



SILESIA. BLUE SKY RESTORED



EDUCATIONAL GUIDE

on air pollution control

for teachers of grades 4 – 8

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INTRODUCTION



Dear All,

I am delighted to provide you with this educational guide that has been created to support teachers in educating the youth on air pollution control. The issue of air pollution that we face globally and locally requires robust action. Education plays a key role in this situation as it makes it possible to shape conscious eco-friendly attitudes among the younger generation.

The Silesian Province, as one of the most industrialized and densely populated areas in Poland, faces specific challenges with regard to air quality. The project

“Silesia. Blue Sky Restored” – the biggest initiative of this kind in Europe – is an expression of our commitment to improving the environment. But to achieve our goals, it is necessary to work with teachers who have direct impact on shaping the responsible attitudes of citizens in their job.

Your role in ecological education is invaluable. This guide has been designed as a practical tool which will assist you in teaching students about air pollution control, with an emphasis on issues related to low emissions and smog. It also contains basic information on climate challenges. The included materials aim to broaden knowledge and inspire to take action to improve air quality, and thus protect the climate.

Ecological education is a process that requires not only providing information, but most importantly building a sense of responsibility for the environment in students. Your commitment in this area will contribute to the shaping of attitudes that will have a long-term impact on our society and environment. I believe that thanks to your efforts, young people will understand how important it is to preserve the air quality and how significant the everyday actions they can take are.

I encourage you to make full use of the potential of this guide in your teaching work. I am sure that it will be a valuable support in your job, contributing to the increased ecological awareness among students. Together, we can improve air quality, which will benefit both us and future generations.

I wish you every success in your educational quest. Kind regards,

Wojciech Saługa
Silesian Province Marshal

Katowice, October 2024

1. CLIMATE CHANGE AND CLIMATE GOALS

Climate goals comprise measures to slow down climate change and limit human impact on the environment. Achieving climate neutrality by 2050, which means balancing greenhouse gas emissions with their absorption, is the key element of these measures. It requires cutting down emissions, implementing technologies, and carbon dioxide absorption practices.

Apart from preventive actions, it is necessary to adapt to climate change already taking place. This includes modernisation of infrastructure, development of agriculture that is resistant to droughts, and preparing healthcare systems for the effects of extreme weather events. Another important element is the protection and restoration of ecosystems such as forests, which not only absorb CO₂ but also support biodiversity.

Energy transition remains a priority, assuming a shift from fossil fuels to renewable energy sources such as solar and wind power. Financial support for climate action, especially in the developing countries that experience climate change effects the most severely, is crucial to achieve these goals.

Promoting sustainable development and innovation, such as circular economy, contributes to minimisation of waste and more effective use of resources. Climate education and increasing awareness are key to make the society understand causes and consequences of climate change, and engage in actions to protect the environment.

Manifestations of climate change

The climate is changing, which is evidenced by, for example, heat records set in 2023 on all continents and the highest average temperatures ever recorded. In 2011-2020, more than half of European regions experienced extreme droughts. At the same time, climate change has increased the intensity and frequency of floods in Europe (in 1991-2017, they affected lives of 8,7 million people). Extreme weather phenomena are one of many environmental consequences. Other, such as melting of glaciers, make the sea levels rise.

Did you know that...

cars account for approximately 20% of global carbon dioxide emissions, and traffic jams in cities further increase air pollution?



Effects of climate change

Authors of the cyclical “The Lancet Countdown” report, endorsed by the renowned British medical journal “The Lancet”, **point out numerous climate change consequences**, such as **health effects, changes in the working environment, intensification of infectious diseases, disruption of food security, population migration**. The Intergovernmental Panel on Climate Change (IPCC) lists three types

of consequences and effects caused by climate change:

- **direct effects** that refer to changes in the frequency of extreme weather phenomena, including heat waves, droughts, torrential rain,
- **indirect effects related to the environment**, which include air pollution (air pollution shapes the pace, extent and regional distribution of climate change impacts),
- **indirect effects related to the functioning of humans as social beings**, such as social conflict, compulsory migration, undernourishment and stress.

This brochure focuses on the issues of air pollution, which co-exists with climate change processes.

Causes of climate change

The main causes of climate change and the closely related air pollution are:

- **industrial activity**, including the burning of coal, oil, and gas,
- **the municipal and residential sector** (including housing construction, service facilities, local boiler rooms, etc.),
- **emissions of fluorinated greenhouse gases** (so-called F-gases) resulting from the use of refrigeration and air conditioning equipment,
- **increased mobility of people** associated with the use of means of transport (mainly cars and planes),
- **agricultural activities** involving intensive livestock farming (especially cows and sheep, which produce large amounts of methane during digestion) and the use of nitrogen fertilisers,
- **deforestation** that weakens the trees' climate regulating effect related to the absorption of CO₂ from the atmosphere, as well as releases carbon stored in them,
- **consumerist lifestyle**, manifested in **fast fashion** (for example, one of the giants of the clothing industry releases an average of 24 new collections per year, whereas previously there were only two collections per year: spring-summer and autumn-winter); clothing produced in excess in the fast fashion industry is often incinerated, contributing to greenhouse gas emissions.

Did you know that...

plants produce oxygen during photosynthesis and simultaneously remove pollutants from the air, including dust and carbon dioxide?



Climate change and air pollution

Issues related to air pollution and climate change are often mixed up in the debate on environmental quality. This is mainly because **they have common sources**, which are tall chimney stack of power plants and industrial plants, chimneys of houses, and exhaust pipes of vehicles powered by internal combustion engines.

But we are talking about **different substances**. Climate change is mainly caused by greenhouse gases such as carbon dioxide (CO₂) and methane (CH₄). While air pollution is mainly caused by the excessive particulate matter concentration (PM10 and PM2.5) and other harmful substances (benzo(a)pyrene, nitrogen dioxide (NO₂), sulphur dioxide (SO₂), ozone (O₃), and carbon monoxide (CO)).

The **direct consequences** of excessive concentrations of these substances in the air are also

different. For example, carbon dioxide in the current concentration does not affect human lives immediately. The negative effects of persistently high CO₂ levels are felt over a longer period of time and lead to adverse climate changes such as heat waves, droughts and vegetation fires, lowering river and groundwater levels, which inhibits tree and crop growth, floods, rising sea levels, and shifting climate zones, which affects the distribution and abundance of many plant and animal species.

The situation is different with regard to particulate matter contained in polluted air. Negative effects of the excessive concentration become visible more quickly, leading to the deterioration of health of people living in areas with the increased air pollution level.

Measures to reduce greenhouse gas emissions usually lead to a reduction in emissions of substances harmful to health. The relationship is bidirectional: improving air quality often goes hand in hand with reducing greenhouse gas emissions, which can ultimately slow down climate change.

Climate neutrality goals

Climate change is a global issue and therefore requires cooperation between all countries. At the global level, decisions aimed at reducing greenhouse gas emissions and protecting the climate are made during the annual COP (Conference of Parties) Climate Summits, organised as part of the United Nations Framework Convention on Climate Change – UNFCCC. During the COP, progress in implementing previously agreed targets is also reviewed. **In December 2018, Katowice hosted the UN Climate Summit – COP24.** Over 21,500 people representing nearly 200 countries participated in the summit, which lasted nearly two weeks. As a result, the **Katowice rule book was developed**, setting out a path for achieving global temperature reduction targets.

An important commitment to climate goals and accelerating efforts to achieve them was made at the COP21 Climate Summit in Paris in 2015. At that time, world leaders adopted the **Paris Agreement**, which obliged all 195 signatory countries to present long-term scenarios for reducing greenhouse gas emissions by 2050. The long-term goal is to limit the increase in global average temperature to no more than 1.5°C above pre-industrial levels (before 1750).

Did you know that...

cycling instead of driving can reduce greenhouse gas emissions in cities by up to 20%?



The Paris Agreement came into force on 4 November 2016 when its ratification conditions was met by at least 55 countries responsible for at least 55% of global greenhouse emissions. **The agreement has been ratified by all EU Member States.**

The European Union has set out its path to climate neutrality, i.e. achieving a balance between greenhouse gas emissions and their absorption or storage, in a document entitled the **European Green Deal**. The document published in December 2019 sets out the priority areas whose implementation will lead to transforming the EU economy into a low-carbon, environmentally friendly, and healthcare-oriented economy.

The eight policy areas of the European Green Deal include climate protection, eliminating air, water and soil pollution, an energy-efficient construction sector, clean, affordable and secure energy, and sustainable agriculture and food systems.

The European Green Deal aims to reduce greenhouse gases, thereby reducing the impact of transport emissions on both climate change and air pollution.

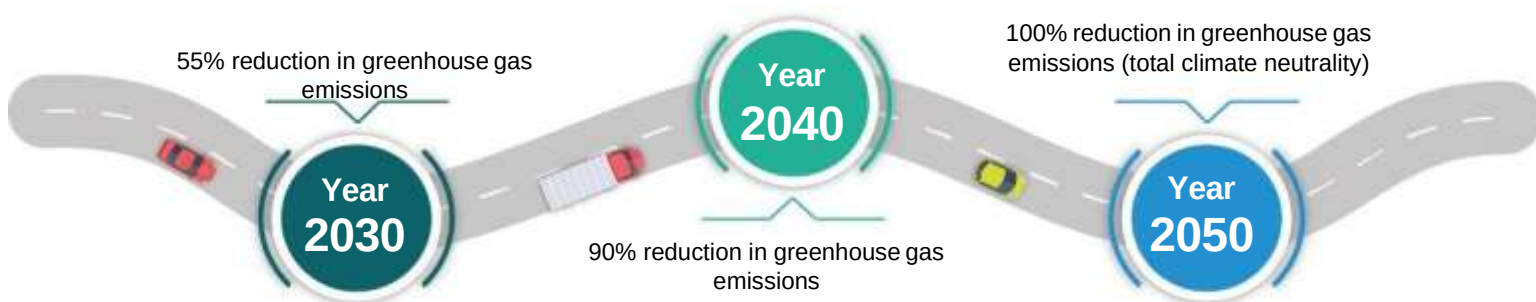
One of the principal initiatives of the European Green Deal is the **Fit for 55** package covering **proposals of changes in legislation in terms of climate, energy, and transport to reduce the EU's greenhouse gas emissions by 55% until 2030**, compared to 1990, so that it is possible to achieve climate neutrality by 2050. In February 2024, European Commission recommended setting an additional, indirect goal on the way to achieving climate neutrality – reducing the EU's greenhouse gas emissions by 90% until 2040.

In the Silesian Province, climate protection measures are being implemented in many areas, one of which is air protection. Measures in this regard have been recorded in the *Low-carbon economy policy for the Silesian Province* document (Resolution of the Silesian Province Management Board no. 668/108/V/2016 of 19.04.2016). Measures were already in place before.

- The Air Protection Programme in the Silesian Province, covering the Silesian agglomeration, the Częstochowa agglomeration and the Bielsko-Biała city zone, was introduced by Regulation No. 15/04 of the Silesian Province Voivode of 24 March 2004.

The document currently in force for the entire Silesian Province is the *Air Protection Programme for the Silesian Province*, adopted by the Silesian Provincial Government by Resolution No. VI/62/8/2023 of 20 November 2023, which identified corrective measures to improve air quality by reducing PM10 and PM2.5 particulate matter and benzo(a)pyrene, limiting the adverse impact of air pollution on the health and lives of the inhabitants of the Silesian Province.

Roadmap to climate neutrality



SOURCES

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Lesson ideas

"Facts association"

1. Match the cause of climate change with its description.

Causes of climate change:	Description
a) industrial activity	1. increases the production of mainly methane and nitrogen oxides
b) fluorinated greenhouse gases	2. used in cooling and air-conditioning equipment
c) increased mobility of people	3. related to burning fossil fuels
d) agriculture	4. related to providing consumers with fashionable, trend-inspired clothes, quickly and at low prices
e) deforestation	5. weakens the process of absorbing carbon dioxide from the atmosphere
f) fast fashion	6. one of the main sources of carbon dioxide and methane emissions

Key: a-3, b-2, c-6, d-1, e-5, f-4

2. Assess whether the following statements are true or false:

1. Air pollution and climate change have common sources. (T)
2. For example, carbon dioxide in the current concentration affects human lives immediately. (F)
3. Taking measures to improve air quality often involves reducing greenhouse gas emissions. (T)
4. The long-term goal of the Paris Agreement is to limit the increase in global average temperature to no more than 1.5°C above pre-industrial levels. (T)

2. AIR QUALITY ASSESSMENT

In the course of 24 hours, we take approximately 23,000 breaths, usually completely unconsciously. The air we breathe into our lungs consists of 78% *nitrogen* and 21% *oxygen*. However, **air quality is determined by the remaining 1%, which may contain various chemical compounds, gases, and particulate matter, such as argon, water, carbon dioxide, ozone, methane, helium, hydrogen, and many others.** Air quality is affected by the concentration of particulate matter as they are the biggest threat to human health.

Factors affecting air quality

The following factors have a significant impact on air quality:

- **emission from households** – many households use fuels of low quality or ineffective heating systems,
- **increased transport** – emission of exhaust fumes and continuous lifting and stirring up of dust from worn tyres and brake pads,
- **proximity to industrial plants,**
- **shrinking green areas,** which serve to filter pollutants,
- **geographical location** – low-lying terrain (e.g. location in a basin or river valley) hinders air circulation and causes pollutants to accumulate,
- **weather** – low rainfall and windless conditions cause pollutants to accumulate,
- **dense development** – the development of ventilation and air regeneration corridors hinders the circulation and exchange of air masses.

Components of polluted air

According to the World Health Organization (WHO), **polluted air is air whose chemical composition may adversely affect human health, plants and animals, and cause changes in the environment, particularly in the condition of water or soil.**

The most basic classification distinguishes between **physical, biological and chemical pollutants.** **Physical pollutants** include:

- **chemically neutral dusts** (e.g. asbestos, which can damage the lung epithelium),
- **ionising and non-ionising electromagnetic waves** (e.g. cosmic radiation, radio waves),
- **sound waves** (noise), light.

Biological pollutants include microorganisms (e.g. bacteria), metabolic products (allergens) and other biological dusts (e.g. pollen, spores).

Chemical pollutants are the most important. Chemical pollutants are one of the main causes of climate change, decreasing biodiversity, and health problems. Chemical substances that pollute the air may be liquid, solid, or gaseous. There are 167 such substances in Poland. However, most of them occur locally and are linked to a specific emission source, such as an industrial plant. The most dangerous ones – also because they are emitted most often – are **sulphur dioxide, nitrogen dioxide, and nitrogen oxides, ozone, polycyclic aromatic hydrocarbons (PAHs) – above all benzo(a)pyrene, particulate matters (PM10 and PM2.5), and heavy metals.**

Sulphur dioxide (SO₂) is a highly toxic gas with a pungent and suffocating odour. When it combines with water drops in the atmosphere and falls to the ground in the form of acid rain, it causes soil acidification and a decrease in its fertility, inhibits plant growth and contributes to their death. It is emitted to the atmosphere mainly by the industry and coal-burning furnaces in houses. The SO₂ concentration in the air depends on meteorological conditions, which, on one hand, can further natural ventilation of the atmosphere, and on the other, transmit pollution.

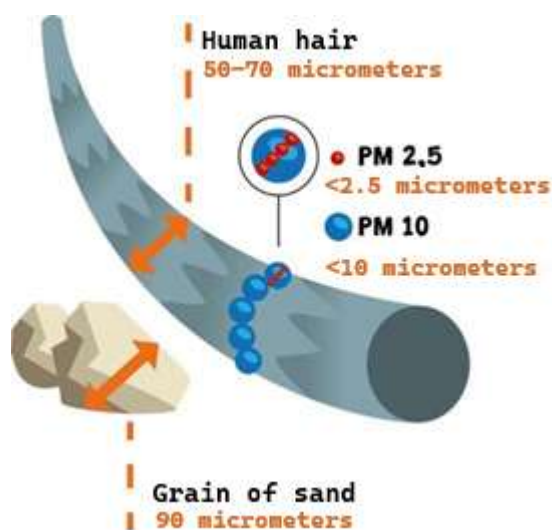
Nitrogen oxides cause carcinogenic and mutagenic compounds to form in the soil. A significant source of their formation is road transport using internal combustion engines (primarily diesel engines). In certain weather conditions, they create the **photochemical smog** (so-called summer smog) phenomenon in combination with gaseous hydrocarbons. After oxidation in the presence of steam, they form acid rain.

Ozone in the stratosphere creates a shield protecting the Earth's biosphere, but it is undesirable in the troposphere. It occurs in the troposphere as a result of photochemical reactions occurring in the air polluted with nitrogen oxides, hydrocarbons, and carbon monoxide, with the primary source being road traffic.

Benzo(a)pyrene is a **highly toxic** chemical compound. It is produced during the incineration of coal, wood and waste (especially PET plastics) in unsuitable conditions. It is released into the atmosphere from car exhaust fumes and as a result of industrial processes.

PM2.5 and PM10 particulate matter are mixtures of solid and liquid particles that carry trace elements which determine their toxicity (arsenic, nickel, cadmium, lead). **The diameter of PM2.5 dust particles does not exceed 2.5 micrometres** (for comparison, a human hair has a diameter of 50-70 micrometres, while a grain of sand is 90 micrometres), **which makes them very easy to penetrate the bloodstream.**

That is why PM2.5 particles are considered the most harmful fraction for health. **Heavy metals** are a group of metals and semi-metals that are particularly dangerous and toxic for the environment, life and health of humans and other living organisms. **Their toxic effect is related to their ability to accumulate in organisms and the environment.** These metals can enter the body through the digestive tract, skin or respiratory tract.



In particular, they accumulate in the organs responsible for detoxification or elimination of metals, i.e. the liver and kidneys. Their accumulation in bones, the brain and muscles is also frequently observed.

Air quality standards

In October 2024, the Council of the European Union adopted the Ambient Air Quality Directive (AAQD), which introduced more restrictive limits for key air pollutants. Under this directive, the Member States should implement the new provisions into their legal systems in no more than two years.

The WHO guidelines from 2005 were updated in September 2021 after many years of intensive research and discussions with experts from around the world in order to more effectively counteract the negative impact of air pollution on public health.

The guidelines recommend achieving average annual concentrations of **PM_{2.5} not exceeding 5 µg/m³**, **average annual NO₂ concentrations not exceeding 10 µg/m³** and **average 8-hour O₃ concentrations (during the 6-month period of highest ozone concentrations) not exceeding 60 µg/m³**. The applicable **WHO guidelines (as at 25.03.2024) are much more restrictive than the values applicable in Poland, setting permissible levels of air pollution several times lower.**

Did you know that...

some cities are testing "living walls" covered with algae, which absorb CO₂ and produce oxygen more efficiently than trees.



In **Poland**, the basic obligations, rules, and criteria to assess air quality can be found in the following acts:

- **Act of 27 April 2001 – Environmental Protection Law** (consolidated text: Journal of Laws [Dz.U.] of 2024, item 54),
- **Regulation of the Minister of the Environment of 26 January 2010 on reference values for some substances in the air** (Journal of Laws of 2010, no. 16, item 87),
- **Regulation of the Minister of the Environment of 24 August 2012 on the levels of some substances in the air** (consolidated text: Journal of Laws of 2021, item 845),
- **Regulation of the Minister of Climate and the Environment of 3 October 2022 amending the Regulation on assessing the levels of substances in the air** (Journal of Laws of 2022, item 2131).

The most important pollutants have determined standards for their concentration in the air, which should not be exceeded. **For sulphur dioxide, nitrogen dioxide, carbon monoxide, benzene, PM₁₀ and PM_{2.5} particulate matter, and lead in the PM₁₀ dust, permissible levels are determined.**

The **permissible level** is the level of a substance that is to be achieved within a specified period and which should not be exceeded after that period. The permissible level is an air quality standard.

The **target level** is determined for ozone, PM2.5 particulate matter, heavy metals (arsenic, nickel, cadmium, mercury, lead, chromium, copper, zinc) and benzo(a)pyrene. This is the level of substance to be achieved within a specified period of time through economically viable technical and technological measures. This level is set in order to avoid, prevent or limit the harmful effects of a given substance on human health or the environment as a whole. **Long-term target** levels are also specified for **ozone**.

The **long-term target level** is the level of a substance below which, according to current knowledge, a direct harmful effect on human health or the environment is unlikely. This level is to be achieved in the long term, except where action would entail excessive costs associated with the use of a specific ozone reduction technology.

Air quality index

Air quality monitoring in Poland is carried out as part of the **National Environmental Monitoring Programme**. The air quality index is an indicator that makes it possible to assess the air quality at a given moment.

The **Polish Air Quality Index** is published on the **Chief Inspectorate for Environmental Protection's** website based on calculations coming from automatic measurement stations functioning as part of the National Environmental Monitoring. It is calculated based on 1-hour results of measurements of concentrations of: sulphur dioxide (SO₂), nitrogen dioxide (NO₂), PM10, PM2.5, and ozone (O₃). There are 6 ranges for each pollutant which make it possible to assess the possible impact of the current conditions on health, and to observe appropriate health-related recommendations. Using the index may be particularly useful for people from high-risk groups, for whom air pollution poses a significant health risk, including the elderly, the chronically ill, pregnant women and young children.

The air quality index allows to make a decision as to the necessity of using remedial measures, for example, abandoning going for a walk until the air quality improves.

Table 1. Air quality index

Air quality index	PM10 [µg/m ³]	PM2.5 [µg/m ³]	O ₃ [µg/m ³]	NO ₂ [µg/m ³]	SO ₂ [µg/m ³]
Very good	0-20	0-13	0-70	0-40	0-50
Good	20.1-50	13.1-35	70.1-120	40.1-100	50.1-100
Moderate	50.1-80	35.1-55	120.1-150	100.1-150	100.1-200
Passable	80.1-110	55.1-75	150.1-180	150.1-230	200.1-350
Bad	110.1-150	75.1-110	180.1-240	230.1-400	350.1-500
Very bad	>150	>110	>240	>400	>500
No index	The air quality index is not determined because there is not measurement of pollution prevailing in the province				

Source: Chief Inspectorate for Environmental Protection, https://powietrze.gios.gov.pl/pjp/content/health_informations.

Table 2. Health recommendations related to the air quality index

Category	Health information
Very good	The air quality is very good, air pollution does not pose a threat to health, conditions conducive to all outdoor activities with no limits.
Good	The air quality is satisfactory, air pollution does not pose any risk for health or poses a negligible risk. You can stay outside and do any activity without limits.
Moderate	The air quality is acceptable. Air pollution may pose a threat to health in specific cases (for the ill, the elderly, pregnant women and young children). Moderate conditions for outdoor activities.
Passable	The air quality is adequate, air pollution poses a threat for health (especially for the ill, the elderly, pregnant women, and young children) and may have adverse health effects. Consider limiting (shortening or spreading over time) outdoor activities, especially if the activity requires prolonged or intense physical effort.
Bad	The air quality is bad, the ill, the elderly, pregnant women, and young children should avoid being outside. The rest of the population should limit any outdoor physical activity to the minimum – especially the one requiring prolonged or intense physical effort.
Very bad	The air quality is very bad and has adverse effect on health. The ill, the elderly, pregnant women, and young children should absolutely avoid being outside. The rest of the population should limit staying outside to the bare minimum. Any physical activity outside is discouraged. Prolonged exposure on the substances in the air increases the risk of changes in, for example, the respiratory system, the cardiovascular system, and the immune system.

Source: Chief Inspectorate for Environmental Protection, https://powietrze.gios.gov.pl/pjp/content/health_information.

Air quality zones

According to the currently applicable division, **there are 46 zones in Poland**, for which air quality assessments are carried out. They include **agglomerations with more than 250K inhabitants**, **cities with more than or close to 100K inhabitants**, which formed separate zones until 2019 (Legnica is a city where the number of inhabitants fell below 100K, but it is still treated as a separate zone) and the remaining **province** area, which is not included in the agglomerations and cities.

In the **Silesian Province**, the air quality is monitored by **31 measurement stations divided into 5 zones**, which are:

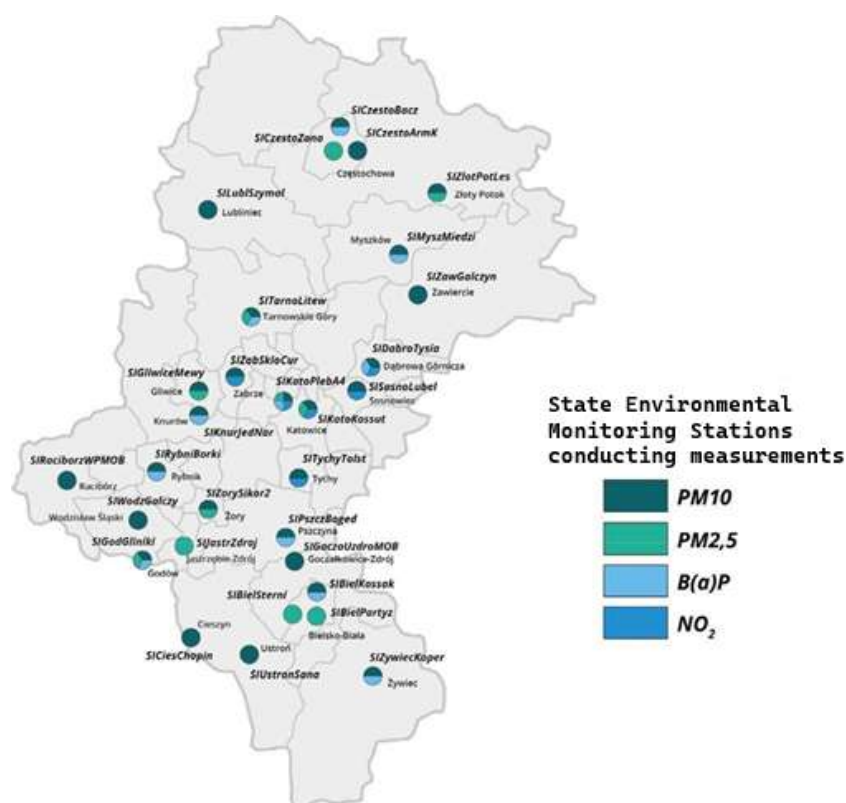
- **the upper-Silesian agglomeration** (Katowice, Sosnowiec, Gliwice, Zabrze, Bytom, Ruda Śląska, Tychy, Dąbrowa Górnicza, Chorzów, Jaworzno, Mysłowice, Piekary Śląskie, Siemianowice Śląskie, Świętochłowice),
- **the Rybnik and Jastrzębie-Zdrój agglomeration** (Rybnik, Jastrzębie-Zdrój, Żory, Pszów, Radlin, Rydułtowy, Wodzisław Śląski,
- the **Bielsko-Biała city**,
- the **Częstochowa city**,
- the **Silesian zone** – covers the Silesian Province area excluding the above-mentioned zones.

Did you know that...

prolonged exposure to smog can cause genetic changes that increase the risk of cancer?



Figure 1. Location of measurement points of the National Environmental Monitoring in the Silesian Province



Source: Update of the Air Protection Programme for the Silesian Province, Katowice 2023, Appendix to Resolution No. VI/62/8/2023 of the Silesian Provincial Government of 20 November 2023, Official Journal of the Silesian Province, item 8625, p. 355;

https://dzienniki.slask.eu/WDU_S/2023/8625/akt.pdf

With regard to all substances subject to assessment, the zone is classified into one of the following classes:

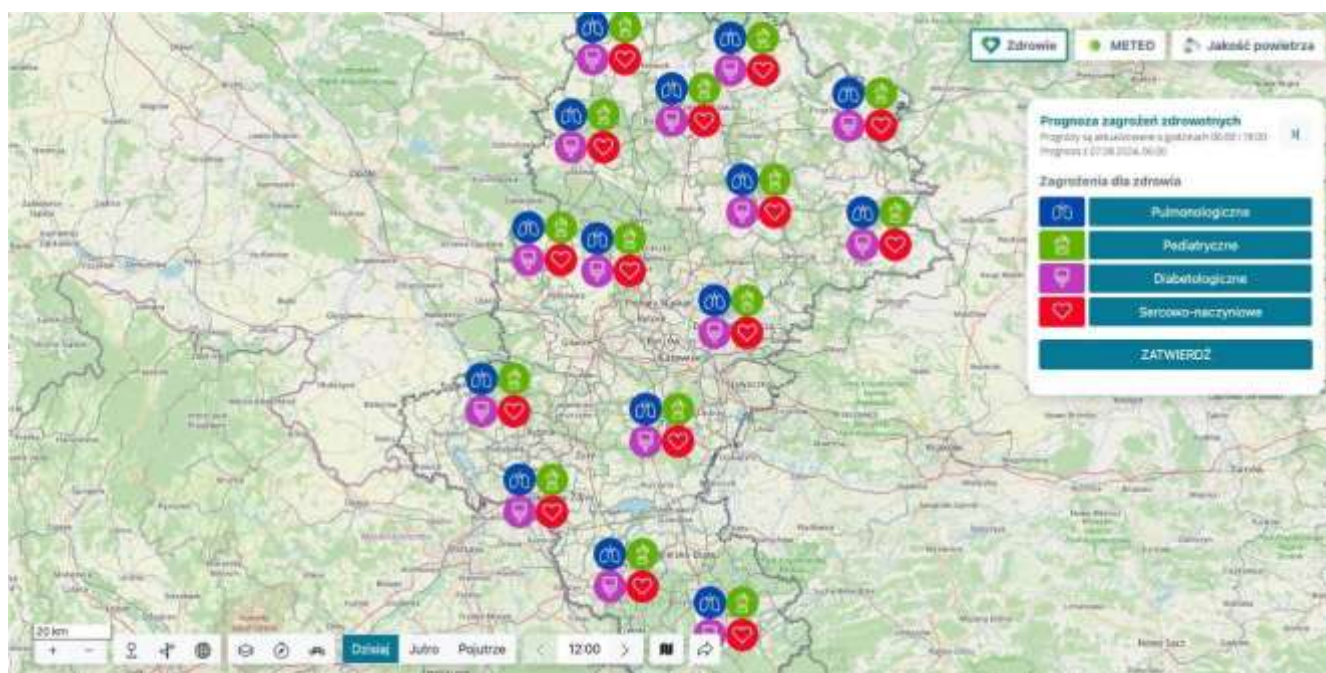
- **class A** – if the pollution concentration in the area does not exceed permissible levels, target levels, and long-term target levels,
- **class C** – if the pollution concentration in the area exceeds permissible levels or target level plus the tolerance margin, of the margin is determined,
- **class D1** – if the ozone concentration in the area does not exceed the long-term target level,
- **class D2** – if the ozone concentration in the area exceeds the long-term target level.

Air quality monitoring in the Silesian Province

The current air pollution can be checked on an ongoing basis for locations where measurement stations are located. It is possible via the Chief Inspectorate for Environmental Protection's website [<https://powietrze.gios.gov.pl/pjp/current>], which presents results of current 1-hour measurements of concentrations of specific pollutants, directly from the national air quality database. Data presented on the website are also available in the **mobile app "Jakość powietrza w Polsce" (en. Air quality in Poland)**. One of the features is the "Forecast Map", which makes it possible to view two-day forecasts for air pollution with PM10 particulate matter, nitrogen dioxide (NO₂), sulphur dioxide (SO₂) in the winter season, and tropospheric ozone (O₃) in the summer season.

Information on the air quality, weather conditions and health hazards resulting from air pollution is presented on the **Silesian SMOGSTOP** [<https://sla-skiesmogstop.pl/portal/home>] website and mobile app under the same name. You can download the Silesian SMOGSTOP mobile app from Google Play store [<https://play.google.com/store/apps/details?id=pl.ietu.silesian.smogstop>] and App Store [<https://apps.apple.com/pl/app/%C5%9Bl%C4%85skie-smogstop/id1534870062?l=pl&platform=iphone>]. Once you create an account, you can access personalised health messages and air quality messages for specified locations.

Figure 2. Silesian SMOGSTOP website



Source: <https://slaskiesmogstop.pl/portal/home>

SOURCES

- [1] Update of the Air Protection Programme for the Silesian Province, Katowice 2023, Appendix to Resolution No. VI/62/8/2023 of the Silesian Provincial Government of 20 November 2023, Official Journal of the Silesian Province, item 8625, https://dzienniki.slask.eu/WDU_S/2023/8625/akt.pdf.
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<https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20210000845/O/D20210845.pdf>.
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<https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20220002131/O/D20222131.pdf>.
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<https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU19910770335/U/D19910335Lj.pdf>.
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<https://iris.who.int/bitstream/handle/10665/345329/9789240034228-eng.pdf?sequence=1&isAllowed=y>.
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Lesson ideas

"Air observation"

1. Air quality index

Task the students with observing the air quality index for a place they live for a whole week. To this end, they should use the Silesian SMOGSTOP website of the Silesian SMOGSTOP mobile app. The air quality index can be viewed after clicking on the "Air quality" tab and selecting the place of residence on the map.

For each day of observations, students mark in a table, using words and colours, the air quality index for their place of residence according to the indication read on the website or in the app. They should use the following designations:

Very good	Good	Moderate	Sufficient	Bad	Very bad
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Proposed layout of the table for marking observations:

Day 1 (DD.MM.YYYY)	Day 2 (DD.MM.YYY Y)					Day 7 (DD.MM.YYYY)
Very good	Good					Moderate

Discuss the results with students.

3. AIR POLLUTION

Sources of air pollution

A **source of air pollution** is understood to be a place where pollutants are introduced (emitted) into the air.

The sources of pollution are:

- **energy facilities** (producing electricity and heat in power plants and power stations, heating plants, refineries and others),
- **industrial plants,**
- **municipal boiler rooms,**
- **individual (domestic) furnaces,**
- **transport** (road, air, rail and shipping),
- **wastewater and waste management** (e.g. dumps or landfills),
- **agriculture** (e.g. use of plant protection products, burning of plant residues),
- **chemical transformations and reactions occurring in the polluted the atmosphere,**
- **natural sources** (e.g. volcanic eruptions, forest fires, chemical weathering of rocks, cosmic dust).

Emissions and sources of air pollution worldwide and in the EU

The highest levels of air pollution on Earth are observed in urban and industrial regions, and its main sources are: **anthropogenic emission (human activity)** related to industrial and transport activities.

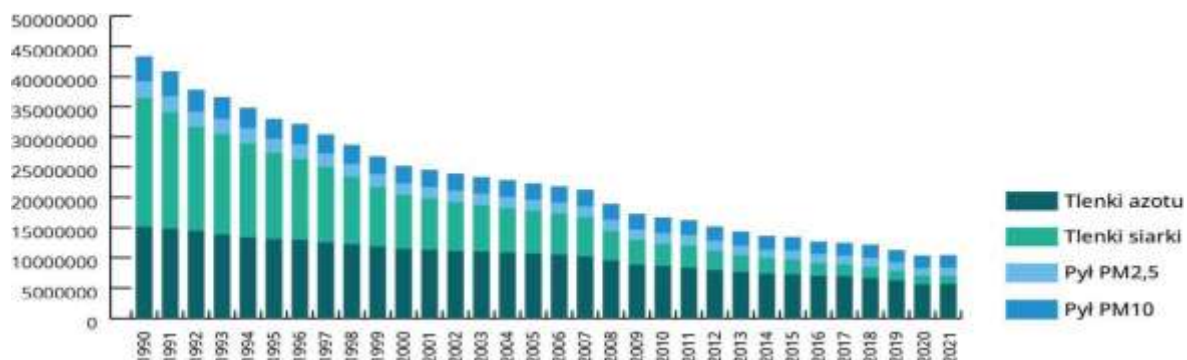
Did you know that...

one mature deciduous oak tree can purify as much air in a year as 10 people need to breathe?



Energy consumption and agriculture are the biggest sources of air pollution in Europe. Since the 1980s, the EU has been introducing increasingly stringent regulations aimed at reducing air pollution. Mainly thanks to these measures, emissions of the most significant pollutants have fallen significantly. Between 1990 and 2021, the EU achieved the greatest reduction in **sulphur oxide emissions (fifteen-fold)**, and the **smallest reduction in particulate matter (two-fold)**.

Chart 1. Emissions of key pollutants in the EU-27 between 1990 and 2021 (in tonnes)



Source: European Environment Agency (EEA); https://ec.europa.eu/eurostat/databrowser/view/env_air_emis_custom_8249852/default/table?lang=en.

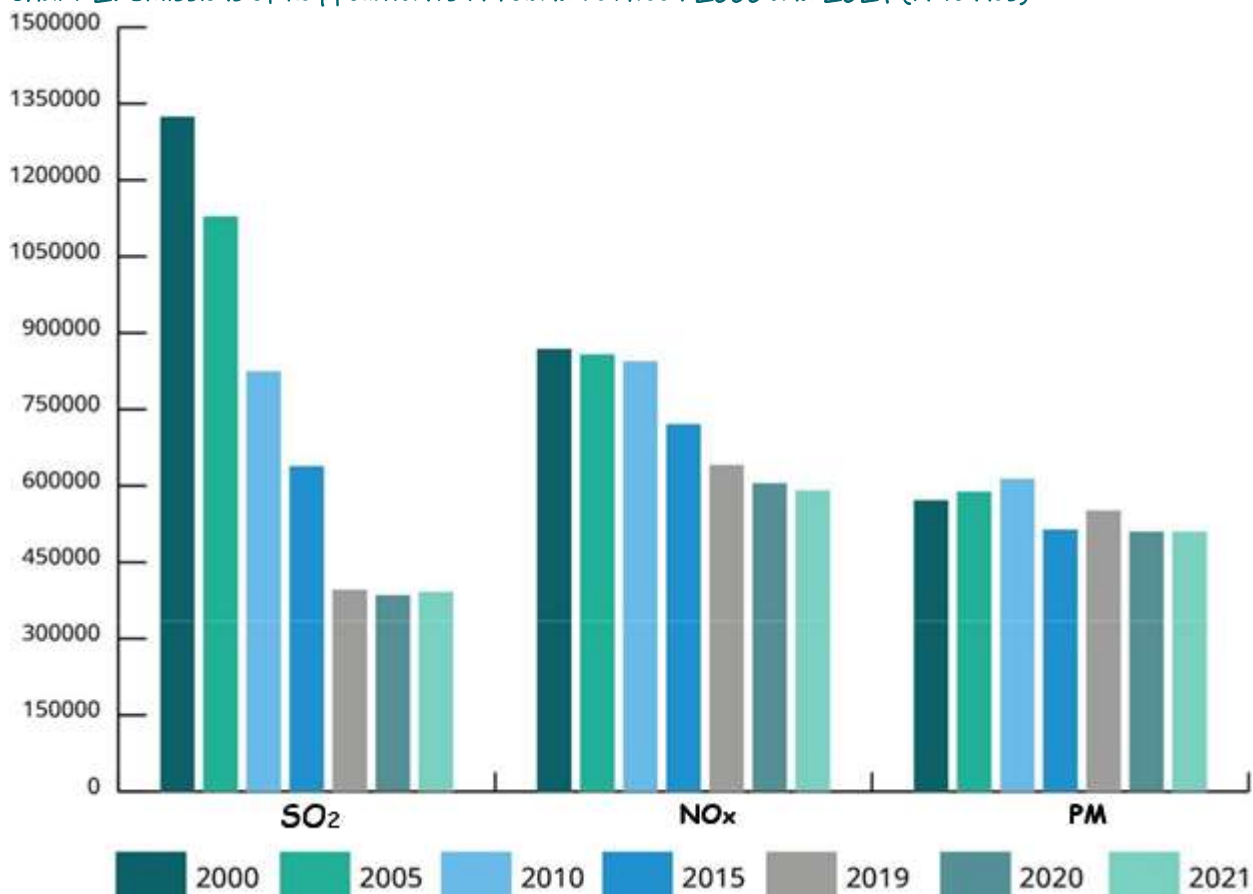
Emission of individual types of pollution by EU Member States has different sources. **The main source of nitrogen oxides (NO_x) is road transport (37%).**

For particulate matter – the use of energy by households, businesses and institutions (58% for PM_{2.5} and 44% for PM₁₀), sulphur dioxide – energy supply (41%) and manufacturing and mining (37%).

Emissions and sources of air pollution in Poland

At the beginning of the 21st century, sulphur dioxide ranked first among air pollutants in **Poland**. In recent years, **sulphur dioxide pollution has stopped being a problem almost completely**, as its emission standards are not exceeded nowadays. This results from, for example, structural changes in the industry after 1989, but also from EU regulations imposing on the industry the obligation to use technology reducing emissions of harmful substances to the environment. **Emission of nitrogen oxides and particulate matter** is also decreasing, but the process is much slower.

Chart 2. Emissions of key pollutants in Poland between 2000 and 2021 (in tonnes)



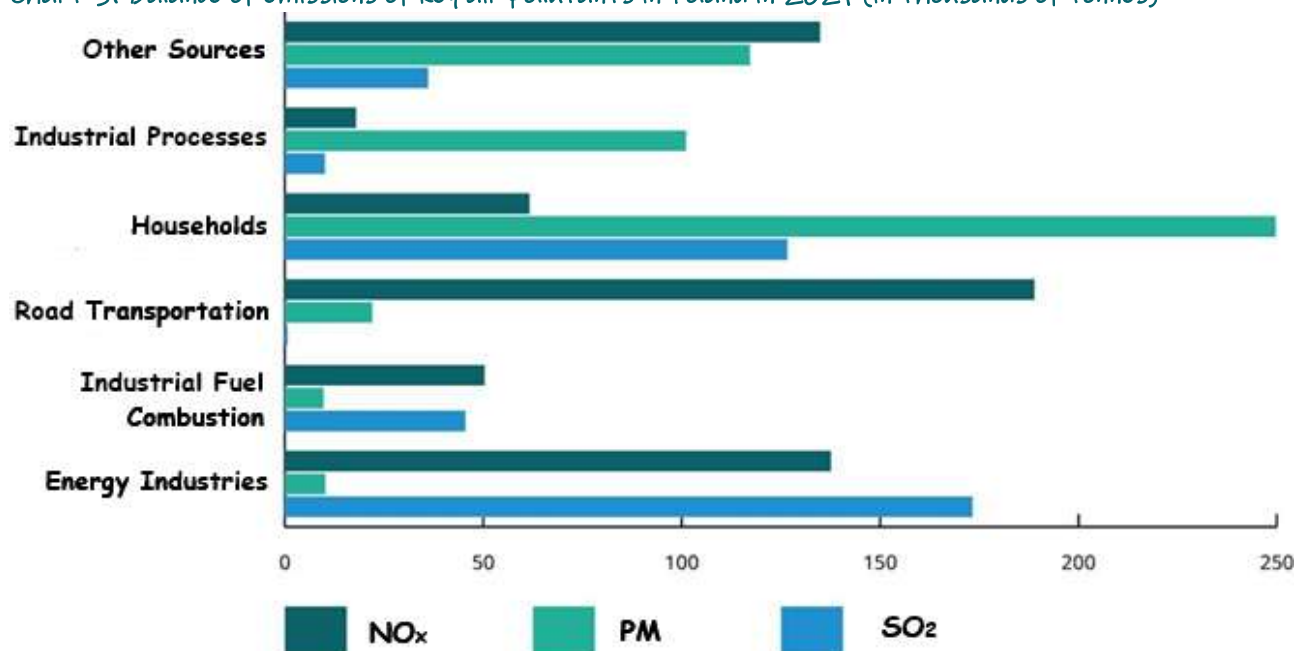
Dust – particulate matter with diameters below 1 mm that adversely affect human health and the environment state and quality.

Source: data from the National Centre for Emissions Balancing and Management – Institute of Environmental Protection – National Research Institute;

https://stat.gov.pl/download/gfx/portalinformacyjny/pl/defaultaktualnosci/5484/1/24/1/ochrona_srodowiska_2023_tablice.zip.

In Poland, the main source of air pollution emissions in 2021 were, as in the previous years, households, fuel burning for energy and heat generation in power, and heat and power plants, and for nitrogen oxides – also transport.

Chart 3. Balance of emissions of key air pollutants in Poland in 2021 (in thousands of tonnes)



Dust – particulate matter with diameters below 1 mm that adversely affect human health and the environment state and quality.

Source: data from the National Centre for Emissions Balancing and Management – Institute of Environmental Protection – National Research Institute;

https://stat.gov.pl/download/gfx/portalinformacyjny/pl/defaultaktualnosci/5484/1/24/1/ochrona_srodowiska_2023_tablice.zip.

The largest source of nitrogen oxide emissions in 2021 was fuel combustion in the road transport sector, accounting for 32% of total emissions of this pollutant in Poland, followed by the energy industry (23% of total emissions) and other sources (including primarily the municipal and residential sector, responsible for 20% of total NO_x emissions). Households accounted for almost half of dust emissions, while sulphur dioxide (SO₂) emissions were mainly generated by the energy industry (44%) and households (32%).

Emissions and sources of air pollution in the Silesian Province

The air quality in the Silesian Province is adversely affected by:

- **High level of industrialisation**
The Silesian Province is the most industrialised region in Poland and its characteristic feature is a significant share of heavy industry based on local resources, mainly hard coal.
- **Specific settlement structure**
The settlement structure of the Silesian Province comprises 167 municipalities and 72 cities. It stands out among other provinces for its density of cities, which is 58 cities per 10,000 km² (almost twice as high as the average for Poland, which is 31 towns per 10,000 km²).
- **High population density**
Silesia has a population of 4.4 million, making it the most populous region in Poland after the Mazovia Province. At the same time, the area is characterised by the highest population density in Poland – 352 people per 1 km², which is almost three times higher than the Poland's average (120 people/km²).

- **Significant share of old residential buildings**
In 2021, the Silesian Province had one of the largest areas of land developed and urbanised for residential purposes in the country, with an area of 54,887 ha (14.5% of the total area of this type in Poland; only the Mazovia Province had more – 58,022 ha), as well as land designated for industrial use (the highest in the country – 22,517 ha; 17.4% of the total area designated for this purpose in Poland). In the region, buildings constructed between 1945 and 1970 account for a significant share (36.4% compared to 31.0% nationally) of the residential building fabric.
- **Dense road network and large number of vehicles**
Density of public roads in the Silesian Province in 2022 ranked second in the country (201,0 km per 100 km²) and exceeded the state average of 136,7 km per 100 km² by a mile. Similarly, the region maintained its second position in the country in terms of the number of motor vehicles and tractors (3.6 million).

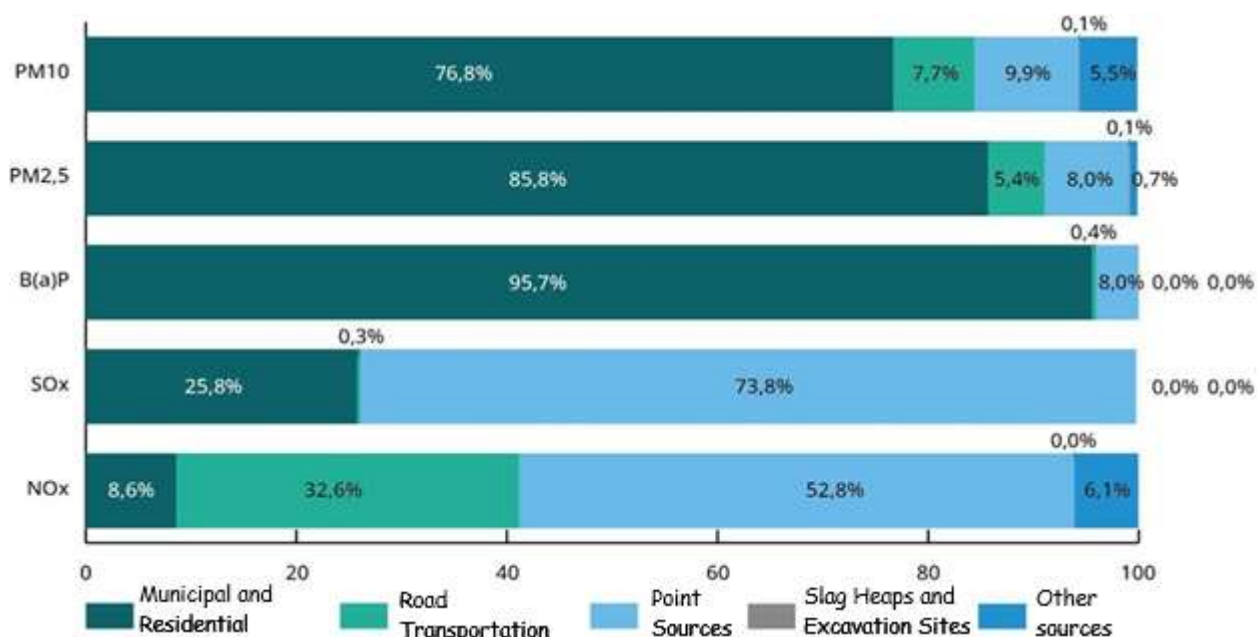
As shown by the report on the annual air quality assessment published by the Regional Department of Environmental Monitoring in Katowice, in 2023, **the major source of air pollution in the Silesian Province in terms of particulate matter and bezno(a)pyrene in the matter was emission from individual heating of residential buildings (municipal and residential sector).** Due to this, the problem escalates mainly during the heating season, lasting from October to March.

Near roads, transport significantly contributes to overall emissions (traffic pollution in the form of dust generated mainly by the friction of brakes, tyres and road surfaces, and in the form of nitrogen oxides emitted from vehicle exhaust pipes). **The highest emission from the road transport industry occurs in big cities** and along transport routes with the highest volume of traffic during the day. Due to the road transport impact, the A4 motorway passing through Katowice contributed to exceeding the average annual permissible level of nitrogen dioxide in the Upper-Silesian agglomeration. No nitrogen dioxide exceedances were recorded in the other zones. The Upper-Silesian Agglomeration accounts for 43% of nitrogen oxide emissions and more than 20% of the PM₁₀ and PM_{2.5} emissions in the Province. In the country, the Silesian Province accounts for around 9% of road transport pollution emissions.

Industrial activity also had an impact on the level of local air pollution.

In the Silesian Province, the largest share of particulate matter pollution comes from steelworks, power plants, coking plants and mining. Dąbrowa Górnicza (19% of emissions in the Province), Rybnik (8.3%) and Jaworzno (6.1%) contribute the most to PM₁₀ emissions from local sources. In terms of nitrogen oxide emissions, the largest sources of pollution are power plants, steelworks and coking plants. The highest levels of this type of pollution are emitted in Dąbrowa Górnicza (24% of the Province's total), Jaworzno (15.3%) and Rybnik (9.6%). The emission of sulphur oxides from industrial activity is dominated by steelworks and power generation. In the case of these pollutants, Dąbrowa Górnicza accounts for 25.5% of the total emissions in the Province, Jaworzno for 9.3%, and Rybnik for 9.2%. The impact of natural emission sources, unrelated to human activity, was the cause of ozone levels exceeding the long-term target in the Silesian zone.

Chart 4. Contribution of individual emission sources to air pollution in the Silesian Province in 2023.



Source: Annual assessment of air quality in the Silesian Province. Provincial report for 2023, Chief Inspectorate for Environmental Protection, Regional Department of Environmental Monitoring in Katowice, Katowice 2024; <https://powietrze.gios.gov.pl/pjp/documents/download/114162>.

Measures taken in the Silesian Province to improve air quality are yielding results, although progress is slow. In recent years, we have observed the improvement of air quality, the concentration of the majority of pollutants have achieved lower levels, and the areas of exceeding permissible levels have been smaller. **The concentration standards for PM10 and PM2.5, as well as benzo(a)pyrene have been exceeded the most often.** For example, although the average annual concentrations of PM10 did not exceed the permissible average annual level, the permissible frequency of exceeding 24-hour concentrations of 35 days per calendar year was recorded at 13 of the 27 measurement stations measuring its concentration (the worst situation occurred in Pszczyna, where exceedances were measured over 75 days). The concentration of sulphur dioxide in the air remained below permissible levels throughout the entire Province.

Table 3. Results of measurements of air quality in the zones of the Silesian Province, 2017 and 2022

Zone	Air quality class index the zone	Type of exceedance	No. of stations recording exceedances in 2017	No. of stations recording exceedances in 2022
Upper Silesian Agglomeration	C	permissible frequency of exceeding the permissible level of 24h concentrations of PM10	7 of 7	2 of 7
		permissible level of annual average concentration of PM2.5	3 of 3	1 of 3
		level of annual average concentration of benzo(a)pyrene	2 of 2	2 of 2
		permissible level of annual average concentration of nitrogen dioxide	1 of 7	1 of 6

Zone	Air quality class index the zone	Type of exceedance	No. of stations recording exceedances in 2017	No. of stations recording exceedances in 2022
Rybnik and Jastrzębie-Zdrój Agglomeration	C	permissible frequency of exceeding the permissible level of 24h concentrations of PM10	2 of 2	1 of 2
		permissible level of annual average concentration of PM2.5	1 of 1	2 of 2
		level of annual average concentration of benzo(a)pyrene	1 of 1	1 of 1
Bielsko-Biała City	C	permissible frequency of exceeding the permissible level of 24h concentrations of PM10	2 of 2	0 of 2
		permissible level of annual average concentration of PM2.5	1 of 1	1 of 2
		level of annual average concentration of benzo(a)pyrene	1 of 1	1 of 1
Częstochowa City	C	permissible frequency of exceeding the permissible level of 24h concentrations of PM10	2 of 2	1 of 2
		permissible level of annual average concentration of PM2.5	1 of 1	1 of 1
		level of annual average concentration of benzo(a)pyrene	1 of 1	1 of 1
Silesia Zone	C	permissible frequency of exceeding the permissible level of 24h concentrations of PM10	10 of 12	9 of 14
		permissible level of annual average concentration of PM2.5	2 of 3	3 of 5
		level of annual average concentration of benzo(a)pyrene	6 of 6	6 of 6

Source: own work based on the "Update of the Air Protection Programme for the Silesian Province, Katowice 2023, Appendix to Resolution No. VI/62/8/2023 of the Silesian Provincial Government of 20 November 2023, Official Journal of the Silesian Province, item 8625, https://dzienniki.slask.eu/WDU_S/2023/8625/akt.pdf.

The spread of pollution has a significant impact on the air pollution balance. On one hand, high chimneys of industrial plants located in the Province make the pollution generated by them partly move with the air circulation outside the Silesian Province, but on the other hand, the flow of pollution from other areas of Poland and Europe is also recorded.

Low emission

In Poland, the main source of substances that pollute the air the most (apart from arsenic, 50% of which comes from copper metallurgy and around 10% from non-ferrous metal processing) is the low emission, which is why we should focus on it the most in our fight for clean air.

Low emission

Low emission is the product of burning solid and liquid fuels from sources located below 40 metres, primarily domestic chimneys, small boiler rooms and farms, and car exhaust pipes.

High emission

It is the combustion products that enter the air above 40 metres. It is released to the atmosphere mainly from high chimneys of industrial plants, most often at heights from 50 to more than 200 metres.



Note! Do not confuse the low emission with low-carbon economy, that is the activities of states and governments aiming to curb emissions of harmful substances into the atmosphere, mainly carbon dioxide and methane.

The adverse effect of low emission on air pollution is clearly visible in the Silesian Province. Low emission poses a great threat to health as it **relates to the air that we directly breath** (they are at our height). The toxins in it come straight to our bodies, unlike substances released as a result of high emission that disperse in a large mass of air at a height of 50 to 200 metres. Although high emission is also harmful and causes climate change, it does not have as direct an impact on the human body as the low emission.

The main sources of low emission are:

- **municipal and residential sources** – individual households and farms, as well as local boiler rooms not connected to municipal heating systems, often heated by combustion of poor quality solid fuels,
- **road transport** – cars and other internal combustion engine vehicles.

The share of municipal and residential sources from the Silesian Province in emissions of individual pollutants in Poland was 9.1% for PM10, 8.8% for PM2.5, 10.9% for bezno(a)pyrene, 12.6% for sulphur oxides, and 10,8% for nitrogen oxides. The main factors causing emissions from heating sources are: **the use of outdated heating equipment with low energy efficiency** and **the use of very low-quality fuels**, including, for example, coal sludge or flotation concentrate, i.e. raw material recovered from mine mud, and insufficiently dried timber. The use of inefficient heating equipment results in incomplete fuel combustion and the release of fuel residues in the form of dust along with warm air. In addition, it often happens that various types of waste are illegally burnt in domestic furnaces.

municipal, for example, plastics, furniture covered in paints or varnishes the burning of which releases extremely toxic compounds, such as hydrogen cyanide, benzo(a)pyrene, or dioxins.

One of the key causes of difficulties in the fight against low emission is **energy poverty** resulting in problems with satisfying the needs of households within, for example, heating buildings of a low energy standard. It is estimated that energy poverty affects approximately 10% of households in the Silesian Province [*Recommendations 2.0 – analysis of conditions relating to obligations associated with the implementation of the so-called anti-smog resolution*]. Energy poverty caused by low income of households was exacerbated by the sharp rise in energy prices, which happened at the end of 2021, particularly in relation to coal prices.

The second key source of pollutions from low emission is **equipment and vehicles with internal combustion engines**, especially diesel ones. Road transport, apart from emissions of exhaust fumes, gives rise to the problem of dust resulting from the wearing down of brake pads and car tyres.

Did you know that...

the word "smog" comes from the English words "smoke" and "fog"?



One of the measures taken by the European Union to curb the emission of exhaust fumes is the establishment of the **European exhaust emission standard**, which determines standards of permissible exhaust emissions in new vehicles sold in the European Union. These standards have been in place since 1993 and have been modified regularly ever since. The newest one – Euro 6 – has been in force since 2021.

The establishment of **low emission zones** in cities is another example of measures to tackle air pollution caused by exhaust fumes. They are areas which can be entered only when a specified exhaust emissions standard is met. Such zones are established more and more often by authorities of many European cities. There are more than 320 such zones in Europe, with half of them in Italy and every fourth in Germany. As follows from the Clean Cities Campaign's report "*The development trends of low-and zero-emission zones in Europe*", it is anticipated that there will be as many as 507 clean transport zones in Europe until 2025. In Poland, plans to create such zones have been put forward by the authorities in Kraków, Warsaw, Wrocław, Poznań, Łódź, Tri-City and Katowice. Their implementation has its advocates and opponents, who point out to, for example, hindered movement around the city centre for the elderly, people with disabilities, and poor people who cannot afford buying a car meeting the strict exhaust emission standards. One solution can be creating park and ride (P+R) car parks on the outskirts of cities where you can leave your car free of charge and use public transport or rent a bike to go to the city centre. That is why P+R car parks are usually built near bus and tram terminals or suburban rail stops (in case of Warsaw, also near subway stations), where bike parking facilities are also built.

Smog

Smog is an atmospheric phenomenon caused by human activity and unfavourable weather conditions. It is made up of harmful chemical compounds, such as sulphur oxides and nitrogen oxides, as well as solid substances, that is, for example, dusts or carcinogenic polycyclic aromatic hydrocarbons (PAHs). **A number of factors influence the level of local air pollution.** It is estimated that **weather conditions determine as much as 70% of air pollution volume.** Among weather factors, the most important are the number of days with rainfall, wind speed and direction, and atmospheric pressure, which plays the greatest role in trapping pollutants.

Did you know that...

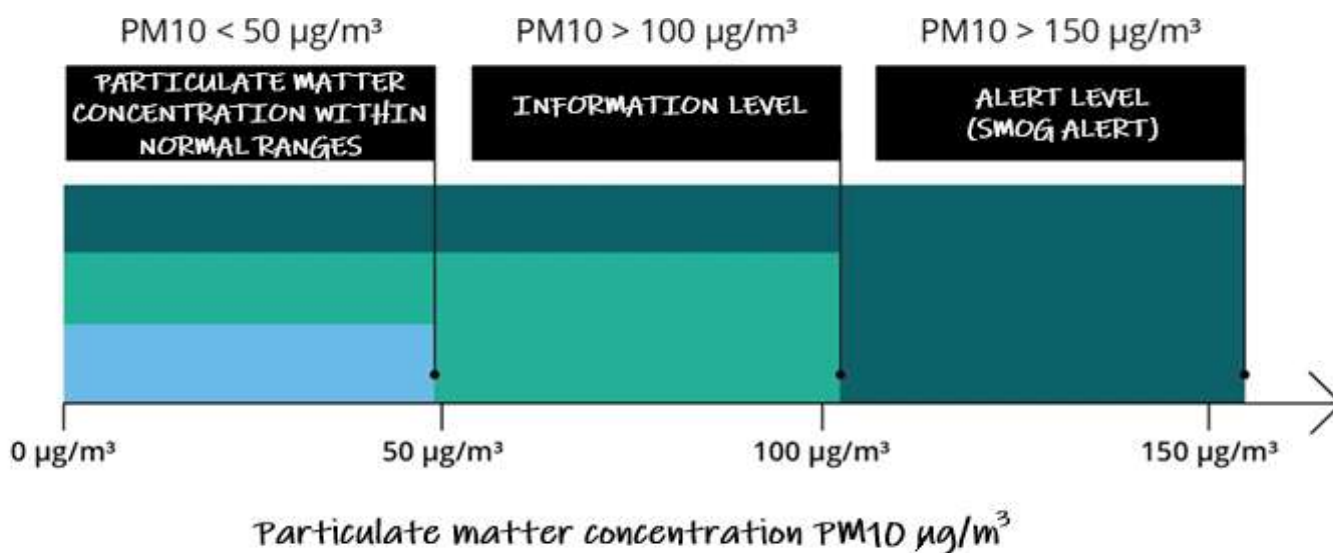
every second, you breathe the air that could be on another continent before?



Polish smog – due to weather conditions where it is created and its composition – is different from other types of smog specified in scientific literature, that is, London smog and California smog.

Smog occurring in the Silesian Voivodeship is characterised by the high concentration of particulate matter, especially PM₁₀ and PM_{2.5}, as well as benzopyrene. Emissions analyses carried out as part of the Air Protection Programme for the Silesian Province indicated that **surface sources, mainly individual solid fuel combustion sources from the municipal and residential sector and the service sector, have the greatest impact on air quality.** These sources are responsible for 51% of total PM₁₀ emissions, 44% of total PM_{2.5} emissions and 94% of benzo(a)pyrene emissions.

According to the applicable law, when the daily limit for PM₁₀ is exceeded two times, i.e. the level of 100 micrograms per cubic metre, **the informing level** starts to apply, and when the average value of the standard is exceeded three times in 24 hours, i.e. 150 micrograms per cubic metre, **the alarm level** is announced (the so-called smog alarm)



Using the smog calculator available at:

<https://smog.edu.pl/omnicalculator-nauczyciele>, you can check the amount of benzo(a)pyrene (carcinogenic substance present also in cigarettes) breathed when outside for a specified period of time, calculated in terms of cigarettes.



SOURCES

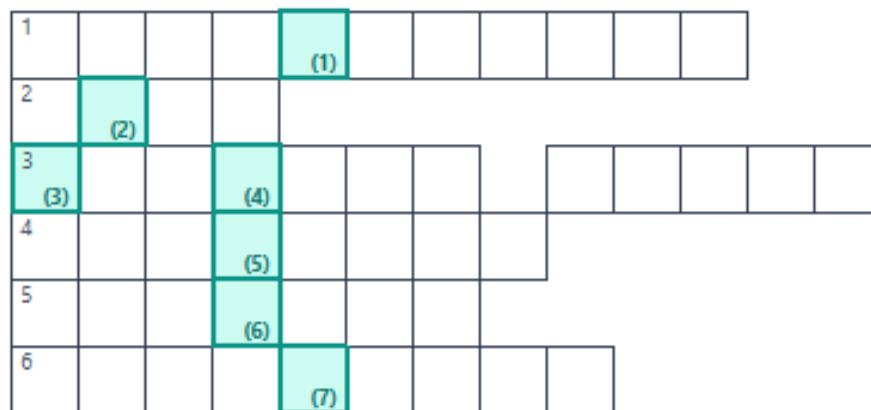
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LESSON IDEAS

"Smog crossword"

1. Solve the crossword. Letters from the darker boxes will create the solution when read from top to bottom.

1. A highly carcinogenic chemical substance present in polluted urban air and cigarette smoke.
2. A harmful atmospheric phenomenon caused by human emissions combined with unfavorable weather conditions.
3. Toxic gases released by vehicles; establishing Clean Transport Zones helps tackle their emission in city centers. *(Two words)*
4. Modern industrial development whose growth created massive new artificial sources of air pollution.
5. Any machine or engine-driven conveyance that emits harmful nitrogen oxides from its exhaust pipe while driving.
6. The sector of the economy responsible for heavy emissions along main roads and major urban traffic arteries.



COMPLETED SECRET SOLUTION WORD

1 E 2 M 3 I 4 S 5 S 6 I 7 O 8 N



4. CONSEQUENCES OF AIR POLLUTION

The effects of air pollution can take different forms: **environmental, health-related, and economic and social.**

Environmental consequences

Air pollution contributes to the occurrence of many phenomena such as:

- **The greenhouse effect**

The greenhouse effect occurs as a result of the accumulation of carbon dioxide and water vapour (as well as methane, nitrogen oxides, freons and ozone), which trap heat in the atmosphere. **The result is global warming**, which can lead to the melting of glaciers, rising sea levels and climate change.

- **Acid rain**

Acid rain occurs when air polluted with sulphur and nitrogen oxides combines with water or water vapour in the air and falls to the ground as rain. These rainfalls cause **damage to forest ground cover and vegetation, disrupt photosynthesis, poison animals, accelerate metal corrosion and damage buildings.**

- **Ozone depletion**

In the upper layers of the atmosphere, at an altitude of 15–50 km, the Earth is surrounded by a layer of ozone, which acts as a natural sunscreen, protecting it from excessive ultraviolet radiation. As a result of environmental pollution, the ozone layer is becoming thinner and a so-called ozone hole is forming, through which harmful radiation reaches our planet, **contributing to an increase in air temperature and climate change.**

- **Water management issues**

Particulate matter can decrease the amount of sun radiation reaching the Earth, affecting the rate at which water evaporates and is transferred to the atmosphere.

It also affects cloud formation and the ability to transport water.

Consequences for health

Numerous studies conducted worldwide indicate a link between exposure to air pollution and the occurrence of various adverse health effects in all organs and systems of the human body.

Did you know that...

one tree can absorb annually as much as 6-7 kg of carbon dioxide, and one hectare of a forest can neutralise exhaust fume emissions from four passenger cars over a year? In the Finnish research centre, Hyytiälä, scientists have been carrying out one of the longest in the world measurements of interactions of trees with the atmosphere as they want to check how trees help us in the fight against climate change.



Table 4. Adverse effects of air pollution on human health

Circulatory system	arteriosclerosis, vasoconstriction, hypertension, pulmonary embolism
Respiratory system	asthma, chronic obstructive pulmonary disease, bronchitis and pneumonia, lung cancer

Brain and nervous system	stroke, haemorrhage, dementia, impaired psychomotor and intellectual development, mood and behavioural disorders
Reproductive system	lower weight and head circumference in newborns, premature birth, impact on the functioning of newborn lungs
Urinary system	reduced kidney function, bladder cancer
Eyes	increased tearing or dryness
Skin	faster ageing, atopic dermatitis
Bones	bone demineralisation

Source: own work

The World Health Organization (WTO) estimates that annually around 3 million people die prematurely due to air pollution. In Poland, 50,000 people die prematurely due to illnesses associated with high levels of air pollution every year.

The people most at risk from the adverse effects of particulate matter are the elderly (over 65 years old), people with coronary heart disease, diabetes and chronic respiratory diseases, tobacco smokers, women and obese people. **The adverse effect of air pollution takes its toll at every age.** Air pollution adversely affect healthy children, even in the foetal period. By impairing blood flow through the placenta, it causes the foetus to develop more slowly. It also affects the cognitive, linguistic and motor skills of children in their early years. Studies show that children attending schools located in areas with high concentrations of air pollution show poorer cognitive development and weaker memory than their peers from schools located in clean areas. **Children and infants are particularly vulnerable to air pollution from particulate matter because their immune, respiratory and central nervous systems are not yet fully developed.** Compared to adults, children often spend more time outdoors and, due to their smaller lung capacity, breathe more frequently, inhaling a much greater amount of air in relation to their body weight than adults.

During adolescence, smog can also have a negative impact on young people's health and lead to lifelong complications. **Elevated levels of PM2.5 in polluted air, originating from vehicle exhaust fumes, construction materials and industrial sources, result in higher blood pressure in adolescents.** Research conducted during the coronavirus pandemic showed that **smog increased the number of deaths by 15% worldwide, 19% in Europe and as much as 28% in Poland** (which placed our country in second place worldwide). **Smog has been linked not only to excess deaths from COVID-19, but also to a higher number of breast cancer cases among women.**

Did you know that...

one of the easiest methods to limit smog is the regular maintenance of household furnaces?



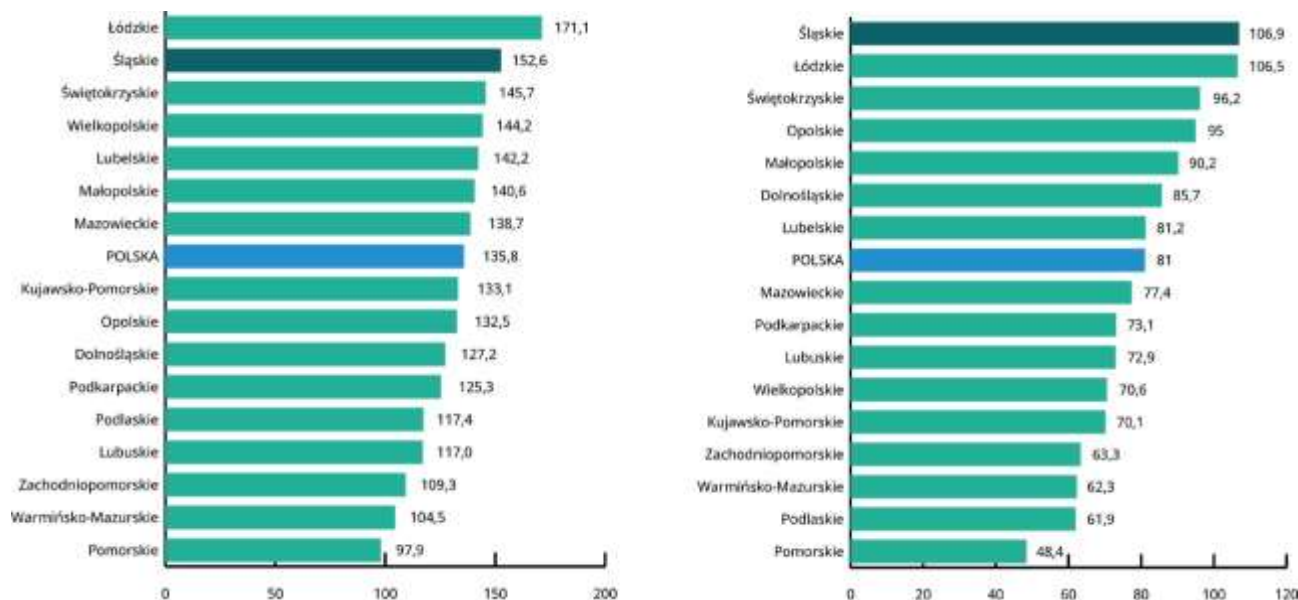
Research that confirms the strong relationship between higher daily average concentrations of air pollution and the increased number of daily hospital admissions due to the exacerbation of symptoms of respiratory system and cardiovascular system illnesses have been carried out in the Upper-Silesian Agglomeration by the Medical University of Silesian in Katowice. **By comparing data** on all causes of hospitalisation between 2006 and 2012, available in the Silesian Cardiovascular Database, with data from the Provincial Inspectorate for Environmental Protection

in Katowice on air quality during the same period, the following was found:

- **increased risk of heart attack** at higher concentrations of nitrogen oxides and PM10 particulate matter,
- **higher probability of stroke** at higher concentrations of nitrogen oxides, carbon monoxide and PM10 particulate matter,
- **more frequent hospitalisations due to pulmonary embolism** at higher concentrations of nitrogen oxides,
- **more frequent hospitalisations due to atrial fibrillation** at higher concentrations of nitrogen oxides,
- **an increased number of visits to primary health care clinics** at higher concentrations of nitrogen oxides and PM10,
- **link between overall mortality** and higher concentrations of sulphur dioxide, nitrogen oxides, carbon monoxide, PM10 and PM2.5 particulate matter,
- **higher mortality from cardiovascular causes** at higher concentrations of sulphur dioxide, nitrogen oxides, PM10 and PM2.5 particulate matter,
- **association between smog alerts and a higher incidence of stroke** with a 7–14-day delay, as well as **cardiovascular** and **overall mortality** both on the day of the alert and with a delay of up to 14 days.

According to data from the Global Burden of Disease Study (GBD), the Silesian Province ranked second in 1990 and it was already in the unenviable first place in Poland in terms of the number of deaths caused by air pollution per 100,000 inhabitants, despite a significant decrease in the number of deaths caused by this factor over the years.

Chart 5. Number of deaths caused by air pollution per 100,000 inhabitants in 1990 (left chart) and 2019 (right chart)



Source: <https://basiw.mz.gov.pl/mapy-informacje/mapa-2022-2026/analizy/czynniki-ryzyka-i-profilaktyka/>.

Did you know that...

soot resulting from the burning of fossil fuels settles on glaciers which makes them melt faster?



Socio-economic costs

Socio-economic costs resulting from air pollution are mainly **costs caused by health consequences** resulting from air pollution and **costs of measures to curb emissions** from individual solid fuel heating systems. Moreover, one cannot overlook the difficult-to-quantify costs associated with reduced food quality, poorer perception of the attractiveness of tourist destinations, and residents' reduced willingness to engage in physical activity, which will ultimately generate economic and social costs.

The costs resulting from health consequences are associated with **lower life expectancy, chronic diseases, increased healthcare expenditure and lower productivity**. According to a study commissioned by the European Public Health Alliance (EPHA), **in 2018, an average Polish family incurred costs of PLN 1,067 per year due to serious illnesses caused by air pollution from heating residential buildings and cooking**. [This amount is almost twice the European average.] **Almost two-thirds of the costs (64%) were generated due to coal-based heating**. Authors of the reports claim that every coal furnace contributed to increasing overall health costs in Poland by PLN 4,919. Heat pumps do not contribute to the occurrence of air pollution directly, **which means that replacing coal-based furnaces with heat pumps could significantly lower the socio-economic health-related costs of air pollution**.

In the Silesian Province, the costs of poor air quality calculated based on the volume of PM_{2.5} emission **was estimated in 2022 at nearly PLN 5 billion**, i.e. around twice the Silesian Province's budget at that time. They comprise: higher mortality, hospital visits due to cardiovascular and respiratory system illnesses, emergency medical service interventions due to respiratory or cardiovascular attacks, absence at work or school, as well as costs of treating cardiovascular and respiratory system illnesses.

Table 5. Costs of poor air quality based on the volume of PM_{2.5} emissions for 2022 for individual zones in the Silesian Province

Zone	Estimates costs of poor air quality (in mPLN)
Upper Silesian Agglomeration	775.99
Rybnik and Jastrzębie-Zdrój Agglomeration	241.15
Bielsko-Biała city	90.56
Częstochowa city	129.55
Silesian Zone	3,669.70
TOTAL	4,906.95

Source: Update of the Air Protection Programme for the Silesian Province, Katowice 2023, Appendix to Resolution No. VI/62/8/2023 of the Silesian Provincial Government of 20 November 2023, Official Journal of the Silesian Province, item 8625, p. 332; https://dzienniki.slask.eu/WDU_S/2023/8625/akt.pdf.

SOURCES

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- [2] Mielecka-Kubień Z., Wójcik A., *Air pollution and the health of residents of large cities in the Silesian Province*, *Wiadomości Statystyczne*. The Polish Statistician, 2020, vol. 65, 6, 39–51; https://ws.stat.gov.pl/WS/2020/6/gus_ws_2020_06_zo-

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- [5] <https://basiv.mz.gov.pl/mapy-informacje/mapa-2022-2026/analizy/czynniki-ryzyka-i-profilaktyka/>.
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Lesson ideas

"Consequences and pollution"

1. Enter the consequences of air pollution selected from the list below in the designated spaces:

acid rain | ozone hole | smog | greenhouse effect

- 1. _____ occurs when air polluted with sulphur and nitrogen oxides combines with water or water vapour.
- 2. _____ contributes to a decrease in air temperature.
- 3. _____ is an atmospheric phenomenon caused by human activity and unfavourable weather conditions. It is made of harmful chemical compounds.
- 4. Occurs as a result of the accumulation of carbon dioxide and water vapour (as well as methane, nitrogen oxides, freons and ozone), which trap heat in the atmosphere. This phenomenon is called the _____, it can lead to the melting of glaciers, rising sea levels, and climate change.

2. Complete the following sentences by inserting the appropriate words from the options provided:

- 1. Particulate matter can decrease/increase the amount of solar radiation reaching the Earth.
- 2. The greenhouse effect occurs as a result of accumulation of carbon monoxide/carbon dioxide and water vapour, which trap heat in the atmosphere.
- 3. The ozone hole contributes to the increase/decrease in air temperature on Earth.

Key:

- 1. Particulate matter can decrease/~~increase~~ the amount of solar radiation reaching the Earth.
- 2. The greenhouse effect occurs as a result of accumulation of ~~carbon monoxide~~/carbon dioxide and water vapour, which trap heat in the atmosphere.
- 3. The ozone hole contributes to the increase/~~decrease~~ in air temperature on Earth.

5. WAYS TO PREVENT LOW EMISSION

Issues related to the prevention of low emission focus on the following matters:

- **eliminating air pollution** – taking measures to prevent new pollution from occurring and to reduce and remove the existing pollution;
- **sustainable industry** – taking measures to reduce the carbon footprint of energy-intensive industries;
- **clean energy** – by reducing the carbon footprint of the energy system and broader use of renewable energy sources;
- **construction and renovation** – taking measures related to construction and renovation of private and public buildings in an energy-efficient manner;
- **sustainable mobility** – supporting multi-modal transport (of people and goods) and electro-mobility (electric vehicles).

Did you know that...

growing pot plants such as ferns or snake plants can improve indoor air quality?



Programmes to improve air quality

Under Article 96 of the Act of 27 April 2001 Environmental Protection Law, **provincial governments may develop legal regulations to improve air quality in the region, the so-called anti-smog resolutions.** The resolutions impose on the region residents specific obligations regarding the use of heat sources and installation of heating systems in new buildings. They are mainly restrictions on the use of solid fuel furnaces in the form of a total ban or a ban on using the most polluting types of equipment, as well as using specific fuels, such as coal and wood, or they determine minimum quality requirements for such fuels. Furnace efficiency and performance are described by classes. Furnace classification was first introduced in Poland in 2002. At that time, class 1, 2 and 3 furnaces were available on the market. A higher class meant that a particular model emitted significantly less harmful substances in its exhaust fumes, and its overall performance and efficiency were of the highest standard. In 2012, another two classes of furnaces – 4 and 5 – were introduced, while withdrawing class 1 and 2 models from sale.

The Silesian Province, as the second one in Poland, has taken steps to fight air pollution by adopting the anti-smog resolution. Resolution No. V/36/1/2017 adopted by the Silesian Provincial Government **on 7 April 2017 introduces restrictions on the use of installations that involve combustion of fuels in the Province.** The aim of this regulation is, for example, to counteract high concentrations of particulate matter, PM10 and PM2.5, as well as benzo(a)pyrene, which regularly exceed the permissible levels in the region.

The anti-smog resolution of the Silesian Province covers all boilers, furnaces and fireplaces for solid fuel, regardless of their intended use. This applies to heating buildings, heating water, preparing meals, and production and technological processes. These regulations, effective as of **1 September 2017, apply to the entire municipal and residential sector, as well as to business activities where furnaces with a capacity not exceeding 1 MW are used.**

The resolution bans the use of:

1. **lignite** and **solid fuels** produced using this lignite,
2. **silt** and coal **flotation concentrates**, as well as mixtures produced using them,
3. **fuels in which the mass fraction of hard coal with a grain size of less than 3 mm exceeds 15%**,
4. **solid biomass with a moisture content exceeding 20% in its working state.**

The anti-smog resolution introduces transition periods for compliance with the new requirements. The deadlines for replacing furnaces depend on their date of manufacture and their classification. In practice, this means that older and less efficient furnaces must be replaced more quickly in order to accelerate the process of reducing pollutant emissions.

Table 6. Furnace replacement dates depending on their date of manufacture

Year of manufacture of the furnace / Furnace type	2006 and older furnaces without a manufacturer's data plate	2007-2012	2013-2017	Class 3 furnaces or class 4 acc. to PN-EN 303-5:2012 standard
Replacement date	Until the end of 2021	Until the end of 2023	Until the end of 2025	Until the end of 2027

Source: Resolution No. V/36/1/2017 of the Silesian Province Government of 7 April 2017 on the introduction of restrictions in the Silesian Province on the operation of installations in which fuels are burned; <https://powietrze.slaskie.pl/content/uchwala-sejmiku-nr-v3612017>.

Introducing the anti-smog resolution in the Silesian Province was a necessary step in the fight against air pollution. The region, due to its industrial heritage, population density, and many old heating sources in the municipal sector, struggles with serious air quality problems. Emission-curbing measures are key to improve residents' health and protect the environment.

Eco-advisers from the "Silesia. Blue Sky Restored" project play a huge role in achieving the objectives of the anti-smog resolution. They operate locally, providing advisory services to residents and initiating and coordinating local activities to improve air quality. Thanks to their work, the residents not only gain knowledge, but also the support in obtaining funds to replace their old furnaces and modernise heating systems.

In Poland, the strategic document that sets out objectives and directions of activities that should be included in air protection programmes was the **National Air Protection Programme**, announced by the Minister of the Environment on 9 September 2015 in Monitor Polski. In December 2021, the National Air Protection Programme was updated until 2025 (with a perspective until 2030 and until 2040) to determine remedial measures to be implemented in the short term by 2025, in the medium term by 2030, and in the long term by 2040.

The first comprehensive strategic document for the Silesian Province was the **Air Protection Programme for the Silesian Province** adopted by Resolution No. IV/57/3/2014 of 17 November 2014 by the Silesian Provincial Government (published in the Official Journal of the Silesian Province on 1 December 2014). The document covered the essential elements that were the diagnosis of the problem, the assessment of possibilities for a change of the present state and directions of remedial measures with planned results to be achieved (including the achievement of permissible levels of substances in the air), the justification of measures taken in the Programme,

the air quality assessment methodology, as well as legal and economic analyses. After subsequent updates of the Programme, its currently applicable version was adopted by the Silesian Provincial Government by Resolution No. VI/62/8/2023 on 20 November 2023.

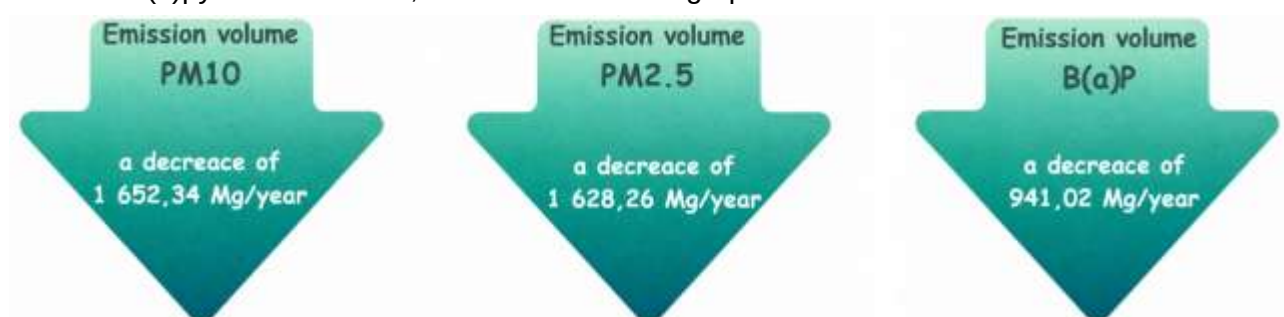
The remedial measures set out in the Programme are aimed at all municipalities of the Silesian Province and are consistent with the anti-smog resolution. The level of PM₁₀, PM_{2.5} and bezo(a)pyrene reduction to be achieved until 2027 has been determined. **The measures provided for in the Programme aimed at reducing air pollution focus on supporting the replacement of heating equipment that does not meet the provisions of the resolution to more modern ones, as well as on supporting processes of thermal modernisation of energy-inefficient buildings.**

As a result of the implementation of the Air Protection Programme for the Silesian Province in 2023, the following **tangible results** were achieved, as presented in the infographic below.



Source: own study based on the Report on the implementation of the Air Protection Programme for the Silesian Province for 2023, Katowice 2024; <https://powietrze.slaskie.pl/download/content/3238>

Measures taken in 2023 brought measurable **ecological effects** – the reduction of PM₁₀, PM_{2.5}, and bezo(a)pyrene emissions, as shown in the infographic below.



Source: own study based on the Report on the implementation of the Air Protection Programme for the Silesian Province for 2023, Katowice 2024; <https://powietrze.slaskie.pl/download/content/3238>

The **Clean Air government programme** has been operating in Poland since 2018. The objective is to improve the energy efficiency and reduce emissions of dusts and other pollutants into the atmosphere from the existing single-family houses and to avoid emissions of pollutants from newly built single-family houses. **The following types of activities are subsidised:**

- **disassembly and replacement of old generation solid fuel heating sources** that do not meet specific requirements;

- **replacement of equipment and installations**, that is, solid fuel furnaces, heat distribution units, electric heating systems, oil-fired boilers, condensing gas boilers, heat pumps, including connections;
- **use of renewable energy sources**, that is, solar panels, photovoltaic micro-installations;
- **thermal modernisation of single-family houses** in areas other than those mentioned above, i.e. insulation of external and internal partitions, replacement and installation of external fixtures and fittings, installation and modernisation of internal heating and hot water systems.

The willingness of local communities to take individual environmentally friendly actions depends largely on the activity of a local government. Numerous campaigns were conducted in Rybnik and Radlin to encourage residents to apply for subsidies. Thanks to the measures taken, **spectacular results have been achieved in improving air quality in Rybnik**. Just a few years ago, Rybnik headed the World Health Organisation's ranking of the most polluted places in Europe, but it is now well on its way to achieving air quality that complies with the organisation's standards.

In 2010, there were 134 days with exceeded air pollution concentration standards, in 2014 – 127, in 2018 – 108, in 2021 – 67, and in 2023 – just 16 days with exceeded daily level of PM10. As results from the analysis of the European Clean Air Centre, which has examined the improvement of air quality **in Rybnik in recent years, as much as 71% of the improvement has been achieved thanks to anti-smog measures**, such as the replacement of old, the most air-polluting heating equipment where coal or wood is burned. Only 29% of the improvement can be attributed to weather factors, i.e. the effect of a “warm winter”.

The **Stop Smog Programme** has been implemented in the Silesian Province. The Programme provides for **the opportunity to get a subsidy for the removal or replacement of high-emission heat sources with low-emission ones, thermal modernisation of single-family residential buildings, connection to the district heating or gas network, ensuring access to energy from RES installations for buildings, and reducing the energy demand of single-family residential buildings for heating and hot water**. In this case, applicants may be municipalities, poviats, inter-municipal associations and metropolitan associations.

It is also worth mentioning the **Marshal's Programme for Air Quality Improvement**, which strengthens and expands measures to prevent the negative impact of pollution on human health and the environment by providing municipalities with financial support in the form of targeted subsidies for the implementation of the provisions of the so-called anti-smog resolution and measures carried out under the Air Protection Programme.

Eco-advisory support

As part of the **LIFE integrated project “Silesia. Blue Sky Restored”**, a group of **74 municipal representatives, known as eco-advisors**, was created and trained to work locally within municipalities. **Their task is to provide advisory services to residents and to initiate and coordinate local activities aimed at improving air quality.**

Eco-advisors have a wide range of activities that covers, for example:

- **support in obtaining a subsidy** – they help the residents in obtaining a subsidy to replace their heating source, increase the energy efficiency of buildings,
- **technical advisory** – they give professional advice on replacing a heating source and improving the energy efficiency.
- **education** – they provide education to the residents on improving air quality,
- **initiating green activities** – they initiate and coordinate local activities and investments to improve air quality and curb greenhouse gas emissions,
- **inspections and enforcement** – they take active part in inspections of furnaces in respect of observing the anti-smog resolution and the waste burning prohibition,
- **local administration support** – they help to obtain external financial support for municipalities in terms of environmental activities.

You can find an eco-advisor at: przywracamylekit.slaskie.pl/ekodoradcy

SOURCES

- [1] *Low-carbon economy policy for the Silesian Province. Regional energy policy until 2030, Katowice 2020;* <https://www.slaskie.pl/download/content/102300>.
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- [3] *Report on the implementation of the Air Protection Programme for the Silesian Province for 2023, Katowice 2024;*
- [4] <https://powietrze.slaskie.pl/download/content/3238>.
- [5] Resolution No. VI/36/1/2017 of the Silesian Province Government of 7 April 2017 on the introduction of restrictions in the Silesian Province on the operation of installations in which fuels are burned; <https://powietrze.slaskie.pl/content/uchwala-sejmiku-nr-v3612017>.
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- [7] przywracamylekit.slaskie.pl/ekodoradcy.

LESSON IDEAS

"From high to zero emission"

1. What can each of us do to reduce air pollution

Explain to students that we all have influence on air quality by conscious actions and decisions, and by changing habits.

Conduct a discussion about measures that positively affect air quality. The list of possible measures should include:

- replacing a solid-fuel furnace to an environmentally friendly heating source (for example, a heat pump)
- building insulation
- taking care of the condition of chimney flues
- not burning waste (especially things made of plastic, metal or varnished wood, particle boards)
- investing in greenery, such as: protecting green areas, planting trees
- replacing a car with one that meets higher emission standards (e.g. electric or hybrid) or consumes less fuel

- using public transport instead of driving a car, riding a bike or walking

And when it is hard to function completely without a car:

- driving more economically (at moderate speed, with no rapid acceleration)
- taking care of the technical condition of the car
- switching off the engine when stationary
- using Park and Ride car parks that function on the outskirts of big cities and switching to public transport
- car-sharing: arranging with neighbours and friends to travel together to school or work

- 2. Name three actions subject to a subsidy from the “Clean Air” government programme** whose objective is to improve the energy efficiency and reduce emissions of dusts and other pollutants into the atmosphere from the existing single-family houses and to avoid emissions of pollutants from newly built single-family houses.

Examples of answers:

1. *disassembly and replacement of old generation solid fuel heating sources that do not meet specific requirements;*
2. *replacement of equipment and installations, that is, solid fuel furnaces, heat distribution units, electric heating systems, oil-fired boilers, condensing gas boilers, heat pumps, including connections;*
3. *use of renewable energy sources, that is, solar panels, photovoltaic micro-installations;*
4. *thermal modernisation of single-family buildings in areas other than those mentioned above, i.e. insulation of external and internal partitions, replacement and installation of external fixtures and fittings, installation and modernisation of internal heating and hot water systems.*

6. RENEWABLE ENERGY SOURCES AS THE ENERGY TRANSITION INSTRUMENT

Electricity and heat coming from renewable energy sources (RES) are the cheapest form of energy now, they are resilient to price fluctuations of fossil fuels and an alternative to conventional energy where energy is obtained from the combustion of fossil fuels (e.g. coal).

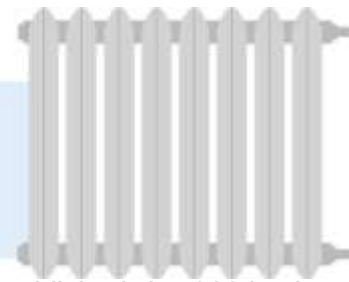
In the future, the differences will grow, for example, due to the need to pay for CO₂ emission permits for residential buildings and public buildings, as well as the inevitable rise of fossil fuel prices resulting from their exhaustion.

According to the Act of 20 February 2015 on renewable energy sources, it is understood as a renewable, non-fossil energy source including wind energy, solar radiation energy, aerothermal energy (energy contained in air heated by solar rays – air source heat pump), geothermal energy, hydrothermal energy, hydro energy, wave, current and tidal energy, ambient energy, energy obtained from biomass, biogas, agricultural biogas, biomethane, biofuels and renewable hydrogen.

Contrary to traditional forms of energy generation, **using renewable energy sources generates less negative consequences for the environment**. Achievement of the goal, adopted by the European Union in 2021, to reduce greenhouse gases by 55% until 2030 compared to the level from 1990 will be only possible as a result of fast development of renewable energy sources.

Did you know that...

reducing the heating temperature in homes by 1°C can reduce CO₂ emissions by approximately 300 kg per year per household?



In the report “Renewables 2023. Analysis and forecast to 2028” published in 2024, the International Energy Agency anticipates that **at the beginning of 2025, renewable energy sources will be the biggest source of global electricity production**, overtaking the coal-based production in this regard. The amount of renewable energy incorporated into energy systems worldwide increased by 50% in 2023, with as much as 75% of the added capacity coming from photovoltaics.

Primary types of renewable energy sources

The following primary types of renewable energy sources can be distinguished:

Solar energy

The process of **processing solar energy into heat or electricity** is called **conversion**. There are three basic types of conversion: photochemical (involving the production of chemical energy using solar energy), **photovoltaic** (involving the direct conversion of solar energy into electricity) and **photothermal** (converting solar energy into heat). Industrial photovoltaic systems are usually accumulated on the so-called PV farms.

Energy from biomass, including biogas

Biomass is all organic matter that can be used to produce energy. It consists of biodegradable products and their fractions, waste and residues from agriculture, forestry and related industries, as well as biodegradable fractions of industrial and municipal waste. **Biomass can be burned or converted into biofuels: solid** (produced from wood chips, straw, hay, energy crops, wood chunks, briquettes and pellets), **liquid** (bioethanol and methyl esters of various fatty acids) and **gaseous** (gas mixtures produced in dry and wet anaerobic fermentation, as well as in the process of gasification and pyrolysis). **Biofuels are used to generate thermal energy, which can then be converted into mechanical energy** (e.g. in car engines) or electricity (in power plants and domestic installations).

Wind energy

This source of energy occurs in nature without limitations. Wind energy is converted into **mechanical energy, which then is converted into electricity**. Wind turbines are primarily used to capture and collect wind energy, often forming wind farms (clusters of wind turbines). **Nowadays, this energy production method is used by household wind installations**.

Geothermal energy

It involves using the thermal energy of the Earth's core. Geothermal energy is used in central heating systems as the primary source of heat, as well as – although less frequently –

to produce electricity. **Heat pumps that extract geothermal energy from the ground water are increasingly used to generate heat from this source.**

Water energy

Hydroelectric power plants can use kinetic energy from the energy of flowing waters, from the energy of waves and tides of seas and oceans caused by gravitational attraction of the Moon and Sun. The principle of operation of a hydroelectric power plant is based on the use of kinetic energy of flowing water, which powers the water turbine.

Pros and cons of renewable energy

The infographic below provides a summary of the pros and cons of different forms of renewable energy.

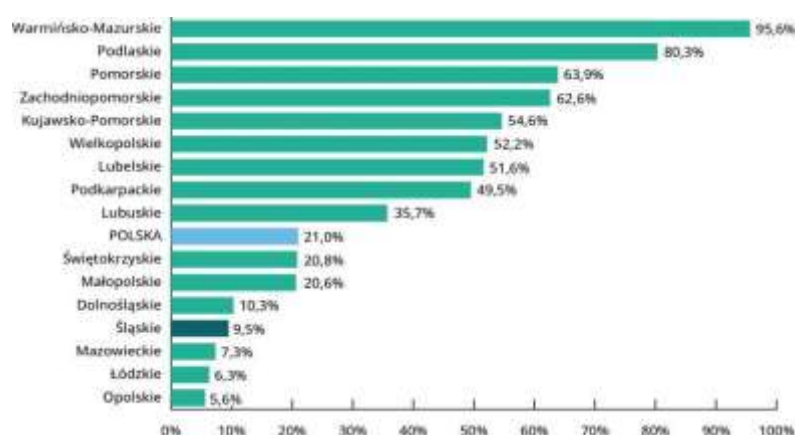
Pros	Cons
Solar energy	
- very clean energy source - relatively high reliability of solar cells - no need for expensive ongoing maintenance	- photovoltaic cells are manufactured from toxic elements – cadmium, arsenic, selenium, tellurium - weather-dependent power plant operation – dependence on sunlight conditions - photovoltaic installations cover large areas
Energy from biomass, including biogas	
- very clean energy source - animal or plant waste is very often used as a substrate – there is no need for expensive disposal	- logistic problems – very often, the substrate must be transported to the power plant - low energy value
Wind energy	
- very clean energy source - building wind farms has been strongly supported by local and EU subsidies recently	- very high construction and maintenance costs - interference with the natural landscape - weather dependence – wind dependence - the operation of wind turbines may interfere with radio and television reception
Geothermal energy	
- constant level of energy obtained - independence from weather conditions - no interference with the landscape - the possibility of producing electricity and heat together - significant geothermal energy resources in Poland (although not all resources can be used for electricity generation due to insufficient temperature, and only for heat production)	- high cost of installation - problems arising during the operation of equipment (corrosion of components) - possible problems with injection of used thermal water
Water energy – hydroelectric energy plants	
- very clean energy source - ability to stop and start the power plant quickly - problems rarely occur during operation - artificially prepared water reservoirs reduce the risk of floods	building a hydroelectric power plants often entails the resettlement of people and irreversible damage to the flora and fauna in a given area
Water energy – sea waves energy	
very clean energy source	- very high sea power plant construction costs - building a power plants entails the occupation of large areas of the sea coast
Water energy – tidal energy	
- very clean energy source - a reliable source of energy – seawater rises and falls regularly twice a day	- high cost of installation - may have a negative impact on the environment - building a power plant entails a significant reduction in ship traffic in the area

Source: based on M. Zabłocki, *The conventional and renewable energy sources sector in Poland. Conditions and problems of development, doctoral thesis, Poznań 2021, p. 169*

RES use in the Silesian Province

The total power of all installed sources of electricity in Poland was over 67 GW in March 2024 (conventional and RES), of which 29.3 GW were renewable energy sources. At the end of 2023, more than 1.4 million micro-installations¹ producing energy was connected to the power grids in Poland and their total installed power was nearly 11.3 GW. The Silesian Province ranked near the bottom in Poland in terms of the share of renewable energy in electricity production overall in 2022, with a ratio more than twice lower (9.5%) compared to the national average (21.0%). This is due not so much to the low level of renewable energy production as to the high level of conventional energy production. The highest share of RES in the overall energy production was recorded in the Warmian–Masurian Province (95.6%) and Podlaskie Province (80.3%).

Chart 6. Change in the share of renewable energy in electricity production by province, 2022

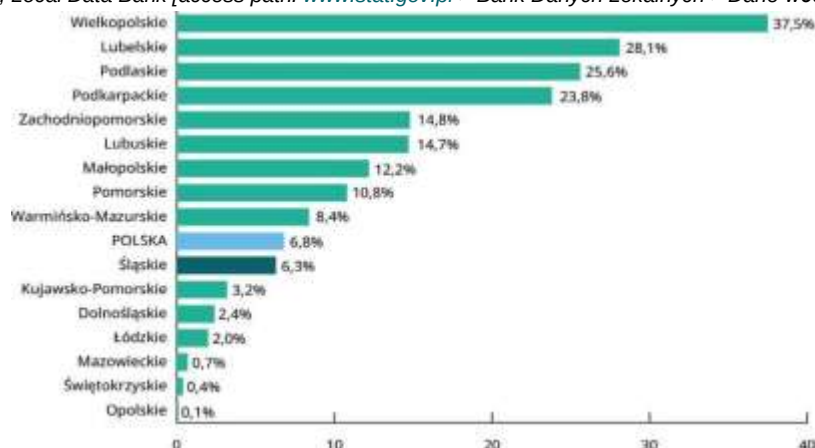


Source: Statistics Poland, Local Data Bank [access path: www.stat.gov.pl] > Bank Danych Lokalnych > Dane według dziedzin > Rynek materia-łowy i paliwowo-energetyczny > Elektroenergetyka > Produkcja energii elektrycznej wg źródeł].

Compared to 2017, the share of RES in overall production of energy increased in the Silesian Province by 6.3 pp in 2022 and slightly deviated from the national average (6.8 pp). A particularly high increase in energy production from RES was achieved by the Greater Poland Province (37.5 pp), Lubelskie Province (28.1 pp), Podlaskie Province (25.6 pp) and Podkarpackie Province (23.8 pp).

Chart 7. Change in the share of renewable energy in electricity production by province, 2017–2022

Source: Statistics Poland, Local Data Bank [access path: www.stat.gov.pl] > Bank Danych Lokalnych > Dane według dziedzin > Rynek



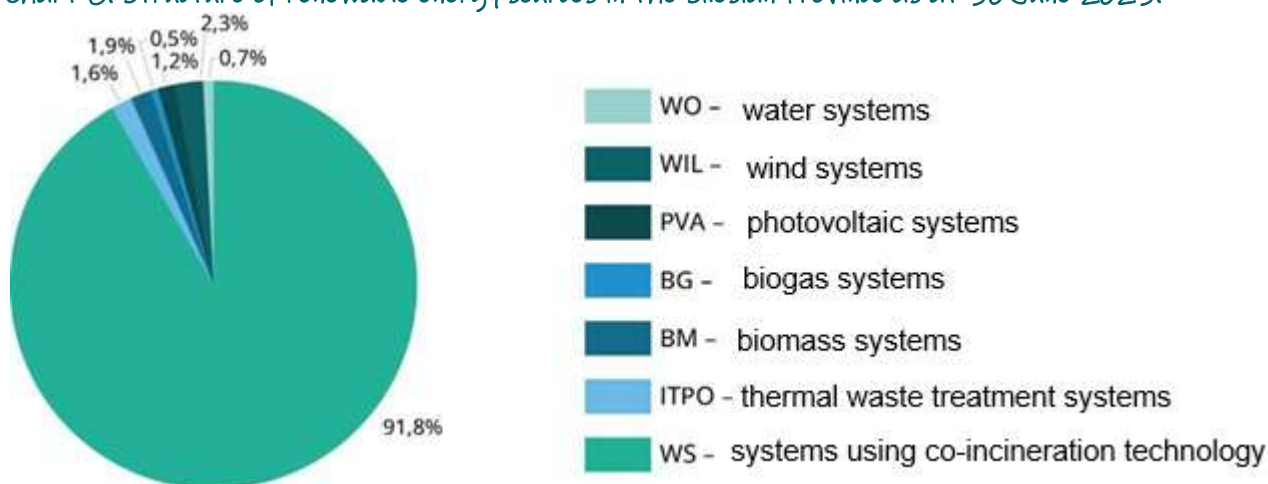
materia-łowy i paliwowo-energetyczny > Elektroenergetyka > Produkcja energii elektrycznej wg źródeł].

¹ Micro-installations are the smallest RES installations connected to the power grid with a rated voltage lower than 110 kV, which, according to the statutory definition (Article 2 item 19 of the RES Act), have the total installed power of no more than 50kW.

As follows from the Energy Regulatory Office's data, as at 30 June 2023, **the structure of renewable energy source in the Silesian Province** (excluding micro-installations, including prosumer installation – people producing energy) is **dominated by installations burning biomass, bioliquids, biogas, or agricultural biogas** with other fuels (91.8%).

The Silesian Province acts as a key energy supplier for other regions of Poland, which is linked to intensive industrial and energy activities. This concentration of energy production results in significant air pollution emissions, mainly from the burning of fossil fuels. As a result, the Silesian Province struggles with higher air pollution levels, while other regions that use the supplied energy can enjoy better air quality.

Chart 8. Structure of renewable energy sources in the Silesian Province as at 30 June 2023.

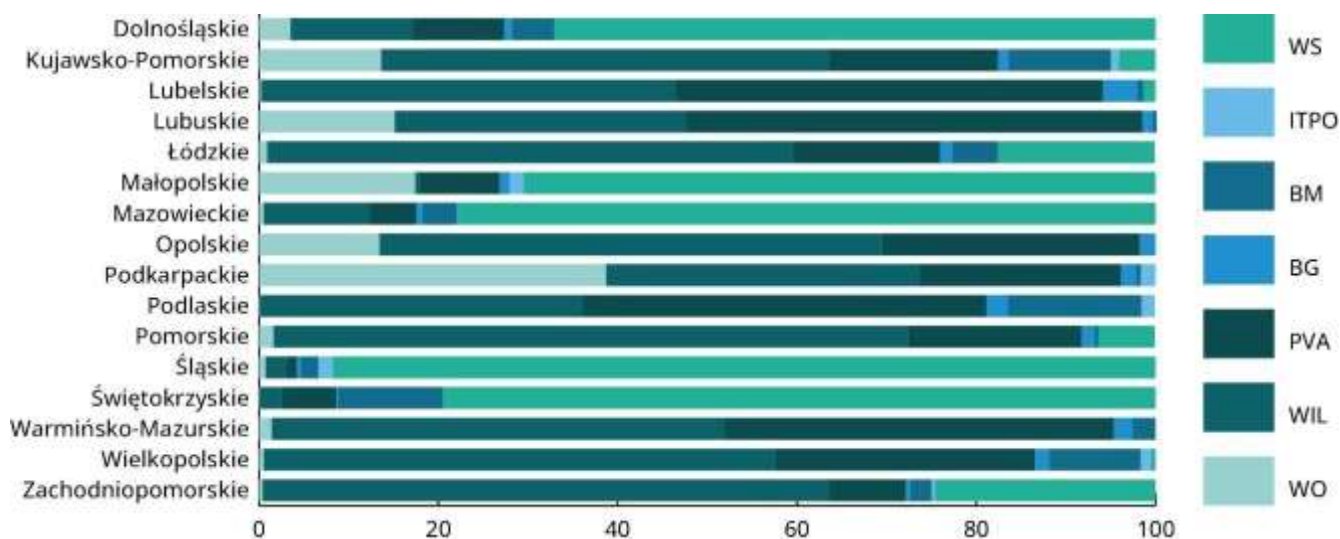


Note: Micro-installations, including prosumer installations, are not included in the published data.

Source: own work based on data from the Energy Regulatory Office [access path: www.ure.gov.pl > Odnawialne Źródła Energii (Renewable Energy Sources) > Potencjał krajowy OZE w liczbach (RES national potential in numbers) > Instalacje odnawialnych źródeł energii (renewable energy sources installation) - stan na (dzień) (as at) > Instalacje OZE (RES installations) – stan na (dzień) (as at)].

Across the provinces, the structure of renewable energy sources shows significant diversity.

Chart 9. Structure of renewable energy sources per provinces as at 30 June 2023.



Note: Micro-installations, including prosumer installations, are not included in the published data.

Source: own work based on data from the Energy Regulatory Office [access path: www.ure.gov.pl > Odnawialne Źródła Energii (Renewable Energy Sources) > Potencjał krajowy OZE w liczbach (RES national potential in numbers) > Instalacje odnawialnych źródeł energii (renewable energy sources installation) - stan na (dzień) (as at) > Instalacje OZE (RES installations) – stan na (dzień) (as at)].

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- [1] Czyżak P., Sikorski M., Wrona A., *What comes after coal? RES potential in Poland*, Instrat Policy Paper 06/2021; <https://instrat.pl/wp-content/uploads/2021/06/Instrat-Co-po-w%C4%99glu.pdf>.
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LESSON IDEAS

"Renewable sources"

1. Complete the table.

Add the characteristics of each type of renewable energy source. Please note that a given energy source may be characterised by several features.

Renewable energy source type:	Feature of a given renewable energy source:
solar energy	
energy from biomass, including biogas	
wind energy	
geothermal energy	
water energy	

Feature of a given renewable energy source:

- 1) the possibility of producing electricity and heat at the same time
- 2) using plant and animal waste
- 3) independence from weather conditions
- 4) using sea tides
- 5) constant level of energy obtained
- 6) very clean energy source

Key: solar energy – 6, energy from biomass, including biogas – 2/3/6, wind energy – 6, geothermal energy – 1/2/3/5/6, water energy – 4/6

7. THERMAL MODERNISATION OF BUILDINGS

A measure that can solve the problem of low emission and reduce energy poverty in Poland is general thermal modernisation of residential and public buildings, which would significantly decrease the heat demand.

Heat demand of buildings

The need for thermal modernisation measures arises from the low thermal efficiency of older buildings, as shown in the infographic below. The differences mainly result from the technology used, which currently allows for higher energy efficiency.

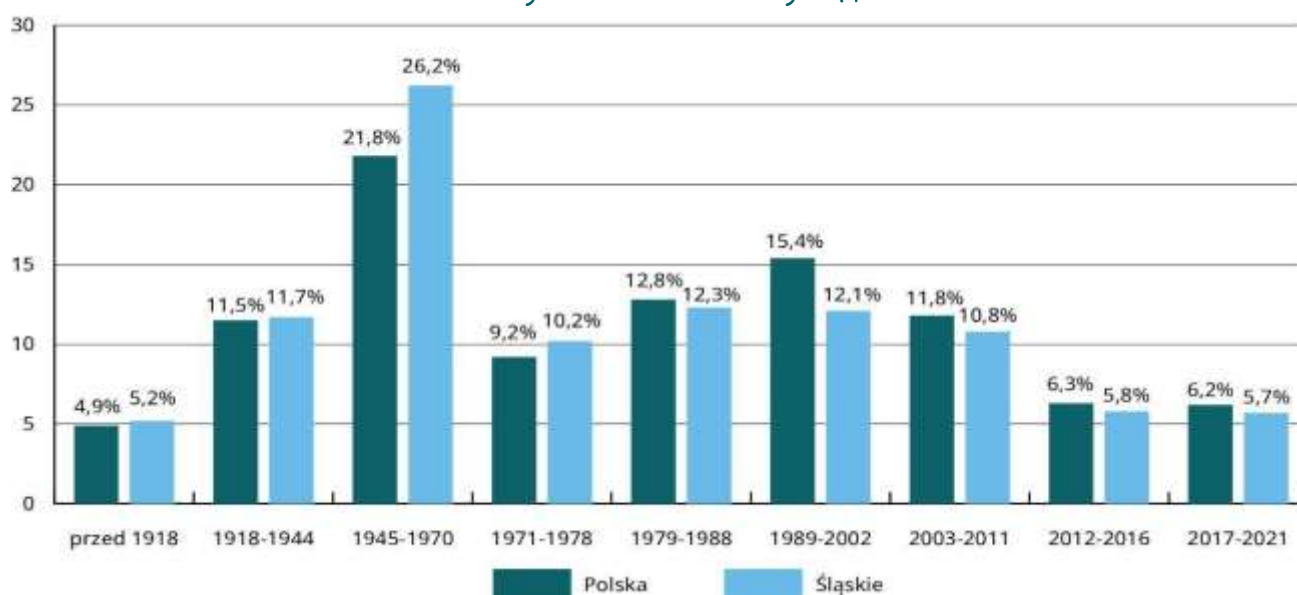
Table 7. Heat demand depending on the building construction technology used

Year of	Heat demand index
	kWh/(m ² /year)
Until 1966	350
Form 1967 to 1985	260
From 1986 to 1992	200
From 1993 to 1997	160
From 1998 to 2007	120
Energy-efficient	80
Low-energy	45
Passive	15

Source: J. Żurawski, *Energy efficiency in construction, part II – energy consumption*, Izolacje 2/2008 http://www.cieplej.pl/imgturysta/file/artykuly/Energooszczedne_budynki_cz2.pdf.

The Silesian Province is characterised by a larger share of old residential buildings and flats compared to the Poland average. In terms of the structure of residential buildings and flats in the Silesian Province, the largest share is accounted for by buildings constructed between 1945 and 1970, which are characterised by low energy efficiency ratings.

Chart 10. Structure of residential buildings and flats in buildings by period of construction



Źródło: own work based on data from Statistics Poland, *Housing conditions in Poland in light of the results of the 2021 National Census of Population and Housing*; https://stat.gov.pl/download/gfx/portalinformacyjny/pl/defaultaktualnosci/6536/5/2/1/warunki_mieszkaniowe_w_polsce_w_swietle_wynikow_nsp_2021.xlsx.

Factors affecting energy efficiency of a building

The energy efficiency of a building is determined by:

1. Structure and shape of the house

Houses with a simple and compact shape have the best thermal properties, as a lot of heat escapes at corners and bends in partitions. The roof can also be an element of the building that causes significant heat loss. The highest level of energy efficiency is provided by the simplest roof, i.e. a single-pitched or gabled roof.

2. Position in relation to the cardinal directions

The energy efficiency of a building is also influenced by its location in relation to the cardinal directions (the possibility of using heat from solar radiation) and the layout of the rooms (the layout of rooms taking into account the daily activities of residents and the associated internal temperature requirements – optimally, living rooms should be located on the south side and bedrooms on the north side).

3. Construction material

Construction materials (e.g. brick, concrete) used to construct external partitions of the building have low insulation parameters. Therefore, a better solution is to use sandwich panels consisting of structural and insulating layers, which ensure greater heat loss reduction.

4. Insulation material

The insulating layer of the partition reduces the impact of the external environment. Insulation material acts as thermal insulation and protects the building against heat loss.

Heat is lost from the building in many ways, as illustrated in the infographic below.



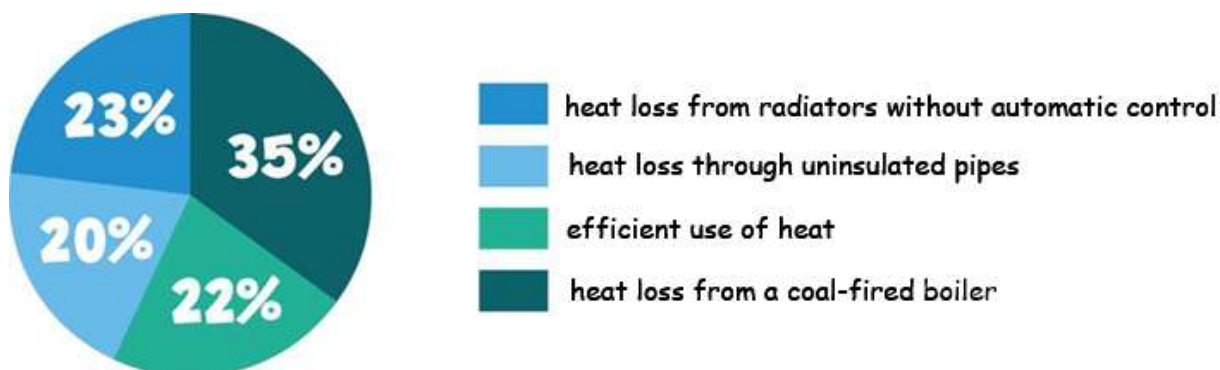
- **Ventilation** – in the process of removing polluted air (e.g. water vapour, carbon dioxide) from a room, air is supplied from the outside, which needs to be reheated in winter. Choosing the right ventilation system is crucial for minimising heat loss. A good alternative to classic gravity ventilation solutions (based on air movement in a vertical chimney caused by temperature differences inside and outside the building and pressure differences) is mechanical ventilation with heat recovery (known as recuperation), where heat is extracted from the air blown out of the building and then used to heat the air blown into the building from outside.

- **Roof** – according to the laws of physics, heated air, being lighter than cold air, rises and heat escapes through the roof.
- **Walls** – constitute a large external surface area of the building. Older houses are not usually characterised by good thermal insulation due to the lack of such requirements in the building regulations at the time.
- **Windows** – the design of windows means that their thermal resistance properties are the weakest compared to other partitions. Heat loss can be particularly significant in older windows. Heat can escape through leaks caused by inadequate adhesion of the window frame to the jamb, worn seals or gaps at the junction with the plaster. Despite their small share in the total external surface area of the house, heat loss through windows is significant.
- **Thermal bridges** – places in external partitions through which heat escapes from inside the house. They form in areas made of poorer quality material, at the joints between adjacent surfaces, and in all gaps.
- **Floor on the ground** – through contact with the external environment, gaps in poorly insulated foundations will cause heat loss.

The **efficiency of the building's heating system**, whose task is to cover the building's heat demand, is affected by:

- **heat generation efficiency** related to the conversion of energy contained in fuel into heat;
- **heat accumulation efficiency**, for example, by using a buffer tank to store heat;
- **efficiency of heat transfer to receivers** (e.g. radiators);
- **efficiency of regulation and utilisation by the system of heat emitters in rooms.**

Heat (in %) lost in various ways



Energy audit

Energy audit is carried out to assess the building's energy demand and determine the scope of works necessary to reduce this demand. The analysis uses data on the building's structure, location, ventilation, as well as heating and hot water system used.

Scope of thermal modernisation of a building

Thermal modernisation of a building can be carried out in various ways, as shown in table 8.

Table 8. Levels of thermal modernisation of buildings and related measures

Level of the building thermal modernisation	Measures to achieve the desired thermal modernisation level
Minor thermal modernisation	• modernisation of replacement of the heating system covering the replacement or modernisation of the heat source
Average thermal modernisation	• modernisation of replacement of the heating system covering the replacement or modernisation of the heat source • replacement of doors and windows • additional insulation of external walls • additional insulation of the roof
Comprehensive thermal modernisation	• modernisation of replacement of the heating system covering the replacement or modernisation of the heat source • using renewable energy sources • modernisation of replacement of the hot water system • replacement of doors and windows • additional insulation of all external partitions (façades, flat roofs, ceilings/floors) • elimination of thermal bridges (places of heat loss) • modernisation of the ventilation system

Source: Sz. Firląg (red.), *Comprehensive thermal modernisation of single-family buildings*, Earth and People Foundation, Warsaw 2019, p. 25; <http://termomodernizacjadomow.pl/wp-content/uploads/2020/06/KOMPLEKSOWA.pdf>.

Benefits of thermal modernisation of a building

Benefits of thermal modernisation of a building may be:

- **Reducing the energy consumption** needed for heating and hot water as well as the costs associated with using the building in a way that ensures a pleasant microclimate in the home;
- **Reducing the adverse impact of the building on the environment** by lowering the heat demand in winter and lowering energy consumption for domestic hot water, thereby reducing fuel combustion and limiting greenhouse gas emissions and air pollution (e.g. particulate matter);
- **Improving the quality of the indoor environment and the comfort of residents**, which includes indoor air temperature, air humidity, air flow rate between rooms, noise and air pollution;
- Increasing the property value by improving the building's aesthetics and functionality;
- **Extending the building's life** by undertaking additional work, e.g. reinforcing structural elements of the roof when insulating it or replacing roofing material.

Thermal modernisation needs related to the replacement or modernisation of heat sources in the Silesian Province

Implementation of the anti-smog resolution in the Silesian Province imposes specific deadlines for replacing furnaces. From 511,909 furnaces in the Central Register of Buildings' Emissions database, nearly 360,000 furnaces was fuelled with coal or coal-derived fuels, which was 70.2% of all furnaces. Chunk wood was used in more than 115,000 furnaces (22.6%). Wood pellets and other types of biomass had a significantly lower share in the mix of fuels used to power furnaces (respectively 6.5% and 0.6%).

As at 25.04.2024, there were nearly 150,000 furnaces of the lowest standards, below class 3 and not suitable to be assigned to any class, in the Silesian Province. (according to declarations made in the Central Register of Buildings' Emissions).

The highest number of furnaces of this standard was recorded in the poviats of Częstochowa (13,099), Żywiec (9,919) and Cieszyn (9,698).

Measures to improve the thermal efficiency of buildings are subsidised by the Clean Air programme. Within its framework, it is possible to carry out relatively simple projects related to the replacement of a building's heating source, which does not require an energy audit. Alternatively, it is possible to obtain funding for comprehensive thermal modernisation of the building, which will result in a reduction in energy consumption to 80 kWh/(m²*year) or a reduction in energy consumption by at least 40%, but this places higher application requirements in the form of the need to conduct an energy audit of the building or residential premises.

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Lesson ideas

"Thermal modernisation"

1. Rank the ways heat escapes from a building, starting from those that let escape the highest amount of heat.
 1. the roof
 2. ventilation
 3. walls
 4. windows
 5. thermal bridges

Key: ventilation – walls – windows – roof – thermal bridges

2. Complete the following sentences by inserting the appropriate words:
 1. Mechanical ventilation combined with heat recovery, where the heat is extracted from the air blown out of the building and then used to heat the air blown into the building from outside, is called _____. (recuperation)
 2. Activities taken to assess the heat demand of the building and determine the scope of works necessary to decrease this demand is _____. (energy audit)
 3. Activities aimed at reducing the heat energy demand of the building is called _____. (thermal modernisation)



You can find more information on how we care
for air quality in the Silesian Province on:

our website:

przywracamyblekit.slaskie.pl

and our social media profiles



with eco-advisors, listed here:

przywracamyblekit.slaskie.pl/ekodoradcy.



See what you can do and how we can help you!

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