



BEST PRACTICES

for your house

Energy efficient house, how to reduce costs of heating
a house through its thermal modernisation

Investment in Szymon's house

Under the technical supervision of Prof. Jacek Smółka, PhD, Eng

#SilesiaBlueSkyRestored

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ABOUT THE “SILESIA. BLUE SKY RESTORED” PROJECT

Starting from January 1st, 2022, the Silesian Voivodeship has been implementing a LIFE integrated project called “Silesia. Blue Sky Restored” whose main goal is smooth and effective implementation of the air protection programme for the Silesian Voivodeship and the anti-smog act.

The scope of the project covers the whole Silesian Voivodeship and all residents, engages 84 partners, including as many as 74 Silesian municipalities and cities. The total value of the project is € 16 515 020. The activities related to the project have already been recognised twice – the Silesian Voivodeship was awarded the title of the Energy Transformation Leader and won the 2022 WPROST Innovator Award.

The project includes both soft activities and investments, aimed at improving the energy efficiency of public buildings or increasing green areas by developing post-industrial areas.

ENVIRONMENTAL CONSULTANTS IN THE SILESIA. BLUE SKY RESTORED PROJECT

As part of the project, a group of 74 representatives of municipalities was created, the so-called environmental consultants, who work locally within a municipality. In the municipalities that do not have their own environmental consultant, residents are supervised by sub-regional environmental consultants. Their role is to provide consultancy services for residents and initiate and coordinate local activities aimed at improving air quality.

The scope of the environmental consultants' activities is broad and includes:

- assistance in obtaining funding – they help residents receive funding for replacing the heating source and improving the energy efficiency of buildings,
- technical consultancy – they provide professional advice on the replacement of the heating source and improvement of energy efficiency,
- education in society – they educate residents on the improvement of air quality,
- initiating eco-friendly activities - they initiate and coordinate local activities and investments aimed at improving air quality and reduction of greenhouse gas emissions,
- inspections and compliance with regulations – they actively participate in the inspections of furnaces for compliance with the anti-smog resolution and the prohibition of waste disposal by burning,
- supporting local administration – they assist in obtaining external financial support for municipalities within the scope of environmental activities.

The full list of environmental consultants can be found at:
przywracamylekit.slaskie.pl/ekodoradcy

INVESTMENT IN SZYMON'S HOUSE

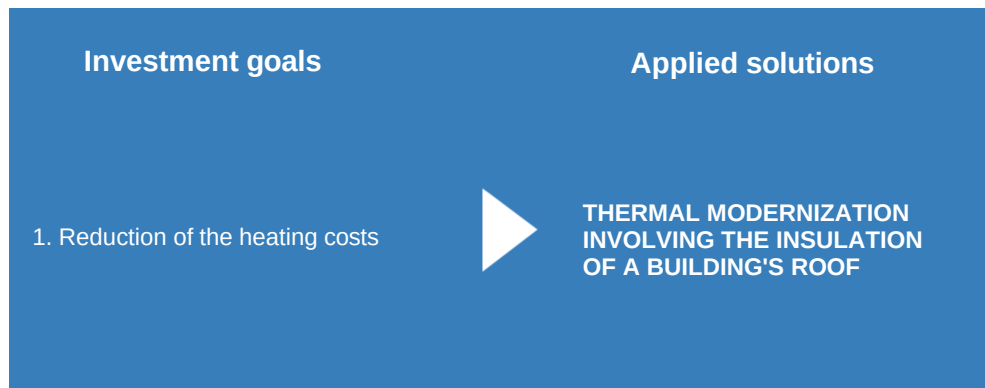
Szymon and his family live in a single-family house in Bielsko-Biała. The house was built in the 70s. Szymon is aware that the technologies that were used in construction over 40 years ago no longer ensure proper insulation in the building. Moreover, with time the materials lost their original properties. As a result, the heating bills in the heating season are high.

In order to reduce the heat loss in the building Szymon analysed a complete thermal modernisation of the roof with the use of modern technologies and materials. Another factor supporting the later decision to complete the investment was the possibility to obtain funding for it. Szymon completed the investment in 2023.



Technical conditions before the investment	
Building type	single-family detached house
Year built	1978
Usable floor area	120 m ²
Estimated annual building heating needs	± 19 200 kWh (160 kWh/m ² x 120 m ²)
Number of floors	3 (including a semi-basement)
Basement	full, unheated basement
Exterior walls construction technology	double layer of slag blocks with air chambers (40 cm thick, in total), insulated with mineral wool, siding covered
Roof construction	pent roof
Roofing material	slag covered with tar paper
Window technology	PVC double-chamber windows
Heating source prior to the investment	a gas boiler (natural gas)
Room heating type	radiators
Water heating method prior to the investment	a gas boiler heating a boiler of 0.16 m ³ (160 litres)
Number of residents	5 adults and 1 child
Average annual hot utility water consumption	about 90 m ³
Average air temperature in the building during winter	21° C

The heating needs are one of the key factors affecting the building heating costs. It specifies the amount of heat needed to maintain proper temperature in the building. The needs include many variables, such as: the building volume to be heated, thermal insulation (exterior walls and roof construction technology, including the type- of the insulation material used), window and door area and their technology, condition of the heating equipment, air temperature, building ventilation type. In the case of older buildings with insulated walls, such as Szymon's house, building's heating needs are estimated at 160 kWh/m².



Szymon achieved the planned investment goal by completing a thermal modernisation involving roof insulation.

Learn more about the benefits of using a similar solution in your house.

APPLIED SOLUTIONS

Thermal modernisation of a building

What affects the energy efficiency of a building

1 The construction and shape of a house

Houses with basic and simple shapes have the best heating properties because a lot of heat is lost in corners and at the bends of dividing structures. The roof is another element of a building that may cause big heat loss. The highest level of energy efficiency can be achieved with a roof with the simplest shape possible i.e. a pent or gable roof.

2 Building materials

Building materials (e.g. brick, concrete) used in the exterior dividing structures of a building have low isolation parameters, therefore the use of layered walls comprised of construction and insulating layers is a better solution, ensuring improved reduction of heat loss.

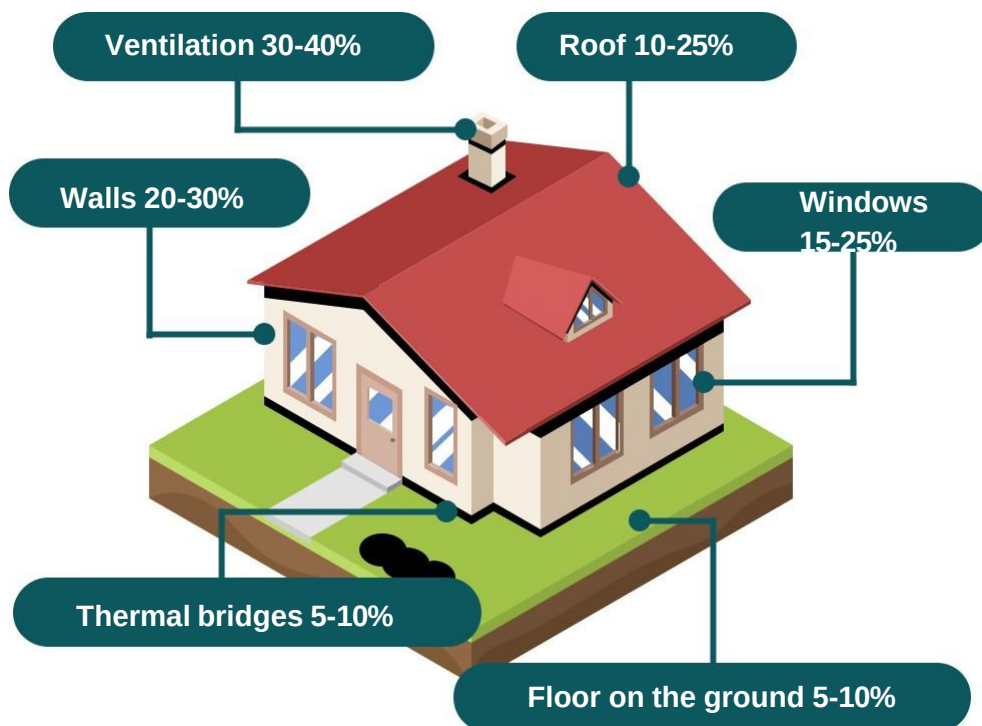
3 Insulation materials

The insulating layer in the dividing structure reduces the effect of the environment on the heat loss inside the building. It is important to remember that the insulation material has two functions – thermal and acoustic insulation. It is possible to use many types of insulation materials with different properties preventing the heat loss in a building and at the same time affecting the building's comfort of use.

4 Thermal conductivity index (lambda)

It is a parameter determining the thermal conductivity of a material. It is usually marked with the Greek symbol lambda (λ), and its value is stated in W/(m*K) (watts per meter-kelvin), showing how much heat flows in one second through 1 m² of a homogeneous material which is 1 m thick, with a temperature difference of 1 kelvin. The higher the value of this index, the more a given material is useful for insulation.

A building loses heat in many ways, which is shown in the infographic below.



- Ventilation – in the process of removing contaminated air from a room (e.g. steam, carbon dioxide) fresh air is supplied from outside, which must be reheated.
- Roof – usually the roof has the largest exterior dividing structure in terms of surface. According to the laws of physics, heated air which is lighter than cool air moves up, while heat gets outside through the roof.
- Walls – they constitute big exterior surface of a building. Walls in older houses usually are not well-insulated due to the lack of such requirements in construction regulations at that time.

Windows – because of the window construction the values of heat resistance are the lowest compared to other dividing structures. Especially in the case of old windows heat loss may be big. The heat may escape through the leaks resulting from improperly adjusted window frames, through old sealing or gaps in places where they connect with plaster. Despite their small role in the whole exterior surface of a house, heat loss through windows is significant.

- Thermal bridges – places in exterior dividing structures through which the heat escapes from the house. They form in places made from low-quality material, where adjacent surfaces connect and in all leaks.
- Floor on the ground – contact with humid and cool ground causes more loss, although not as much as in the case of the roof.

➤ In order to assess the building's needs for energy and specify the scope of works necessary to reduce those needs, an energy audit is carried out. Such an analysis uses data on the building construction (roof, walls, windows, foundations), building location, ventilation and the system used to heat the building and hot utility water.

➤ Energy standards for houses are set by the heat transfer coefficient (U) for individual dividing structures in the building. According to the currently applicable norms (specified in the Ordinance of the Minister of on the technical conditions that must be met by buildings and their location), the coefficient cannot be lower than: 0.15 $W/(m^2K)$ for roofs and flat roofs, 0.20 $W/(m^2K)$ for exterior walls, 0.30 $W/(m^2K)$ for floors on the ground, 0.90 $W/(m^2K)$ for vertical windows, 1.10 $W/(m^2K)$ for roof windows and 1.30 $W/(m^2K)$ for exterior doors.

The value of this coefficient includes the insulating properties of walls measured using the mentioned thermal conductivity index and wall thickness and thermal diffusivity index which specify the conditions for the exchange of heat between a wall and the heated air inside and between a wall and the air surround the building.

In practice the value of the thermal conductivity index has the biggest impact on the insulating properties of a dividing structure and the index should be as low as possible, and the dividing structure should be as thick as possible.

Low thermal conductivity index means that a building releases the heat slower during winter and absorbs it slower during summer. As a result, the costs of heating and air conditioning are lower. These values must be taken into consideration when planning thermal modernisation, if we are going to apply for funding from outside sources.

➤The best way to reveal the sources of heat loss in a building is thermographic inspection. Based on a photo taken with a special camera we can check if the dividing structures provide good insulation from outside and detect thermal bridges. Such inspection is recommended also after completing thermal modernisation. We can then assess if the contractor properly completed the modernisation works, i.e. if the insulation layer was applied correctly, there are no gaps or thermal bridges.



The scope of thermal modernisation of a building

The scope of thermal modernisation of a building may differ.

Thermal modernisation level	Activities aimed at achieving the desired level of thermal modernisation
Basic thermal modernisation	modernisation or replacement of the heating system, including replacement or modernisation of the heat source
Moderate thermal modernisation	- modernisation or replacement of the heating system, including replacement or modernisation of the heat source - replacement of window and door frame woodwork - insulation of exterior walls - roof insulation
Comprehensive thermal modernisation	- modernisation or replacement of the heating system, including - replacement or modernisation of the heat source use of renewable energy sources - modernisation or replacement of the hot utility water system - replacement of window and door frame woodwork - insulation of all exterior dividing structures (facades, flat roofs, ceiling/floor) - removal of thermal bridges (heat loss locations) - modernisation of the ventilation system

The path to comprehensive thermal insulation leads through completion of three groups of activities, presented in the infographic below.

GROUP I

the heat source exchange

renewable energy sources for heat: solar panels, heat pumps, biomas

GROUP II

mechanic ventilation with heat recuperation

insulation of uncovered central heating and hot utility water pipes

installation of valves
thermostatic valves

GROUP III

windows and door frame
woodwork

thermal insulation of exterior walls

thermal insulation of roof or flat roof

ceiling above unheated basement, floor on the ground

GROUP I

GROUP II

GROUP III

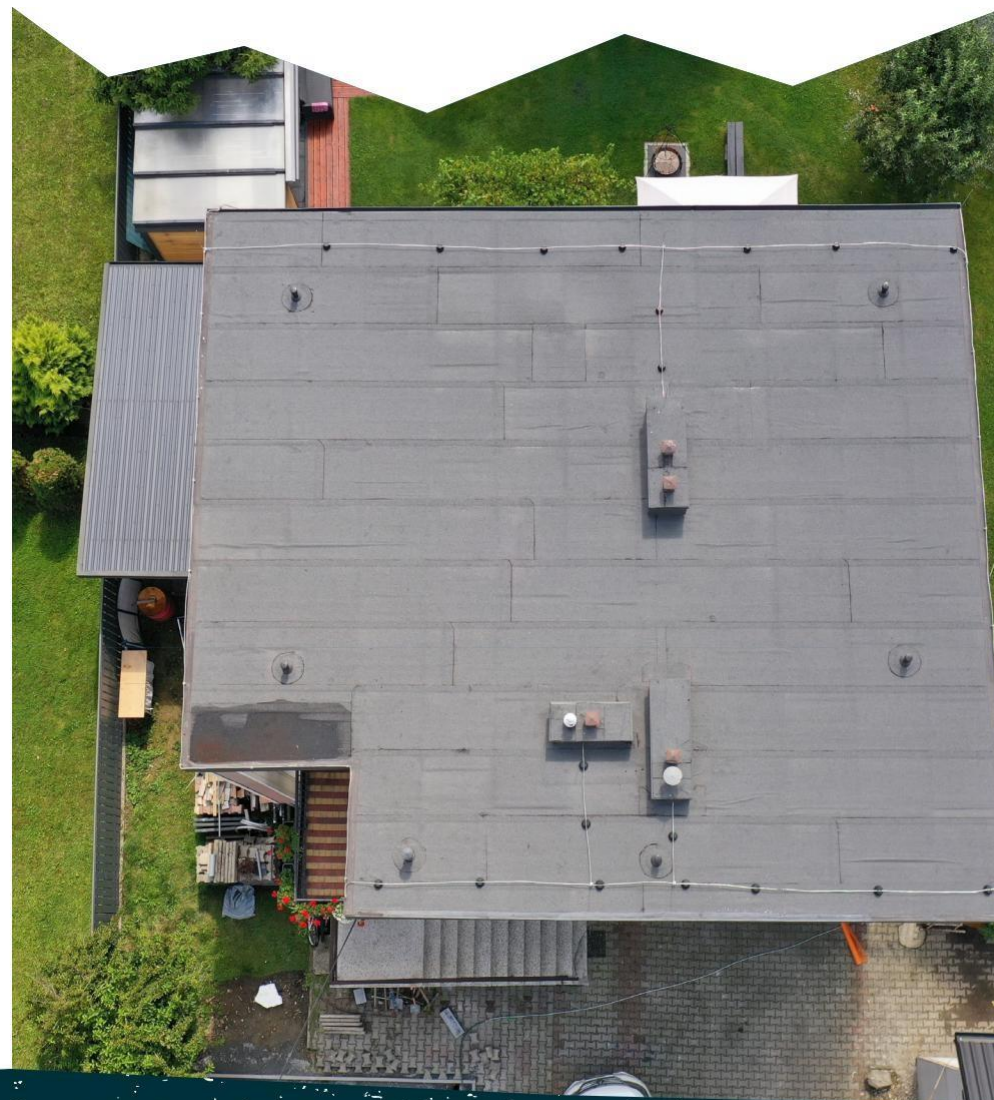
Benefits of thermal modernisation of a building

The benefits of thermal modernisation include:

- ➔ Reduced consumption of the energy needed to heat a building and prepare hot utility water, and the costs related to the use of the building in a way ensuring a healthy microclimate in a house;
- ➔ Reduced negative impact of a building on the environment thanks to decreased heating needs in the heating season and reduced consumption of the energy used to prepare hot utility water, and fewer fossil fuels burnt and limited emissions of pollutants (e.g. ash) and greenhouse gases to the air.
- ➔ Improved quality of internal environment and residents' living comfort, including temperature and humidity of the air inside, the speed of airflow between rooms, noise and air pollution;

➔ Increased value of the property thanks to improved aesthetics and functionality of the building;

➔ Longer lifespan of the building related to additional works which are often undertaken, e.g. strengthening of the elements of the roof construction during its insulation or replacement of the roofing material.



Thermal modernisation of the roof

Review of the currently used roof insulation materials

The primary role of the materials used for thermal insulation is proper heat loss prevention. While selecting specific material one should also consider the price, durability and comfort of use. Apart from the used materials that have been commonly used in recent years – mineral wool and styrofoam – new insulation materials made from new raw materials are now available, e.g.

XPS boards made from extruded polystyrene, polyurethane boards (PIR/PUR) and polyurethane foam (PIR/PUR).

While selecting specific insulation material one should also consider its characteristics, including thermal conductivity index (the lower, the better insulating properties of a material), fire resistance, vapour permeability, acoustic insulation, physicochemical properties and the ease of workability.



The table below summarises basic types of insulation materials that are currently used.

Type of insulation material	Thermal conductivity coefficient	Characteristics
Mineral wool	0.030 – 0.042	+ fire resistance + vapour permeability + good sound absorption (which will work in the case of roof sheets or in a loud environment) + elasticity - necessary to prevent humidity which requires the use of a special vapour barrier film
EPS boards (styrofoam)	0.031 – 0.045	+ low weight + low water absorption + relatively low price (compared to other insulation materials) + ease of workability - poor fire resistance - sensitivity to mechanical damage - low vapour permeability - low level of acoustic



Type of insulation material	Thermal conductivity coefficient	Characteristics
XPS boards (made from extruded polystyrene)	0.029 – 0.034	+ resistance to surface mechanical damage + low water absorption - difficult workability - low resistance to point mechanical damage - losing properties when combined with solvents - low level of acoustic insulation
PUR boards (polyurethane) / PIR (polyisocyanurate)	0.026 – 0.029	+ fire resistance + low water absorption + high stiffness + resistance to adverse weather conditions - relatively high price (compared to other insulation materials) - low level of acoustic insulation
PUR foam (polyurethane) / PIR (polyisocyanurate)	0.019 – 0.024	+ necessary to hire a specialised companies, related to the production of the material on-site, using a special generator + easy to access hard-to-reach areas + time needed to complete insulation + high resistance to damage thanks to high hardness - lack of resistance to UV radiation

Technical solutions used in Szymon's house

Roof insulation

To ensure proper roof insulation Szymon decided to modernise the roof using the existing roof cover. Styrofoam and roofing felt boards were used as the basic insulation material (styrofoam laminated with roofing felt on glass veil) with the thickness of 15 cm. Once the roof was properly primed with the priming layer, felt underlayment was applied. The felt underlayment was covered with styrofoam and roofing felt boards which were attached to the roof mechanically, using pins. The roof coverage was completed with torch-on roofing felt. Apart from the thermal modernisation, Szymon decided to replace the roof gutters and outlet pipes to ensure effective removal of precipitation water from the roof.



EXPERT'S VIEW: ON GREEN HOME TECHNOLOGIES

"The consumption of energy needed to heat a building depends on its condition and heating and ventilation systems used. However, regardless of whether a building is new or have been used for some time, the most important thing is proper insulation of walls, roof, windows and floors, as well as reduction of loss related to room ventilation. Once the heat loss is reduced following thermal modernisation, one can focus on the selection of the proper type and power of the heat source and installation of central heating which ensures a convenient and financially viable indoor temperature of 20-21°C in the heating season. The whole process should be managed a person who is trained in this field, e.g. an environmental consultant, due to the high investment costs and the complexity of technical issues.

The materials available for wall insulation ensure a significant reduction of the heat loss because their conductivity indexes are slightly different. Therefore the selection of a given material, with properly selected thickness of the insulation layer, may depend on the technical parameters, such as the acoustic insulation, vapour permeability and the total cost of thermal modernisation using a given insulation material".

Prof. Jacek Smolka, Ph.D. (Eng)

Silesian University of Technology
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Department of Thermal Technology

THE COST OF THE INVESTMENT, SAVINGS AND FUNDING

Investment costs

Below is a summary of the total costs of the investment completed by Szymon in 2023.

Cost type	Costs in PLN
Purchase and installation of roof insulation materials including modernisation of the gutter system	30,000

How much money did Szymon save on bills thanks to the investment?

The thermal modernisation helped reduce the costs related to gas heating. In 2022 (before the thermal modernisation) gas consumption was 2,467 m³ (resulting in the cost of PLN 3,400). Next year, in 2023 (following the thermal modernisation in August 2023), gas consumption reached 1,828 m³ and its cost was PLN 2,500. The comparison of gas consumption in the next two years shows reduction of its consumption by one-fourth. It is worth mentioning that the presented results of the thermal modernisation refer to the incomplete second half of 2023 and will surely be higher in the next, full reference year. Another factor that could affect the gas consumption in the compared months, is weather (mainly temperature in the winter months when gas consumption is the highest).

Cost type	2022	2023
The cost of gas used to heat the building and utility water	PLN 3,400	PLN 2,500

Other benefits that Szymon has gained from the thermal modernisation of the roof. The first one is independence from the recently unstable gas prices (thanks to the lower consumption). By replacing the gutter system, Szymon will avoid the costs related to the removal of damage caused by precipitation water for years to come. Wrong water drainage may cause the walls to absorb water, freeze or mould, which have a negative impact on health.

Funding for thermal modernisation

In 2023, Szymon benefited from the Clean Air program which provided funding for installation of eco-friendly solutions for houses. The funding for purchase and installation of roof insulation materials was PLN 5,000. During a meeting with an environmental specialist we recommending checking currently available programs.

Funding source	Amount of funding for purchase and installation of roof insulation materials
Clean Air Program	PLN 5,000

Although the actual investment cost was PLN 30,000, part of the costs incurred were refunded to Szymon in the form of funding. Therefore the actual cost of the roof thermal modernisation incurred by Szymon was reduced to PLN 25,000 (PLN 30,000 – PLN 5,000).



THE PROS AND CONS OF THE INVESTMENT



Financial aspect

Benefit	Description
Energy saving	Well-insulated roof keeps heat inside the house, saving significant amounts of energy.
Increased value of the property	A well-insulated building has a higher value in the real estate market.



Environmental aspect

Benefit	Description
Environmental protection	While saving energy needed to heat and cool the building we can reduce emissions of harmful substances, e.g. ash. and greenhouse gases in the air, which helps protect the environment.



Health aspect

Benefit	Description
Noise reduction	Insulation materials effectively reduce noise, increasing the acoustic comfort in the building.



Use aspect

Benefit	Description
Higher thermal comfort	Roof insulation helps maintain fixed temperature in the house, regardless of the season. In winter, it prevents heat from getting outside, and in summer it prevents rooms from overheating.
Building protection	Roof insulation helps protect the of the building structure from damage resulting from humidity or extreme temperatures.



STEPS REQUIRED TO COMPLETE A SIMILAR INVESTMENT

Step	Description	
1	First contact with an environmental consultant on the "Silesia. Blue Sky Restored" project who: - assess the building's needs for heat energy, - presents possible technological solutions including the investment goals - specifies estimated costs related to the investment while using different technological solutions - specifies available funding resources.	☐
2	Independent review of the advantages and disadvantages of individual technological solutions in relation to the cost of the investment and selection of the technological solution.	☐
3	Second contact with the environmental consultant who adjusts the parameters of use of the selected technological solution of the needs of the household.	☐
4	Market research on the companies offering the selected technological solutions, including initial verification (among family members, friends, etc.) and their reliability.	☐
5	Collecting quotations from the companies for installation, an analysis of the agreement and warranty and conditions.	☐
6	Selection of the best proposal.	☐

Step	Description	
7	Contacting the company that presented the best proposal and informing it about the decision.	☐
8	Following positive results of the verification of the reliability of the selected company, signing an agreement with the company on completion of the investment.	☐
9	Third contact with the environmental consultant who helps prepare proper documents that must be submitted to the entity providing funding (before the investment is completed, during or after its completion).	☐
10	After the investment is completed, thorough review of the conditions of use and maintenance of the installation, explanation of possible doubts in this matter.	☐
11	Submission of documents enabling funding for the completed investment to the entity providing the funding.	☐
12	Within 14 days of launching the installation, application submitted to the Central Emission Register of Buildings (https://ceeb.gov.pl/).	☐
13	If the costs related to the thermal modernisation were not funded from a different source, deduction from personal income tax (PIT), in the calendar year following completion of the investment, of the costs incurred in relation to the investment as part of the tax relief for thermal modernisation.	☐



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Learn more about how we restore blue sky in the Silesian Voivodeship at



Województwo
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#SilesiaBlueSkyRestored

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