56 854	303	-	PLN 7 960	**-**
Shallow energy renovation	gas	44 117	235	12 737	PLN 6 618	**PLN 1 342**
Deep energy renovation	gas	21 024	112	35 830	PLN 3 154	**PLN 4 806**

Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

Table Z2.7. Analysis of capex depending on the savings for an office building with fuel change (useful floor area = 630 m²)

Residential building	Fuel	Final energy consumption (heating + DHW) [kWh/year]	Final energy factor [kWh/(m²·year)]	Energy savings [kWh]	Annual cost of heating and DHW	Annual savings
Currently	coal	78 618	125	-	PLN 11 007	**-**
Shallow energy renovation	gas	59 460	94	19 158	PLN 8 919	**PLN 2 088**
Deep energy renovation	gas	33 755	53	44 863	PLN 5 063	**PLN 5 944**

Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

Table Z2.8. Analysis of capex depending on the savings for an office building with fuel change (useful floor area = 633 m²)

Residential building	Fuel	Final energy consumption (heating + DHW) [kWh/year]	Final energy factor [kWh/(m²·year)]	Energy savings [kWh]	Annual cost of heating and DHW	Annual savings
Currently	coal	87 786	139	-	PLN 12 290	**-**
Shallow energy renovation	gas	67 794	107	19 992	PLN 10 169	**PLN 2 121**
Deep energy renovation	gas	38 668	61	49 118	PLN 5 800	**PLN 6 490**

Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

Annex 3. Additional data concerning energy renovation of historic buildings

Table Z3.1. Results of energy efficiency analysis for energy renovation of a historic gymnasium building (useful floor area = 858 m²)

Energy	Calculated energy demand before energy renovation		Calculated energy demand after energy renovation		Energy Savings	Energy savings in %
	kWh/year	kWh/(m²·year)	kWh/year	kWh/(m²·year)	kWh/year	
final energy for CH and DHW	892 900	1 041.0	42 004	49.0	850 895	95%
final energy for lighting	20 843	24.3	20 843	24.3	-	0%
final energy for auxiliary equipment	1 106	1.3	1 106	1.3	-	0%
total final energy	**914 849**	**1 066.6**	**63 954**	**74.6**	**850 895**	**93%**
primary energy for CH and DHW	989 991	1 154.2	126 012	146.9	863 978	87%
primary energy for lighting	62 529	72.9	62 529	72.9	-	0%
primary energy for auxiliary equipment	3 319	3.9	3 319	3.9	-	0%
total primary energy	**892 900**	**1 041.0**	**42 004**	**223.7**	**850 895**	**82%**

Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

Table Z3.2. Results of energy efficiency analysis for energy renovation of a historic boarding school building (useful floor area = 7 563 m²)

Energy	Calculated energy demand before energy renovation		Calculated energy demand after energy renovation		Energy Savings	Energy savings in %
	kWh/year	kWh/(m^2·year)	kWh/year	kWh/(m^2·year)	kWh/year	
final energy for CH and DHW	3 048 147	403.0	209 569	27.7	2 838 578	93%
final energy for lighting	47 464	6.3	21 748	2.9	25 715	54%
final energy for auxiliary equipment	13 951	1.8	13 951	1.8	-	0%
total final energy	**3 109 562**	**411.1**	**245 269**	**32.4**	**2 864 293**	**92%**
primary energy for CH and DHW	3 352 961	443.3	628 706	83.1	2 724 255	81%
primary energy for lighting	142 391	18.8	65 245	8.6	77 146	54%
primary energy for auxiliary equipment	41 854	5.5	41 854	5.5	-	0%
total primary energy	**3 537 207**	**467.7**	**735 806**	**97.3**	**2 801 401**	**79%**

Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

Table Z3.3. Results of energy efficiency analysis for energy renovation of a historic nursing home building (useful floor area = 3 382 m²)

Energy	Calculated energy demand before energy renovation		Calculated energy demand after energy renovation		Energy Savings	Energy savings in %
	kWh/year	kWh/(m²·year)	kWh/year	kWh/(m²·year)	kWh/year	
final energy for CH and DHW	1 322 945	391.2	127 000	37.6	1 195 945	90%
final energy for lighting	39 235	11.6	23 694	7.0	15 540	40%
final energy for auxiliary equipment	6 436	1.9	64 356	1.9	-	0%
total final energy	**1 368 615**	**404.7**	**157 130**	**46.5**	**1 211 485**	**89%**
primary energy for CH and DHW	1 455 239	430.3	380 999	112.7	1 074 240	74%
primary energy for lighting	117 707	34.8	71 083	21.0	46 621	40%
primary energy for auxiliary equipment	19 307	5.7	19 307	5.7	-	0%
total primary energy	**1 592 251**	**470.8**	**471 390**	**139.4**	**1 120 861**	**70%**

Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

Table Z3.4. Results of energy efficiency analysis for energy renovation of a historic boarding school building (useful floor area = 4 390 m²)

Energy	Calculated energy demand before energy renovation		Calculated energy demand after energy renovation		Energy Savings	Energy savings in %
	kWh/year	kWh/(m^2·year)	kWh/year	kWh/(m^2·year)	kWh/year	
final energy for CH and DHW	1 687 222	384.3	160 915	36.7	1 526 307	90%
final energy for lighting	175 600	40.0	175 600	40.0	-	0%
final energy for auxiliary equipment	7 582	1.7	7 582	1.7	-	0%
total final energy	**1 870 403**	**426.1**	**344 096**	**78.4**	**1 526 307**	**82%**
primary energy for CH and DHW	1 273 852	290.2	205 248	46.8	1 068 604	84%
primary energy for lighting	526 800	120.0	526 800	120.0	-	0%
primary energy for auxiliary equipment	22 745	5.2	22 745	5.2	-	0%
total primary energy	**1 823 397**	**415.4**	**754 793**	**171.9**	**1 068 604**	**59%**

Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

Table Z3.5. Results of the energy efficiency analysis for energy renovation of a historic sanatorium building (usable area 7 831 m²)

Energy	Calculated energy demand before energy renovation		Calculated energy demand after energy renovation		Energy Savings	Energy savings in %
	kWh/year	kWh/(m²·year)	kWh/year	kWh/(m²·year)	kWh/year	
final energy for CH and DHW	6 139 985	784.0	2 703 295	345.2	3 436 689	56%
final energy for lighting	587 348	75.0	540 291	69.0	47 057	8%
final energy for auxiliary equipment	29 366	3.8	29 366	3.8	-	0%
total final energy	**6 756 699**	**862.8**	**3 272 953**	**417.9**	**3 483 746**	**52%**
primary energy for CH and DHW	6 753 983	862.4	2 973 625	379.7	3 780 358	56%
primary energy for lighting	1 762 045	225.0	1 620 874	207.0	141 171	8%
primary energy for auxiliary equipment	88 098	11.3	88 098	11.3	-	0%
total primary energy	**8 604 126**	**1 098.7**	**4 682 597**	**597.9**	**3 921 529**	**46%**

Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

Table Z3.6. Results of energy efficiency analysis for energy renovation of a historic hospital building (useful floor area = of 3 404 m^2)

Energy	Calculated energy demand before energy renovation		Calculated energy demand after energy renovation		Energy Savings	Energy savings in %
	kWh/year	kWh/(m^2·year)	kWh/year	kWh/(m^2·year)	kWh/year	
final energy for CH and DHW	2 430 092	713.9	375 927	110.4	2 054 165	85%
final energy for lighting	91 967	27.0	48 974	14.4	42 992	47%
final energy for auxiliary equipment	7 717	2.3	24 660	7.3	-16 943	-220%
total final energy	**2 529 776**	**743.2**	**449 561**	**132.1**	**2 080 214**	**82%**
primary energy for CH and DHW	2 673 101	785.3	874 174	256.8	1 798 927	67%
primary energy for lighting	275 900	81.1	146 923	43.2	128 977	47%
primary energy for auxiliary equipment	23 152	6.8	73 981	21.7	-50 829	-220%
total primary energy	**2 972 153**	**873.2**	**1 095 078**	**321.7**	**1 877 075**	**63%**

Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

Table Z3.7. Results of energy efficiency analysis for energy renovation of a historic hotel building (useful floor area = of 7 347 m²)

Energy	Calculated energy demand before energy renovation		Calculated energy demand after energy renovation		Energy Savings	Energy savings in %
	kWh/year	kWh/(m^2·year)	kWh/year	kWh/(m^2·year)	kWh/year	
final energy for CH and DHW	3 513 479	478.2	1 638 405	223.0	1 875 074	53%
final energy for lighting	185 104	25.2	185 104	25.2	-	0%
final energy for auxiliary equipment	17 811	2.4	17 811	2.4	-	0%
total final energy	**3 716 394**	**505.8**	**1 841 319**	**250.6**	**1 875 074**	**50%**
primary energy for CH and DHW	3 864 827	526.0	1 802 246	245.3	2 062 582	53%
primary energy for lighting	555 311	75.6	555 311	75.6	-	0%
primary energy for auxiliary equipment	53 433	7.3	53 433	7.3	-	0%
total primary energy	**4 473 570**	**608.9**	**2 410 989**	**328.1**	**2 062 582**	**46%**

Source: 'Ekspertyza w zakresie określenia opłacalnych podejść do modernizacji właściwych dla danego typu budynków i strefy klimatycznej', KAPE 2020.

Annex 4. Detailed scope of NSS 5 Smart and energy-efficient construction

I. Materials and technologies

1. Materials with enhanced parameters, in particular: structural, insulation materials, materials with increased resistance to ageing, vapour-permeable, with low embodied energy, high fire resistance, low emissivity, heat reflective and made of plant raw materials, as well as their manufacturing technologies.
2. Materials and technologies used for revitalisation of buildings, including historic ones.
3. Thermomodernisation materials and technologies to be applied on existing thermal insulation requiring improved insulation performance.
4. Materials for accumulating heat and cold and associated manufacturing technologies.
5. Materials and technologies for producing high-performance anti-fungal, anti-bacteria and anti-algae coatings.
6. Materials with variable physical parameters regulated by the parameters of the external environment and/or by the building's energy management system, including materials with variable thermal, spectral, humidity and other properties, and associated manufacturing technologies.
7. Transparent materials and associated manufacturing technologies; windows, glazing systems with variable optical parameters for solar radiation.
8. Long-lasting roofing and other materials, characterised by high resistance to degradation factors, which protect buildings against weather conditions, including materials with variable absorption properties, and associated manufacturing technologies.
9. Materials and technologies which protect buildings against overheating and/or limit heat losses.
10. Research and technologies related to the transport of heat and moisture through the building's envelope depending on the insulation materials and energy retrofit technology deployed.
11. Materials and technologies of high-efficiency and controllability daylighting systems.
12. Materials and technologies of passive solar systems integrated with the building envelope.
13. Active thermal solar energy materials and technologies integrated with the building.
14. Photovoltaic materials and technologies integrated with the building envelope.
15. Energy multifunctional (heating, cooling, ventilation, air conditioning, electricity production) materials and technologies of building envelopes.
16. Energy-efficient lighting, maintainable modular fittings for energy-efficient lighting with minimised embodied energy, fittings with increased cooling efficiency and lifetime of their components, as well as the materials and technologies used to manufacture them.

II. Energy systems of buildings

1. Integrated approach to building management systems.
2. Smart building technologies and systems including new algorithms optimising the use of energy from renewable sources integrated with the building and from local storage systems, advanced energy production and demand forecasting systems.
3. Technologies and systems for integrating groups of smart buildings with smart city infrastructures.
4. Systems for easy and fuller use of smart building functionalities, inter alia easier access and control (gesture and voice control) with the use of cameras, visual identification of threats (e.g. fire or flood), user identification by a smart building.
5. Intelligent prepayment systems for utilities supplied to the building.
6. Active facade systems protecting against overheating.

7. Systems for distribution of energy in the building in line with availability and temporary needs, preceded by the development of a system for the prioritisation of use of various energy sources in the building's integrated energy system.
8. Smart lighting systems.
9. Development of building management algorithms and systems raising user awareness on energy use based on a DSM (Demand-Side Management) system.

III. Development of machinery and devices

1. Waste-free/low-waste technologies and processing lines designed in a way reducing the costs and/or increasing the efficiency of the production of materials, construction products, and completion of building projects.
2. Processing lines, machinery and related devices for production (prefabrication) of building envelope modules with high thermal resistance and low embodied energy.
3. Machines and equipment reducing the energy and labour intensity of the construction process and improving work safety.
4. Energy management devices and systems for automatic and seamless use of multiple power sources in buildings.
5. Direct current building devices and systems.
6. Building/Home Management System (BMS/HMS) controllers installed permanently in household appliances/lighting systems compatible with the building's BMS.
7. Devices and systems for conversion, storage and use of renewable and waste energy.
8. Devices integrating energy conversion and storage systems.
9. High-efficiency micro- or small-scale devices for converting the energy contained in the environment into electricity, heat and cooling for use in buildings.
10. Devices and systems for rationalising the use, abstraction, purification and treatment of water.

IV. Development of programming applications and environments

1. Establishment of an open Software Development Kit to be used for creating higher-level applications with a graphical interface for controlling the operation of equipment in smart buildings and supporting interaction between individual network devices.
2. Integrated diagnostic applications for remote monitoring and testing of BMS/HMS systems.
3. BMS/HMS systems/applications/interfaces improving safety, supporting building services and raising the quality of life for elderly people with partial disability and for people with disabilities (blind, deaf, with motor impairments).
4. Developing standards for communication and exchange of data between active elements of smart buildings and local systems.
5. Design, construction and testing of communication modules for data exchange and management of active elements of smart buildings.
6. Design, construction and testing of integrated energy management systems for autonomous local systems.
7. Design, testing and implementation of algorithms optimising management of resources of autonomous local systems.

V. Integrated design,

1. Development and standardisation of libraries supporting BIM.

2. Design methods and tools leading to smart construction, inclusive of the use of computer simulation and BIM techniques in all design phases (development of tools supporting the design, modelling and simulation of low-energy buildings, both in terms of the technologies used and the economic effect achievable – cost/payback time).

VI. Energy and environmental verification

1. Applications supporting and automating energy auditing of energy refurbished buildings and monitoring the effects.
2. Developing tools for energy and environmental verification of embodied energy intensity and for use of life cycle assessment (LCA) methods.
3. Validation of integrated zero-energy building systems under real operating conditions (‘network of experimental buildings’ based on different systems).
4. Methods and tools for assessing the quality of elements of buildings (existing and under construction) to determine their actual performance.
5. Research, technologies related to the impact of building infrastructure systems on health and work productivity.
6. Innovative system for field testing of construction product parameters impacting the final energy efficiency of buildings.

VII. Processing and re-use of materials.

1. Development of technologies for the re-use of materials, construction and insulation elements (recovery, including recycling) in construction.
2. New technologies and processing lines for the production of materials and products for the construction industry with the use of subsidiary raw materials, by-products and waste.

Annex 5. Detailed assumptions regarding the estimated scale of the financing necessary for the recommended scenario

The scale of the financing necessary for the recommended scenario presented in chapter 9 is estimated on the basis of:

- data on the current area of residential and non-residential buildings (see chapter 3.7),
- the rate of renovation of buildings in the recommended scenario (see chapter 9.4),
- estimated unit costs (as per m^2) of building renovation (see chapter 3.6), taking into account their dynamics in the years 2021-2050 (growth of labour and material costs with a simultaneous decrease in equipment costs and the effect of lessons learnt),
- the current building renovation funding structure in Poland (see chapter 8.1).

The detailed assumptions regarding the current area of buildings in Poland are presented in Table Z5.1.

Table Z5.1. Area of buildings in Poland in 2019

	million m^2
Single-family	702
Multi-family	400
Non-residential	465

Source: KAPE and WiseEuropa estimation.

For the purposes of estimating the financial needs, even pace of the renovation of residential and non-residential buildings is assumed in line with the values assumed in the recommended renovation scenario.

Table Z5.2. Estimated total area of buildings to be renovated in the recommended scenario in Poland until 2050.

	Target energy efficiency of buildings after renovation by PEF [kWh/(m2·year)]				
	up to 50	**50-90**	**90-150**	**150-230**	**230-330**
	Area to be renovated in 2021-2030, million m^2				
Single-family	75	27	38	99	11
Multi-family	43	15	21	56	6
Non-residential	50	18	25	65	7
	Area to be renovated in 2031-2040, million m^2				
Single-family	152	66	63	0	0
Multi-family	87	38	36	0	0
Non-residential	101	44	42	0	0
	Area to be renovated in 2040-2050, million m^2				
Single-family	216	22	0	0	0
Multi-family	123	12	0	0	0
Non-residential	143	14	0	0	0

Source: WiseEuropa and KAPE estimation.

The estimated ranges of costs of renovation to the individual target levels are presented in Table Z5.3. The estimates take into account the increase in the costs of materials and services, the effect of learning, and the effects of staged energy renovation in the initial period, which reduce the costs of achieving the individual energy efficiency levels.

Table Z5.3. Estimated unit capex on renovation of buildings until 2050, PLN/m²

	Target energy efficiency of buildings after renovation by PEF [kWh/(m²·year)]				
	up to 50	**50-90**	**90-150**	**150-230**	**230-330**
	Unit capex 2021-2030				
Single-family	915	817	787	725	724
Multi-family	839	750	721	665	664
Non-residential	702	627	604	557	556
	Unit capex 2031-2040				
Single-family	982	896	883		
Multi-family	901	821	810		
Non-residential	754	687	678		
	Unit capex 2041-2050				
Single-family	1 129	1 041			
Multi-family	1 036	955			
Non-residential	867	799			

Source: WiseEuropa and KAPE estimation.

The estimated total area of buildings to be renovated and the associated unit capex can be used for estimating the cumulative capital expenditures until 2050.

Based on the results of an analysis of the panorama of low-carbon investments mobilised by public funds in 2014-2019, the following parameters have been adopted in order to estimate the scale of public financing in the recommended scenario, assuming that the current intensity of support is maintained:

- public financing (subsidies, tax allowances, etc.) covers 31% of the capital expenditures to be spent on residential buildings,
- public financing (subsidies, institution's own contribution, etc.) covers 85% of the capital expenditures on non-residential buildings in the public sector,
- the amount of co-funding for non-residential buildings in the private sector represents 13% of the spending in the public sector.

Annex 6. Summary of the fulfilment of enabling condition 2.1 'Strategic policy framework to support energy efficiency renovation of residential and non-residential buildings'

Table Z6.1. Fulfilment of the criteria of enabling condition 2.1 'Strategic policy framework to support energy efficiency renovation of residential and non-residential buildings'

Criteria to be fulfilled for enabling condition 2.1	**How the criterion is fulfilled**
1. A national long term renovation strategy to support renovation of the national stock of residential and non-residential buildings is adopted, in line with the requirements of the Directive 2010/31/ EU on energy performance of buildings, which:	Adoption of the Strategy by a Cabinet resolution.
a. Entails indicative milestones for 2030, 2040 and targets for 2050	The 2030, 2040 and 2050 milestones are defined as part of the recommended renovation scenario (Chapter 9.4).
b. provides an indicative outline of budgetary resources to support the implementation of the strategy	The budgetary resources to support the implementation of the strategy are presented in the section containing the detailed overview of the national financial tools to support the renovation of buildings (Chapter 5.3). The strategy also presents an indicative scale of support for building renovation under the recommended scenario (Chapter 9.4).
c. defines effective mechanisms for promoting investments in building renovation	The strategy provides a detailed overview of the national financing tools to support the renovation of buildings (Chapter 5.3) and describes the building renovation financing tools, indicating the mechanisms helping investors undertake and complete renovation of buildings (Chapter 8.2).

Annex 7. Report on public consultations and opinion seeking on Draft Cabinet Resolution on the adoption of the 'Long-Term Building Renovation Strategy' pursuant to § 36(2) of Cabinet Resolution No 190 of 29 October 2013 on the adoption of the Cabinet Procedure Rules (Polish Official Gazette 2016, item 1006, as amended)

I. Introduction

The preparation and adoption of the draft 'Long-Term Building Renovation Strategy' fulfils the obligation provided for by Article 2a of Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the energy performance of buildings (OJ L 153, 18.6.2010, p. 13, as amended).

II. Date and duration of public consultation

On 11 February 2021, consultation on the draft Cabinet Resolution on the adoption of the draft 'Long-Term Building Renovation Strategy' began. Stakeholders were able to submit comments to the draft and other documents (draft 'Long-Term Building Renovation Strategy', regulatory impact assessment, explanatory memorandum) until 26 February 2021.

III. Consultation process

1. Respondents to the public consultation

In the course of the public consultation, the draft resolution with attachments was sent to 108 entities, in particular sectoral stakeholders representing the broad construction industry or dealing with energy efficiency of buildings, and organisations representing the interests of local government units. In the opinion seeking process, the draft resolution with attachments was sent to 8 entities, inter alia to Director of Bank Gospodarstwa Krajowego, the Chief Inspector of Construction Supervision, the President of the Central Office of Construction Supervision and the Ombudsman for Small and Medium-Sized Enterprises. The draft resolution along with the other documents, including the Long-Term Building Renovation Strategy, were also published on the website of the Ministry of Development, Labour and Technology (https://www.gov.pl/web/rozwoj-praca-technologia/dlugoterminowa-strategia-renowacji), and a notice on the addition of the draft resolution to the List of Proposed Legislative Acts and Programming Documents of the Cabinet (Wykaz prac legislacyjnych i programowych Rady Ministrów) was published in the Public Information Bulletin of the Prime Minister's Office (https://archiwum.bip.kprm.gov.pl/kpr/form/r57519716,Projekt-uchwaly-Rady-Ministrow-w-sprawie-przyjecia-Dlugoterminowej-Strategii-Ren.html). Thus, every stakeholder could read the draft resolution and all the attachments, and submit their comments. During the public consultation on the draft Cabinet Resolution on the adoption of the 'Long-Term Building Renovation Strategy', comments were provided by more than 30 stakeholders, which/who mainly represented:

a) industry organisations related to construction, energy, engineering and heating,
b) energy companies,
c) local government entities,
d) public administration entities,
e) individuals.

Detailed list of the stakeholders that submitted their comments during the public consultation:

1. Stowarzyszenie ds. Rozliczania Energii;
2. Stowarzyszenie Nowoczesne Budynki;
3. Związek Pracodawców Polskie Szkło ('Polish Glass' Employers' Union);
4. Stowarzyszenie Producentów i Importerów Urządzeń Grzewczych – SPIUG (Union of Heating Equipment Producers and Importers);
5. Polskie Stowarzyszenie Inżynierów i Techników Sanitarnych (Polish Union of Sanitary Engineers and Technicians);
6. Zrzeszenie Audytorów Energetycznych (Association of Energy Auditors)

7. Instytut Techniki Budowlanej (Institute of Construction Technology);
8. Polska Izba Inżynierów Budownictwa (Polish Chamber of Civil Engineers);
9. Stowarzyszenie Producentów Betonów (Concrete Producers Association);
10. Narodowy Instytut Architektury i Urbanistyki (National Institute of Architecture and Town Planning);
11. State Patronage Department of the Ministry of Culture, National Heritage and Sports;
12. INNOVATOR Sp. z o.o.;
13. River Power;
14. Stowarzyszenie Producentów Wełny Mineralnej Szklanej i Skalnej – MIWO (Association of Producers of Glass and Rock Wool (MIWO));
15. Związek Pracodawców – Producentów Materiałów dla Budownictwa (Association of Employers – Producers of Materials for Construction);
16. 4-eco Sp. z o.o;
17. Polskie Stowarzyszenie Budownictwa Ekologicznego PLGBC (PLGBC Polish Green Construction Association);
18. PGNiG S.A. (Polish Gas Company);
19. Lewiatan (Confederation of Private Employers);
20. Pol-lighting Związek Producentów Sprzętu Oświetleniowego (Pol-lighting Association of Lighting Equipment Manufacturing),
21. Związek Powiatów Polskich (Association of Polish Districts);
22. Polski Związek Producentów i Przetwórców Izolacji Poliuretanowych PUR i PIR 'SIPUR' (Polish Union of Manufacturers and Processors of Polyurethane PUR and PIR Insulations 'SIPUR');
23. ROCKWOOL POLSKA,
24. 'Renovation Wave for Europe' Initiative;
25. Polska Spółka Gazownictwa sp. z o.o. w Tarnowie,
26. Instytut Nafty i Gazu – Państwowy Instytut Badawczy – INIG-PIB (Oil and Gas Institute – National Research Institute),
27. Krajowe Forum Chłodnictwa Związek Pracodawców (National Refrigeration Forum Employers' Union),
28. Instytut Rozwoju Miast i Regionów (Institute for the Development of Cities and Regions)
29. Stowarzyszenie Certyfikatorów i Audytorów Energetycznych (Association of Energy Certifiers and Auditors),
30. Polska Unia Właścicieli Nieruchomości (Polish Union of Property Owners),
31. Polskie Stowarzyszenie Producentów Dźwigów (Polish Association of Crane Producers),
32. Department of Aid Programmes, Ministry of Development Funds and Regional Policy,
33. individuals.

Detailed list of the stakeholders that submitted their comments in the opinion seeking process:

1. President of the Statistics Poland,
2. Director of Bank Gospodarstwa Krajowego.

The respondents to the public consultation approved the main strategic assumptions adopted in the 'Long-Term Building Renovation Strategy', including those regarding the recommended scenario of energy renovation of buildings presenting the 2030, 2040 and 2050 action plan. The comments focused on the specific ways in which the policy towards improved energy performance of buildings is to be pursued and on the substantive scope of the document.

The main areas addressed included:

(1) the strategic approach to the renovation of buildings in Poland until 2050, inter alia with regard to the energy carriers to be used;

(2) the scope and way of functioning of programmes supporting the energy renovation of buildings, including the 'Clean Air' Programme and the 'Thermomodernisation and Renovation Fund';

(3) the need to address adaptation of buildings to climate change;

(4) addressing the specificities of historic buildings;

(5) need to add specific technology solutions for improved energy performance of buildings;

(6) editorial and substantive comments, detailing and clarifying the content of the strategy;

(7) adding detail to the definitions in the 'Long-Term Building Renovation Strategy'.

IV. Matters raised by the consultation not addressed

Some of the submitted comments went far beyond the scope of the strategy or were too detailed for them to be addressed in a planning document, so most of them were disregarded.

Acting pursuant to § 51(1)(2) and (3) of Cabinet Resolution No 190 of 29 October 2013 on the adoption of the Cabinet Procedure Rules, I also inform that the draft did not require consultation or agreement with the competent authorities and institutions of the European Union, including the European Central Bank, and that no party has voiced interest in work on the draft strategy under the provisions on lobbying activities in the law-making process.