



BIERZEMY
POWIETRZE
POD SWOJE
SKRZYDŁA

SILESIA. BLUE SKY RESTORED.



EDUCATIONAL GUIDE

on air pollution control

for secondary school teachers

Under content-related supervision of prof. dr hab. inż. Andrzej Szlęk



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

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...

according to the European Environment Agency, between 1980 and 2020, more than 138,000 people in the EU lost their lives due to extreme weather conditions and climate-related events (including 2,121 people in Poland)? In the same period, extreme weather and climate phenomena caused financial losses in the EU of over EUR 487 billion.



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

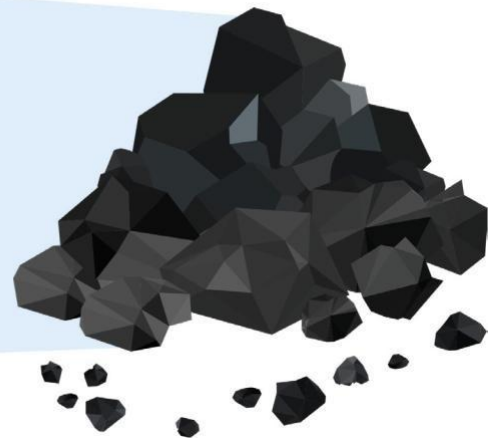
The main causes of climate change and the closely related air pollution are:

- industrial activity, including the burning of coal, oil, and gas,
- 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.
- business practices of simulating environmentally friendly activities, which in reality are not such activities, that is, the so-called greenwashing; one of the most glaring examples of greenwashing that had adverse consequences for air pollution and climate changes was the scandal revealed at one of the top car manufacturers in 2015. The company manipulated the results of exhaust fume emission measurements in such a way that exhaust fume emission reduction was only activated during laboratory tests, while in real-world conditions (while driving) emissions were up to 40 times higher.

Did you know that...

the results of 2021 consumer research showed that **43% of eco-pea coal users** saw it as an eco-friendly product despite the fact that, when combusted, eco-pea coal emits significant amounts of harmful substances? The consumers were misguided by the trade name suggesting the ecological character of the product and using green graphics on the packaging.



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. One of the Katowice COP24 achievements was the development of the common greenhouse gas emission reporting methodology which has made it possible to compare the countries.

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 2020. 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). As proven by scientific research, the global temperature rise by 2°C in relation to the pre-industrial period temperature would bring about serious negative effects for the environment as well as human well-being and health. The Paris Agreement came into force on 4 November 2016 when its ratification condition 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.

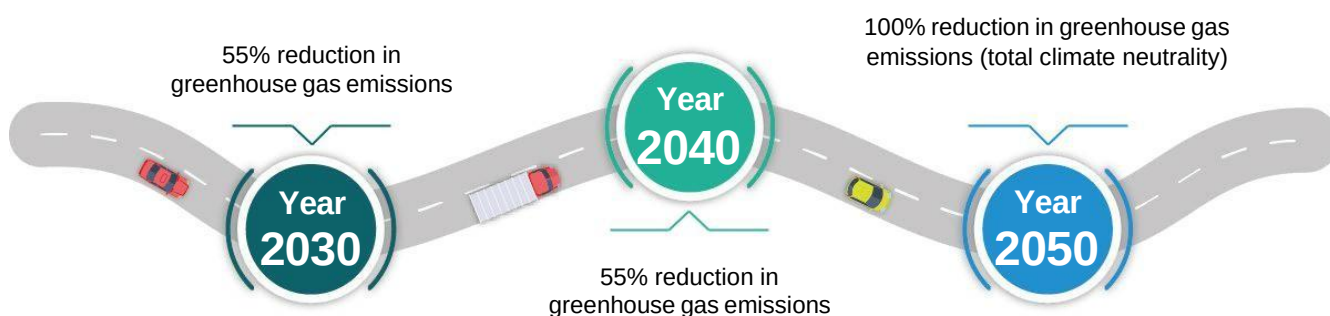
The European Union has set out its path to climate neutrality, i.e. achieving a balance between greenhouse gas emissions and their absorption or storage, in a document entitled the **European Green Deal**. The document published in December 2019 sets out the priority areas whose implementation will lead 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 degradation 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, the 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. *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) describes the strategic framework for activities in this regard. Operational activities have been taken earlier – 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

- [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.
- [2] Konfederacja Lewiatan, Warsaw, December 2022; https://lewiatan.org/wp-content/uploads/2022/12/transformacja_zdrowie_ostateczny.pdf.
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- [5] Romanello M. et al., The 2023 report of the Lancet Countdown on health and climate change: the imperative for a health-centred response in a world facing irreversible harms; "Countdown" 2023, Vol. 402, Issue 10419, [https://doi.org/10.1016/S0140-6736\(23\)01859-7](https://doi.org/10.1016/S0140-6736(23)01859-7).
- [6] Van Dalen K. R. et al., The 2022 Europe report of the Lancet Countdown on health and climate change: towards a climate resilient future; "Countdown" 2022, Vol. 7, Issue 11, [https://doi.org/10.1016/S2468-2667\(22\)00197-9](https://doi.org/10.1016/S2468-2667(22)00197-9).
- [7] Watts N. et al., The Lancet Countdown on health and climate change: from 25 years of inaction to a global transformation for public health, "The Lancet" 2018, Vol. 391, No. 10120, Lancet Countdown project; <https://www.lancetcountdown.org/>.
- [8] https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_pl.
- [9] https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal_pl.

Lesson ideas

1. Using the meta-plan method, discuss actions that you can take as a society to limit the environmental impact.
Meta-plan is one of diagnostic methods that make it possible to examine an issue and creatively look for the best solution. It prompts to the critical analysis of facts, developing judgements and opinions. When working in groups, students write down on sticky notes the proposed solutions that are then discussed by all. The teacher aggregates ideas – as a result, the problem solution plan is developed.
2. Write an article to a journal that discusses the issue of greenwashing.
3. Using the 635 creative problem-solving method, suggest ways to solve the problem of fast fashion.
The 635 methods is one of the creative problem-solving methods. It consists of writing down ideas of solving the problem. Similarly to brainstorming, the first stage takes into account all, even the most unreal, ideas. The method name relates to the work organisation: 6 – means the number of groups, 3 – the number of solutions written down by one group in one "round", 5 – the number of minutes of work in one round. Each group writes down the three suggested solutions on a sheet of paper and then passes it to the group on their right (clockwise). In subsequent rounds, the group can report their own new ideas or develop ideas written down on the sheet of paper. The process lasts until the sheet of paper that the group has at the beginning comes back to it. At the end, all ideas are read aloud and considered by the group.

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:

- the number of sources of emission from houses – many houses 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. Poland has developed a list of 167 such substances (according to the Regulation of the Minister of the Environment of 26 January 2010 on reference values for some substances in the air), but the majority of them occur locally and is linked to a specific source of emissions, for example an industrial facility. 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 highly depends on meteorological conditions, which, on one hand, can further natural ventilation of the atmosphere, and on the other, transmit pollution from distant emission sources.

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.

PM_{2.5} 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 PM_{2.5} 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 PM_{2.5} 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 toxicity is connected with their ability to accumulate in organisms and the environment.

Air quality standards

EU Member States are obliged to implement EU-level agreements on air quality into their legal systems. In most countries, the air quality regulations are based on fixed limit values. Air quality standards in force in the European Union Member States are determined in EU directives on the concentration of pollutants in the air, which should not be exceeded for the sake of protecting human health and crops. In October 2024, the European Union Council adopted a new directive, **Ambient Air Quality Directive (AAQD)**, which introduced more stringent limits for key air pollutants, above all for PM_{2.5} and PM₁₀ particulate matters and nitrogen dioxide (NO₂). 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...

only **1% of land on Earth** meets the air quality standards that are considered safe for human health?



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 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 PM2.5 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, an overall direct harmful effect on human health or the environment is unlikely. The level is to be achieved in the long term, except for situations where it cannot be achieved using economically viable technical and technological measures.

Table 1. Permissible levels of air pollutants due to human life and crop protection and permitted frequency of exceeding them

Substance name	Averaging period of measurement results	Level permissible level	Permitted frequency of exceeding the limit in a calendar year
Benzene (C ₆ H ₆)	calendar year	5 ¹⁾	-
Nitrogen dioxide (NO ₂)	1 hour	200 ¹⁾	18 times
	calendar year	40 ¹⁾	-
Nitrogen oxides	calendar year	30 ¹⁾	-
Sulphur dioxide (SO ₂)	1 hour	350 ¹⁾	24 times
	24 hours	125 ¹⁾	3 times
	calendar year and winter season (from 1 Jan to 31 Mar)	20 ¹⁾	-
Carbon monoxide (CO)	8 hours	10,000 ^{1) 2)}	-
PM ₁₀	24 hours	50 ¹⁾	35 times
	calendar year	40 ¹⁾	-
PM _{2.5}	calendar year	25 ^{1) 3)}	-
	calendar year	20 ^{1) 4)}	-
Lead (Pb) ⁵⁾	calendar year	0.5 ¹⁾	-

¹⁾ Permissible level due to human health.

²⁾ Maximum 8-hour average, from rolling averages, calculated every hour from eight 1-hour averages in a day. Each such calculated 8-hour average is assigned to a day during which it ends; the first calculating period for each day is the period from 5:00 pm of the previous day until 10:00 am of a given day; the last calculating period for each day is the period from 4:00 pm until midnight of that day Central European Time (CET).

³⁾ The permissible level for PM_{2.5} to be achieved until 1 January 2015 (stage I).

⁴⁾ The permissible level for PM_{2.5} to be achieved until 1 January 2020 (stage II).

⁵⁾ Sum of the metal and its compounds in PM₁₀.

Source: 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; <https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20210000845/O/D20210845.pdf>.

Table 2. Target levels of air pollutants due to human life and crop protection and permitted frequency of exceeding them

Substance name	Averaging period of measurement results	Target level	Permissible frequency of exceeding the target level in a calendar year
Ozone (O ₃)	8 hours	120 µg/m ³ ^{1) 2)}	25 days ³⁾
	growing season (1 May – 31 July)	18 000 µg/m ³ .h ^{4) 5) 6)}	-
PM _{2.5}	calendar year	25 µg/m ³ ¹⁾	-
Arsenic (As) ⁷⁾	calendar year	6 ng/m ³ ¹⁾	-
Nickel (Ni) ⁷⁾	calendar year	20 ng/m ³ ¹⁾	-
Cadmium (Cd) ⁷⁾	calendar year	5 ng/m ³ ¹⁾	-
Benzo(a)pyrene ⁸⁾	calendar year	1 ng/m ³	-

¹⁾ Target level due to human health.

²⁾ The maximum 8-hour average from among rolling averages; each such calculated 8-hour average is assigned to a day during which it ends; the first calculating period for each day is the period from 5:00 pm of the previous day until 10:00 am of a given day; the last

calculating period for each day is the period from 4:00 pm until midnight of that day Central European Time (CET).

³⁾ Number of days with exceeded target level in a calendar year averaged over the next three years. In the absence of measurement data for three years, compliance with the permitted frequency of exceedances is verified on the basis of measurement data for at least one year.

⁴⁾ Target level due to crop protection.

⁵⁾ Expressed as AOT 40, which means the sum of differences between the 1-hour average concentration expressed in $\mu\text{g}/\text{m}^3$ and the value of $80 \mu\text{g}/\text{m}^3$, for each hour in a day between 8:00 am and 8:00 pm CET for which the concentration exceeds $80 \mu\text{g}/\text{m}^3$; if there are gaps in the measurement series, the calculated AOT 40 value should be multiplied by the quotient of the number of possible measurement dates and the number of measurements taken during that period.

⁶⁾ The average value for the next five years; in the absence of measurement data from five years, compliance with the permitted frequency of exceedances is verified based on measurement data from at least three years.

⁷⁾ Sum of the metal and its compounds in PM₁₀.

⁸⁾ The overall content of benzo(a)pyrene in PM₁₀.

Source: 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; <https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20210000845/O/D20210845.pdf>.

Table 3. The long-term target levels for ozone in the air due to human life and crop protection

Substance for substances	Averaging period of measurement results	Level of long-term targets name in the air	Deadline for achieving long-term targets for substances in the air
ozone	eight hours ¹⁾	$120 \mu\text{g}/\text{m}^3$ ^{1) 2)}	2020
	growing season (1 May – 31 July)	6000 ³⁾ $\mu\text{g}/\text{m}^3 \cdot \text{h}$	2020

¹⁾ The maximum 8-hour average in a calendar year from among rolling averages; each such calculated 8-hour average is assigned to a day during which it ends; the first calculating period for each day is the period from 5:00 pm of the previous day until 10:00 am of a given day; the last calculating period for each day is the period from 4:00 pm until midnight of that day Central European Time (CET).

²⁾ Long-term target level due to human life protection.

³⁾ Long-term target level due to crop protection.

Source: 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; <https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20210000845/O/D20210845.pdf>.

Air quality index

Monitoring of air quality in Poland is carried out as part of the National Environmental Monitoring, according to the “Strategic programme for the national environmental monitoring for 2020-2025” document, and result directly from the Act of 20 July 1991 on Environmental Protection Inspection (Journal of Laws of 2024, item 425).

The air quality index makes it possible to assess air quality in 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, PM_{2.5}, 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 4. 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 5. 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_informations.

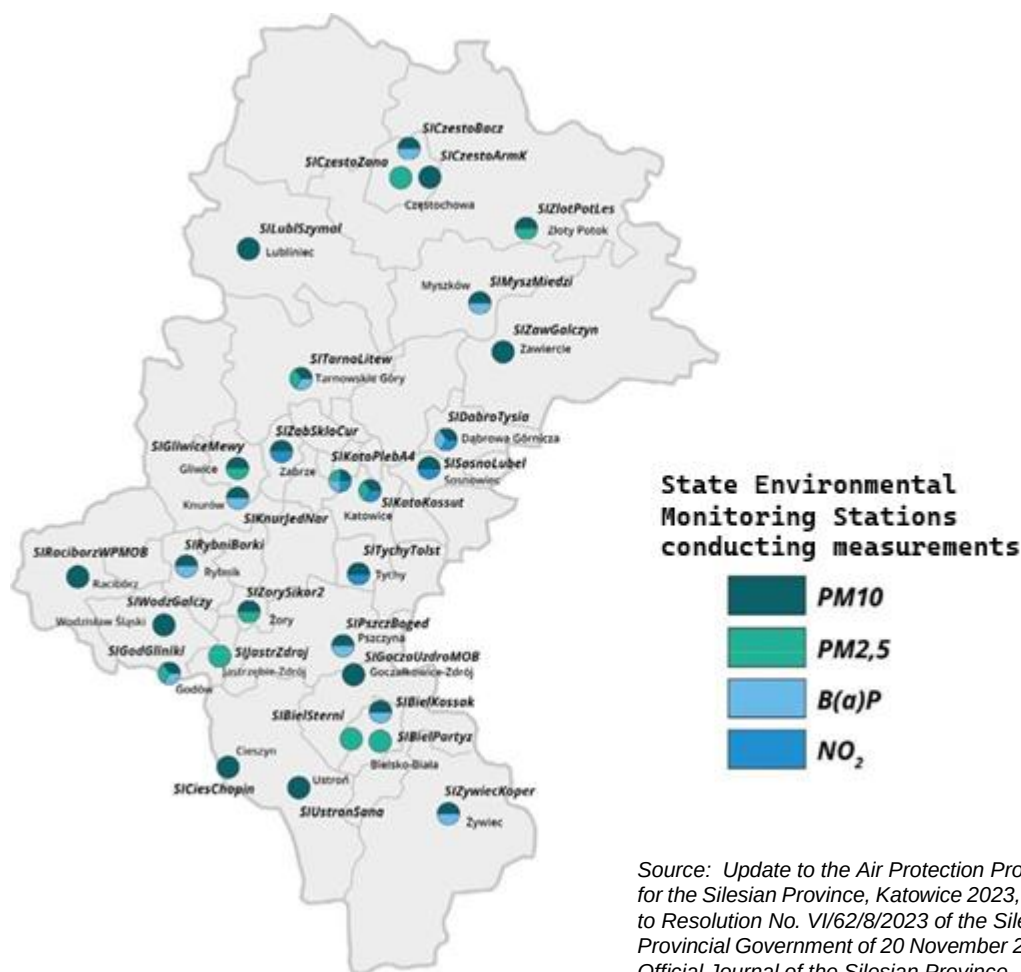
Air quality zones

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.

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



Source: Update to 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

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

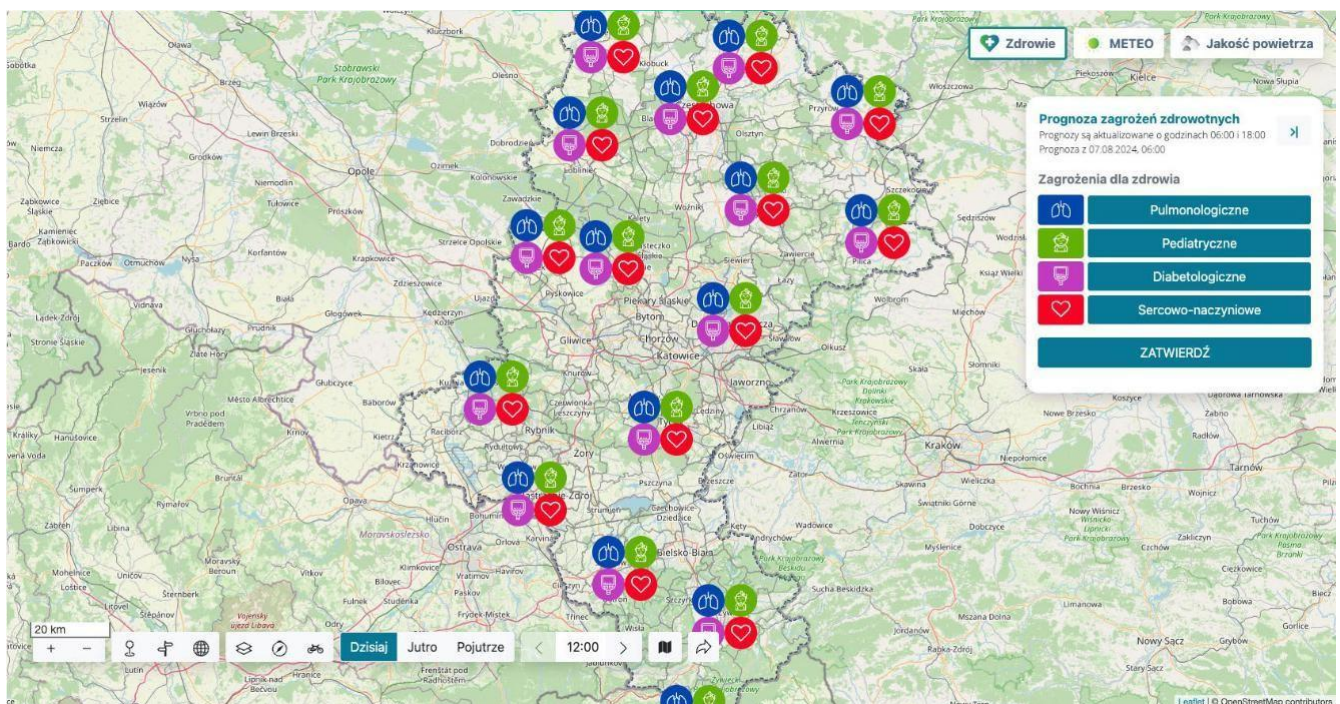
- class A – if the pollution concentration in the area does not exceed permissible levels, target levels, and long-term target levels,
- class C – if the pollution concentration in the area exceeds permissible levels or target level plus the tolerance margin, if the margin is determined,
- class D1 – 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://slaskie-smogstop.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%9BI%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>

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Lesson ideas

1. Using the problem tree method, present the causes and effects of poor air quality in the Silesian Province.
The problem tree method is used to identify problems/barriers to development, which graphically presents cause-and-effect relationships. Causes of the defined problem, which is put in the centre of the graphic, are presented at the bottom of the graphic and the effects of its persistence are presented at the top. The problem tree has a complex structure – it defines the root causes (primary causes) and secondary effects.
2. Using the goal tree method, transform the effects of poor air quality in the Silesian Province into goals to be achieved.
The goal tree method mirrors the problem tree where the problem is transformed into the desired state (goal). Similarly to the problem tree, the goal tree has a graphic form. In the centre, there is a goal, the bottom represents means to achieve the goal, and the top – effects of achieving the goal.

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:

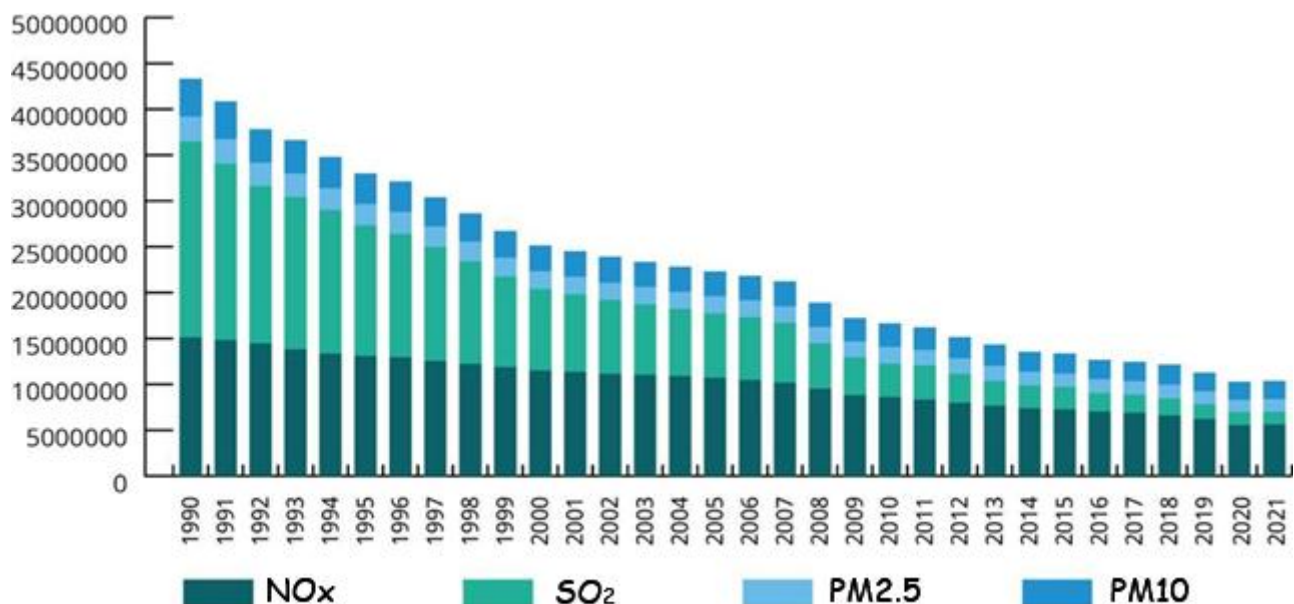
- energy facilities (producing electricity and heat in power plants and power stations, heating plants, refineries and others),
- industrial plants,
- municipal boiler rooms,
- individual (domestic) furnaces,
- transport (road, air, rail and shipping),
- wastewater and waste management (e.g. dumps or 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 related to industrial and transport activities. In 2021, as many as 97% of city residents worldwide were exposed to concentrations of PM2.5 fine particulate matter (the most harmful to human health) exceeding World Health Organisation (WHO) guidelines.

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);

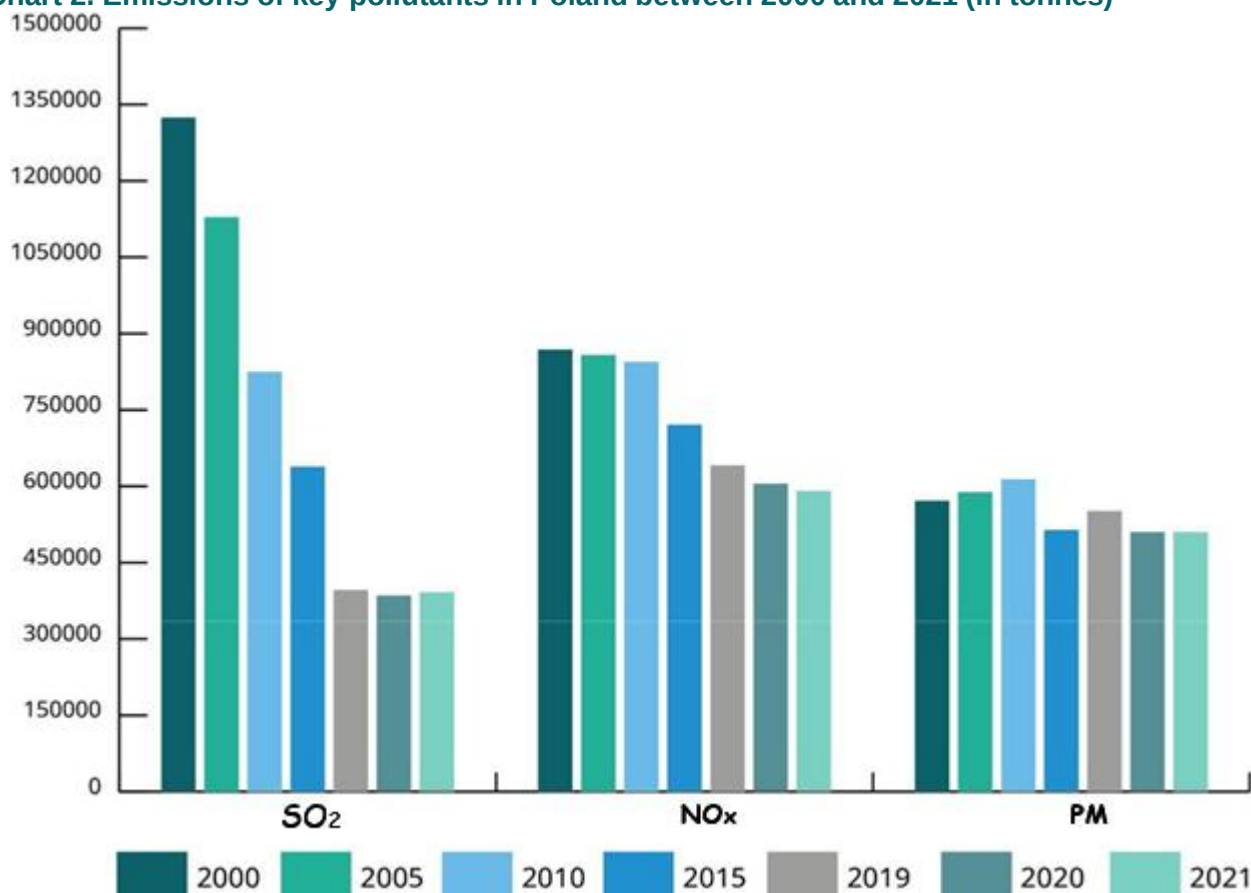
https://ec.europa.eu/eurostat/databrowser/view/env_air_emis_custom_8249852/default/table?lang=en.

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), and for 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)



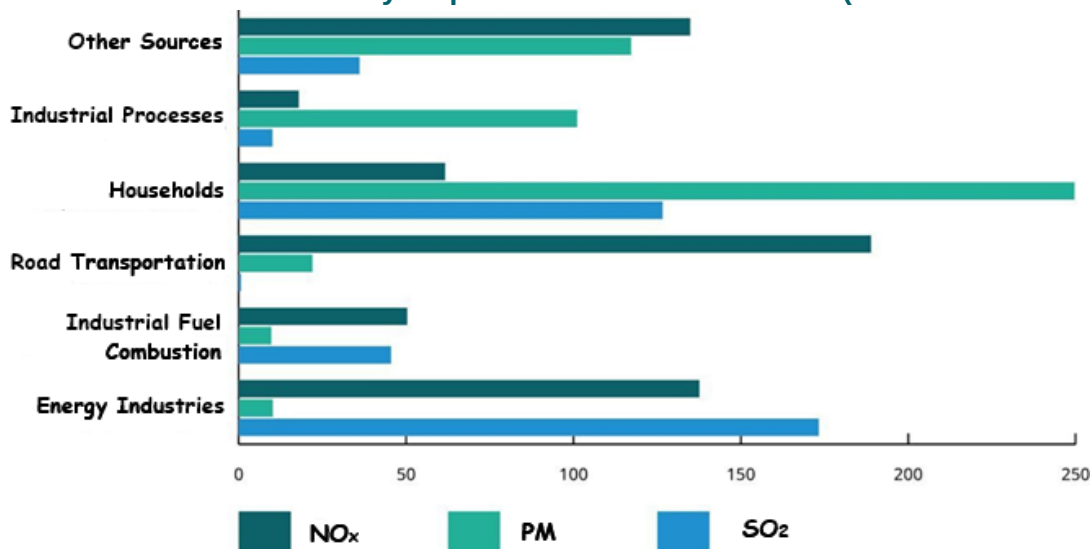
Dust – particulate matter with diameters below 1 mm that adversely affect human health and the environment state and quality.

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, as well as 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 [Low-carbon economy policy for the Silesian Province. Regional energy policy until 2030, Marshal's Office of the Silesian Province, Katowice 2020]

- **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 towns per 10,000 km² (almost twice as high as the average for Poland, which is 31 towns per 10,000 km²) [Statistics Poland, Local Data Bank, access: 24 May 2024].

- **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). The specific nature of the Silesian Province is also shown by the ratio of the urban population to the total population. In this regard,

the region ranked first in the country in 2022 with a ratio of 75,9% compared to the Polish average of 59.6% [Statistics Poland, Local Data Bank, access: 24 May 2024].

- **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). Buildings erected between 1945 and 1970 have a significant share in the regional structure of residential buildings (36.4% compared to 31.0% nationally) [Statistics Poland, National Census of Population and Housing 2021, *Housing conditions in Poland in light of the results of the National Census of Population and Housing 2021*].

- **dense road network and large number of vehicles**

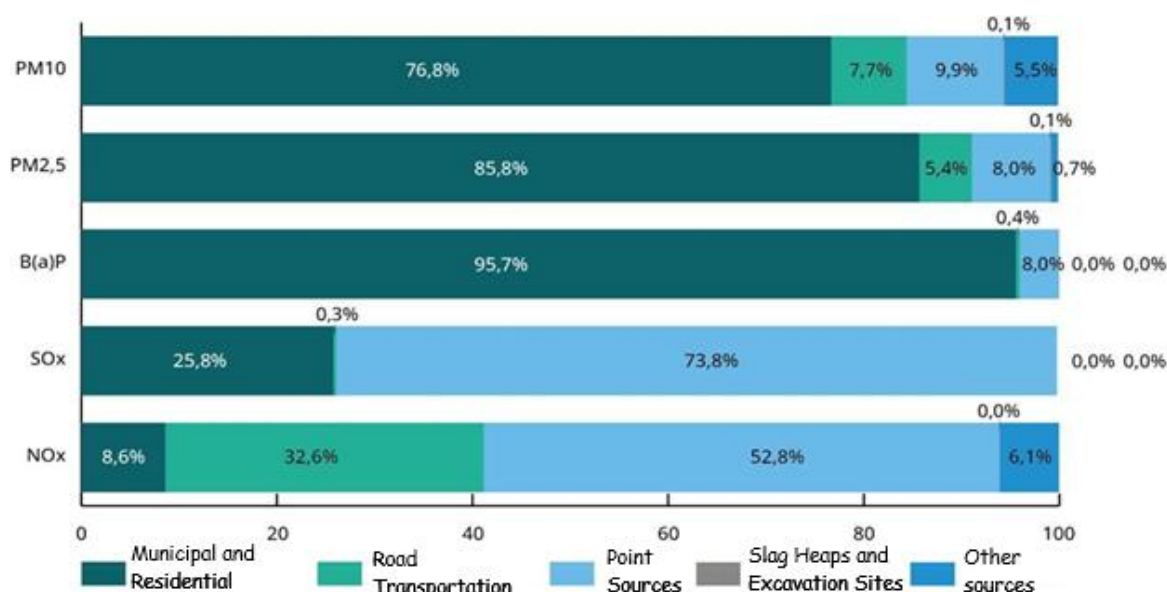
Density of public roads in the Silesian Province in 2022 ranked second in the country (201,0 km per 100 km²) and exceeded the state average of 136,7 km per 100 km² by a mile. Similarly, the region held its second place in the country with regard to the number of cars and tractors (3,6 million) [Statistics Poland, Local Data Bank, access: 24 May 2024].

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.

Transport significantly contributes to overall emissions near roads (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 PM2.5 emissions in the Province. In the country, the Silesian Province accounts for around 9% of road transport pollution emissions.

Industrial activity also had a significant 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 local sources 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. For 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 the 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 concentrations 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 6. 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
		target 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_SI/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. They are 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 height emissions with low-carbon economy**, that is the activities of states and governments aiming to curb emissions of harmful substances into the air, 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 PM_{2.5}, 10.9% for benzo(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 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...

approximately **6.1 million tonnes of dust** from the wearing of car tyres ends up in the atmosphere and water worldwide every year?



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 (maximum amounts of nitrogen oxides, carbon oxides, hydrocarbons and particulate matters emitted in exhaust fumes of internal combustion engine vehicles). These standards have been in force since 1993 and have been regularly amended to make them more and more strict. 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.

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 levels**

[<http://smog.imgw.pl/content/weather>]. 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...

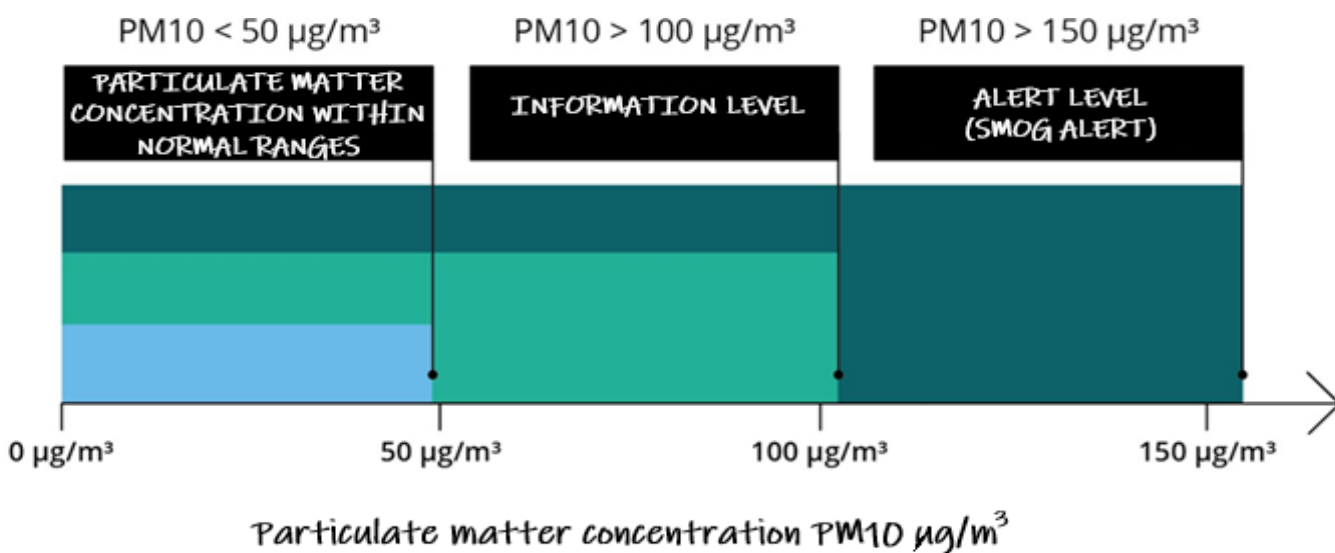
the information about the Great Wall of China being visible from space is a myth, but the huge smog cloud stretching over India from New Delhi to the Bay of Bengal is actually visible from space?



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 PM2.5, as well as benzo(a)pyrene. 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 PM2.5 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/omni-calculator-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.

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- [12] <http://smog.imgw.pl/content/weather>.

Lesson ideas

1. Hold an Oxford debate on: "Private cars should be totally banned from entering city centres." *An Oxford debate is a type of discussion where two teams argue over the rightness of the thesis put forward in the debate. The task of one of them is to prove the rightness of the thesis, while the other is to provide arguments against it. The outcome of the debate is subject to assessment.*
2. Brainstorm on the topic: "How the city authorities can effectively encourage the fight against air pollution?"
Brainstorming is a type of discussion that involves presenting many possible solutions to a given problem. Every idea is recorded, and only in the next stage are they assessed according to the adopted criteria.

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.

Table 7. 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

Did you know that...

- 1) air pollution currently **ranks fourth among the main risk factors for morbidity and mortality globally**, yielding only to high blood pressure, smoking addiction and unhealthy eating?
- 2) air pollution reduces global life expectancy by an average of 1.8 years?



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 negatively affects children's health, even during the foetal period [<https://pulsmedycyny.pl/zanieczyszczenia-powietrza-moga-zaburzac-rozwoj-plodu-i-wzrost-dzieci-badania-1121506>]. 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 much more 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 particulate matter 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...

when breathing polluted air, one feels its effects in a similar way to smoking cigarettes? By breathing smog air for two hours a day in highly polluted cities, one passively "smokes" over 2,000 cigarettes a year (7 a day).



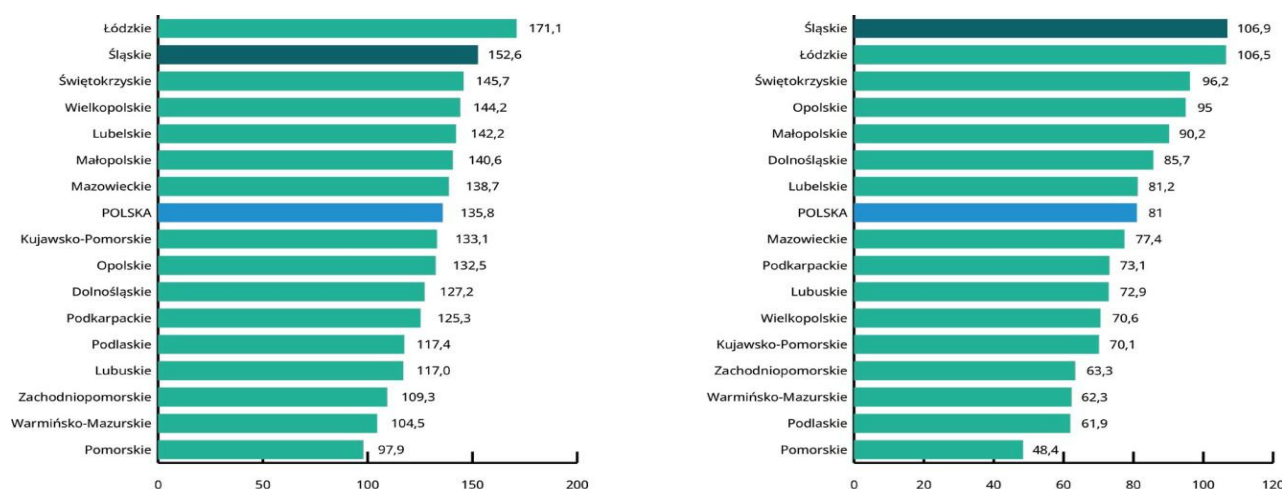
Research that confirms the strong relationship between elevated daily average concentrations of air pollution and the elevated number of daily hospital admissions due to exacerbation of respiratory and cardiovascular system disease symptoms was carried out in the Upper-Silesian agglomeration by the Medical University of Silesia in Katowice Kowalska M., Zejda E.J., Ośródk L., Chwirut A., Kondek P., Daily number of hospital admissions due to cardiovascular and respiratory diseases and air pollution in Zabrze, between 2001 and 2005, *Probl Hig Epidemiol*, 89(1):41-46, 2008; Dzubanek G.,

Marchwińska – Wyrwał E., Piekut A., Rusin M., Hajok I., Air pollution as a significant modifiable health risk factor, *Hygeia Public Health*, 49 (1): 75-80, 2014]. By comparing data on all causes of hospitalisations between 2006 and 2012 available in the Silesian Cardiovascular Database with data from the Provincial Inspectorate for Environmental Protection in Katowice on air quality in the indicated timeframe, the following has been shown:

- 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,
- increased number of visits to primary health care clinics at higher concentrations of nitrogen oxides, PM10 particulate matter,
- 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,
- the relationship 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 [Cieślik A., The relationship between air pollution and the incidence of acute cardiovascular diseases and mortality among residents of the Upper-Silesian agglomeration. Theses for the initiation of doctoral studies in medical sciences, Third Department and Clinical Division of Cardiology, Faculty of Medicine with the Division of Medicine and Dentistry in Zabrze, Medical University of Silesia in Katowice, 2016].

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 2019 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.

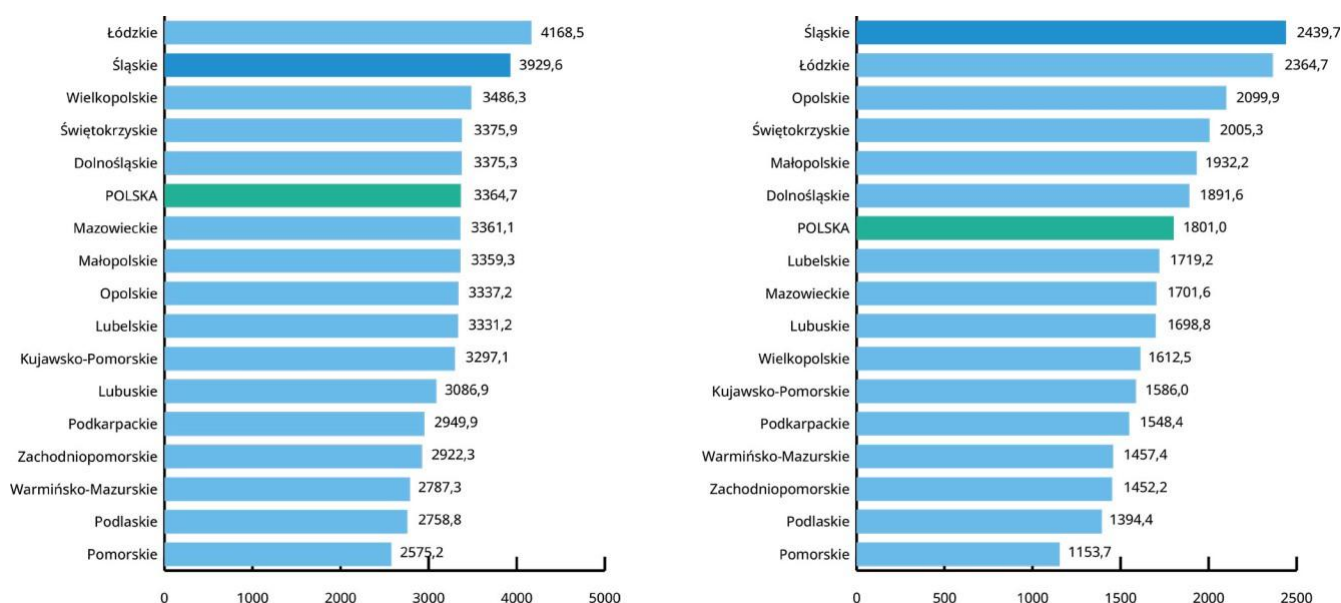
Chart 5. Number of deaths caused by air pollution per 100,000 inhabitants in 1990 (left chart) and 2019 (right chart)



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

A corresponding situation took place in terms of the DALY (*Disability Adjusted Life Years*) index. Also in this case, the Silesian Province, despite the positive changes and decrease in the index level observed between 1990 and 2019, replaced the Łódzkie Province on the first place in Poland.

Chart 6. DALY (Disability Adjusted Life Years) index level due to air pollution per 100,000 residents in 1990 (left chart) and in 2019 (right chart)



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

According to analyses by the WHO, even a small ($0.5 \mu\text{g}/\text{m}^3$) reduction in PM_{2.5} concentration in the Silesian Province will give almost 11 months of life to every resident of the region in long-term exposure, while a PM_{2.5} reduction to the level recommended by the WHO ($10 \mu\text{g}/\text{m}^3$) would give even 5.5 years to each resident [Korczyńska A., Kowalska M., Variation in average life expectancy in selected subregions of the Silesian Province and air quality in 2008–2012, *Medycyna Środowiskowa – Environmental Medicine*, Vol. 17, No. 4, 47-53, 2014]

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. The first type of costs cover the costs related to 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.** [<https://pulsmedycyny.pl/ile-kosztuje-nas-leczenie-chorob-spowodowanych-zanieczyszczeniem-po-wietrze-raport-epha-1146396>]. 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 4919. Heat pumps do not contribute directly to the occurrence of

air pollution, which means that **replacing coal furnaces with heat pumps could significantly reduce the health-related socio-economic costs of air pollution.**

In the Silesian Province, the costs of poor air quality calculated based on the volume of PM2.5 emission was estimated in 2022 at nearly PLN 5 billion, i.e. around twice the Silesian Province's budget at that time.

Table 8. Costs of poor air quality based on the volume of PM2.5 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

[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.

[2] Mielecka-Kubień Z., Wójcik A., Air pollution and the health of residents of large cities in the Silesian Province, *Wiomości Statystyczne. The Polish Statistician*, 2020, vol. 65, 6, 39–51; https://ws.stat.gov.pl/WS/2020/6/gus_ws_2020_06_zofia_mielecka-kubien_andrzej_wojcik_zanieczyszczenie_powietrza_a_stan_zdrowia_mieszkancow.pdf.

[3] Schraufnagel D. E., Balmes J. R., Cowl C. T. et al., *Air Pollution and Noncommunicable Diseases: A Review by the Forum of International Respiratory Societies' Environmental Committee, Part 2: Air Pollution and Organ Systems*, Chest 2019; Vol. 155, Issue 2, pp. 417-426; [https://journal.chestnet.org/article/S0012-3692\(18\)32722-3/abstract](https://journal.chestnet.org/article/S0012-3692(18)32722-3/abstract).

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

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

[6] <https://pulsmedycyny.pl/zanieczyszczenia-powietrza-moga-zaburzac-rozwoj-plodu-i-wzrost-dzieci-badania-1121506>.

[7] <https://pulsmedycyny.pl/ile-kosztuje-nas-leczenie-chorob-spowodowanych-zanieczyszczeniem-powietrza-raport-epha-1146396>.

Lesson ideas

1. Create an artificial lung and test its operation. To do this, you need a transparent 1.5 litre PET bottle, two straws, two balloons, plasticine, four rubber bands, a latex glove, a craft knife/scissors and adhesive tape. Beforehand, check out the explanatory material on the website of the Industria Energy Science Centre: <https://www.youtube.com/watch?v=g0DvLNz2CPA>.
2. Develop a meta-plan of activities leading to a reduction of socio-economic costs resulting from air pollution in the Silesian Province within the next 5 years.

5. WAYS TO PREVENT LOW EMISSION

Regional low-carbon economy policy is pursued within the framework of strategic documents adopted at the level of the European Union, Poland and the region. 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 – assuming the support of multimodal transport and electromobility.

The above-mentioned issues that set the direction for energy transition of the Silesian Province and areas of actions taken to improve air quality are included in the *Low-carbon economy policy for the Silesian Province document. The regional energy policy until 2030* adopted by Resolution of the Silesian Province Management Board No. 2873/194/VI/2020 of 9 December 2020.

Did you know that...

one of the major Polish companies from the fuel sector, in cooperation with scientists from a Polish university, developed an innovative asphalt surface that absorbs air pollution? Eco-asphalt, which contains photocatalytic material that causes pollutants to decompose under the influence of sunlight, reduces not only the substances emitted by vehicles, but also the level of carcinogenic compounds from heating homes with conventional fuels.



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 residents of the region 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, as well as production and technological processes. These regulations, effective from 1 September 2017, apply to the entire municipal and residential sector, as well as to business activities where boilers with a capacity not exceeding 1 MW are used. The resolution bans the use of:

1. lignite and solid fuels produced using this coal,
2. silt and coal flotation concentrates, as well as mixtures produced with their use,
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 9. 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. They operate locally, providing advisory services to residents and initiating and coordinating local activities to improve air quality. Thanks to their work, residents gain not only knowledge but also support in obtaining funds for replacing old furnaces and modernising 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.

The table below shows tangible results of the Air Protection Programme for the Silesian Province achieved in 2023.

Table 10. Report on the implementation of the Air Protection Programme for the Silesian Province for 2023, Katowice 2023

Tangible result type	Upper Silesia Agglomeration	Rybnik-Jastrzębie Agglomeration	Bielsko-Biała City	Częstochowa City	Silesian Zone	All
Number of buildings connected to the district heating network	1 612	69	150	1	411	2 243
Number of buildings where inefficient, individual solid fuel heating sources were removed and replaced with:						
- gas	3 700	906	610	310	4 834	10 360
- renewable heat source (heat pump)	863	449	121	298	5610	7 341
- coal furnace meeting the ecodesign requirements*	80	108	0	0	375	563
- biomass furnace meeting the ecodesign requirements*	144	90	2	0	1 487	1 723
- electric heating	781	14	55	2	300	1 152
- oil heating	13	1	0	0	13	27
Number of buildings where thermal modernisation was carried out	1 044	241	30	125	4 093	5 533

* Ecodesign is a European Parliament directive that came into force on 1 January 2020, which concerns energy and emission requirements for all heating equipment sold on the market.

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, PM2.5, and bezno(a)pyrene emissions, as shown in the table below.

Table 11. Ecological effects of the implementation of the Air Protection Programme for the Silesian Province for 2023

Tangible result type	Upper Silesia Agglomeration	Rybnik-Jastrzębie Agglomeration	Bielsko-Biała City	Częstochowa City	Silesian Zone	All
PM10 emission reduction [Mg/year]	295.48	122.66	55.79	52.90	1 125.51	1 652.34
PM2.5 emission reduction [Mg/year]	291.13	120.91	54.96	52.11	1 109.15	1 628.26
B(a)P emission reduction [kg/year]	168.26	69.81	31.77	30.12	641.06	941.02

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 actions are subject to funding:

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

Of all 2,477 municipalities in Poland, the two municipalities with the highest number of applications submitted under the Clean Air Programme in 2018–2023 are located in the Silesian Province. They are: Rybnik (6,481 applications) and Częstochowa (3,490 applications). The top ten comprises 6 Silesian municipalities, and top twenty – 9 municipalities.

Table 12. Ranking of municipalities in the Clean Air Programme in terms of the number of applications submitted, 2018–2023

Place in the ranking	Municipality	Province	Number of applications
1	Rybnik	Silesian	6 481
2	Częstochowa	Silesian	3 490
3	Łódź	Łódzkie	3 053
4	Jaworzno	Silesian	2 572
5	Radom	Mazovian	2 423
6	Bielsko-Biała	Silesian	2,404
7	Kielce	Świętokrzyskie	2,225
8	Kraków	Lesser Poland	2,197
9	Czerwionka-Leszczyny	Silesian	2,184
10	Wodzisław Śląski	Silesian	2,170
11	Pszczyna	Silesian	2,110
12	Warsaw	Mazovian	1,936
13	Jastrzębie-Zdrój	Silesian	1,789
14	Rzeszów	Podkarpackie	1,778
15	Bydgoszcz	Kuyavian–Pomeranian	1,749
16	Gorzyce	Silesian	1,718
17	Skawina	Lesser Poland	1,681
18	Białystok	Podlaskie	1,666
19	Poznań	Greater Poland	1,651
20	Kartuzy	Pomeranian	1,648

Source: Polish Smog Alert based on data from the National Fund for Environmental Protection and Water Management; <https://polskialarmmogowy.pl/2024/04/czyste-powietrze-jest-tam-gdzie-sa--aktywne-gminy-ranking-pas/>.

In terms of the number of applications per number of single-family buildings in the municipality, the Silesian municipality of Radlin is the leader in Poland. As many as 16 municipalities from the Silesian Province were among the top 20 most active municipalities in the country.

Table 13. Ranking of municipalities in the Clean Air Programme in terms of the number of applications submitted per the number of single-family houses in the municipality, 2018–2023

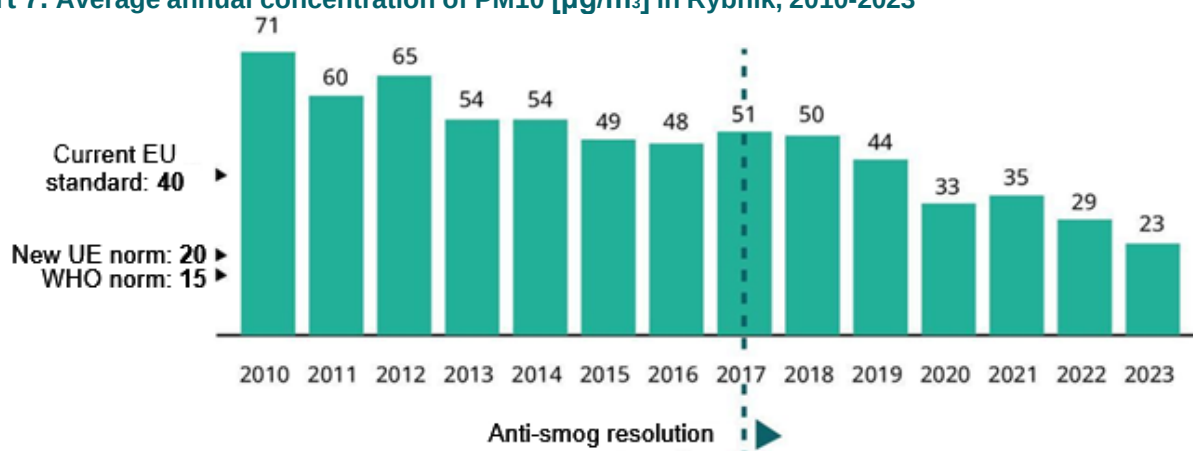
Place in ranking	Municipality	Province	Numbers of applications
1	Radlin	Silesian	1,053
2	Jejkowice	Silesian	370
3	Rydułtowy	Silesian	1,339
4	Górno	Świętokrzyskie	1,285
5	Lyski	Silesian	877

6	Igołomia-Wawrzeńczyce	Lesser Poland	742
7	Godów	Silesian	1,314
8	Wodzisław Śląski	Silesian	2,170
9	Gaszowice	Silesian	866
10	Pszczów	Silesian	803
11	Rybnik	Silesian	6,481
12	Kalety	Silesian	619
13	Lubomia	Silesian	636
14	Gorzyce	Silesian	1,718
15	Czerwionka-Leszczyny	Silesian	2,184
16	Czernikowo	Kuyavian–Pomeranian	647
17	Boronów	Silesian	296
18	Masłów	Świętokrzyskie	966
19	Kornowac	Silesian	404
20	Mszana	Silesian	612

Source: Polish Smog Alert based on data from the National Fund for Environmental Protection and Water Management; <https://polskialarmsmogowy.pl/2024/04/czyste-powietrze-jest-tam-gdzie-sa-aktywne-gminy-ranking-pas/>.

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. The results achieved in terms of improving air quality in Rybnik are spectacular. 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.

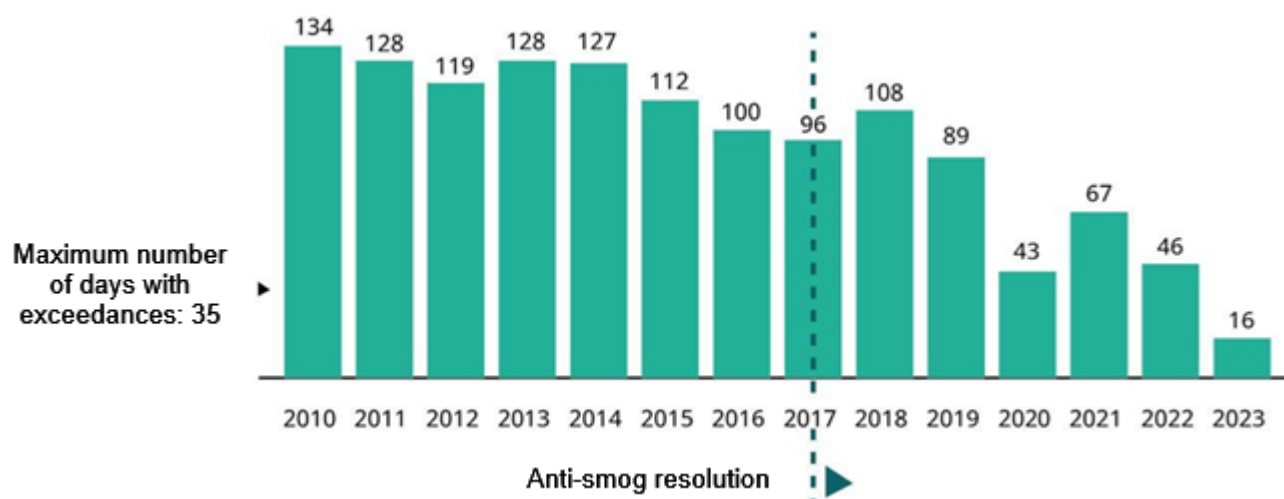
Chart 7. Average annual concentration of PM10 [$\mu\text{g}/\text{m}_3$] in Rybnik, 2010-2023



Source: data from the Chief Inspectorate for Environmental Protection

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”.

Chart 8. Number of days with exceedances of the daily permissible level of PM10 in Rybnik, 2010-2023



Source: data from the Chief Inspectorate for Environmental Protection

In areas where anti-smog resolutions are in place, the **Stop Smog Programme** is carried out. 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 the municipality. 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: przywracamyblekit.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>.

[2] *Air Protection Programme for the Silesian Province*, Resolution No. VI/21/12/2020 of the Silesian Province Government of 22 June 2020, Official Journal of the Silesian Province, Katowice, 29 June 2020, item 507; <https://bip.slaskie.pl/resource/27529/25006/Uchwa%25C5%2582a.VI.21.12.2020.2020-06-22.pdf>.

[3] *Report on the implementation of the Air Protection Programme for the Silesian Province for 2023*, Katowice 2024;
<https://powietrze.slaskie.pl/download/content/3238>.

[4] 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>.

[5] <https://polskialarmsmogowy.pl/2024/04/czyste-powietrze-jest-tam-gdzie-sa-aktywne-gminy-ranking-pas/>.

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Lesson ideas

1. Divide the students into two groups and suggest an educational game that promotes environmentally friendly activities for children aged 7-10 (group 1) and ecological educational activities for teenagers aged 11-15 (group 2).
2. Hold an Oxford debate on: "The development of electromobility is the most effective way to prevent low emission."

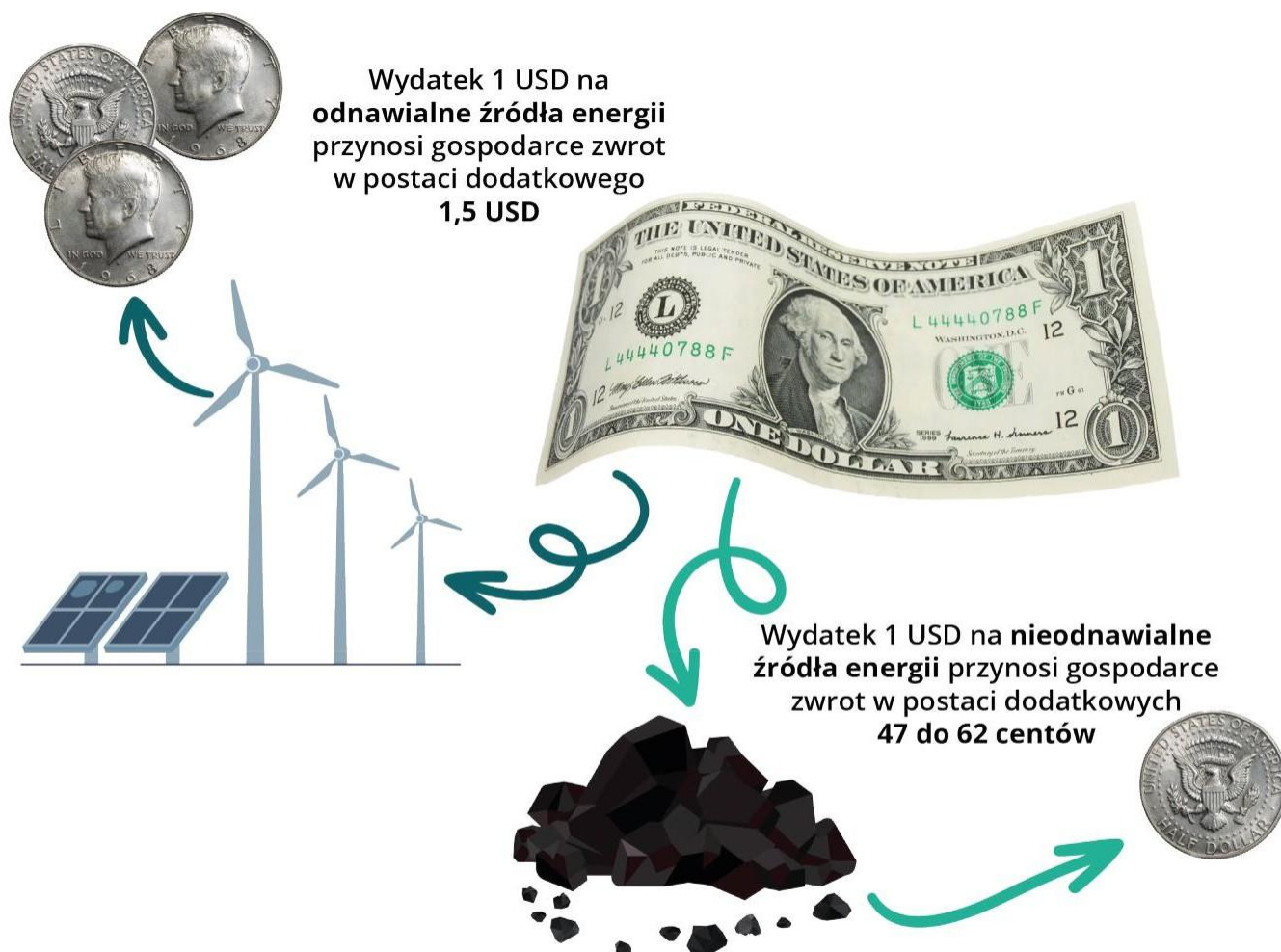
6. RENEWABLE ENERGY SOURCES AS THE ENERGY TRANSITION INSTRUMENT

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, 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.

Apart from benefits for the environment, using renewable energy sources also benefits the economy. It results from the International Monetary Fund's calculations that spending USD 1 on renewable energy sources brings a 150% return to the economy (multiplier of 1.5).



The corresponding multiplier for non-renewable energy sources is around 3 times lower and fluctuates between 0.47 and 0.62. Investment in RES translates into the GDP rise – increasing energy production from renewable energy sources by 1% increases the GDP by 0.03-0.04%, depending on the energy source.

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).

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).

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	
• 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

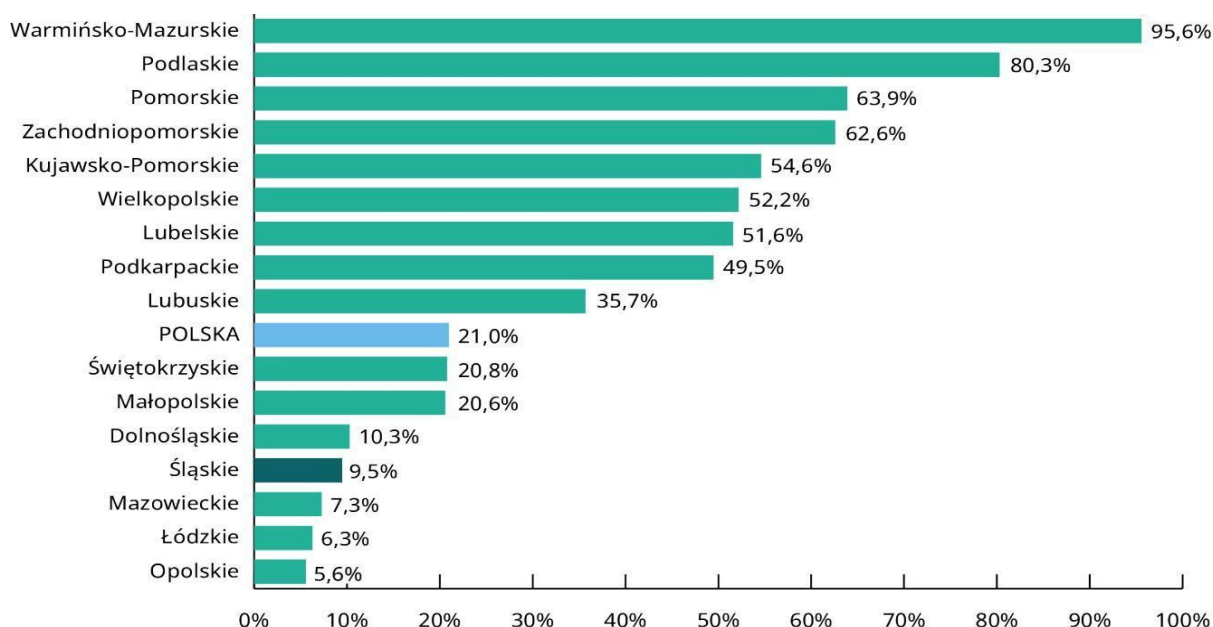
Pros	Cons
Water energy – sea waves energy	
• very clean energy source	• very high sea power plant construction costs • building a power plants entails the occupation of large areas of the sea coast
Water energy – tidal energy	
• very clean energy source • a reliable source of energy – seawater rises 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. Zablocki, *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, over 1.4 million micro-installations¹ generating electricity were connected to the power grids in Poland with the total installed capacity of nearly 11.3 GW. The Silesian Province ranks among the lowest in Poland in terms of the share of renewable energy in total electricity production in 2022, with a rate more than twice lower (9.5%) than 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 9. 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].

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.

Compared to 2017, the share of RES in overall production of energy increased in the Silesian Province by 6.3% in 2022 and slightly deviated from the national average (6.8%). Particularly high growth in energy production from renewable sources was recorded in the following provinces: Greater Poland (37.5%), Lubelskie (28.1%), Podlaskie (25.6%) and Podkarpackie (23.8%).

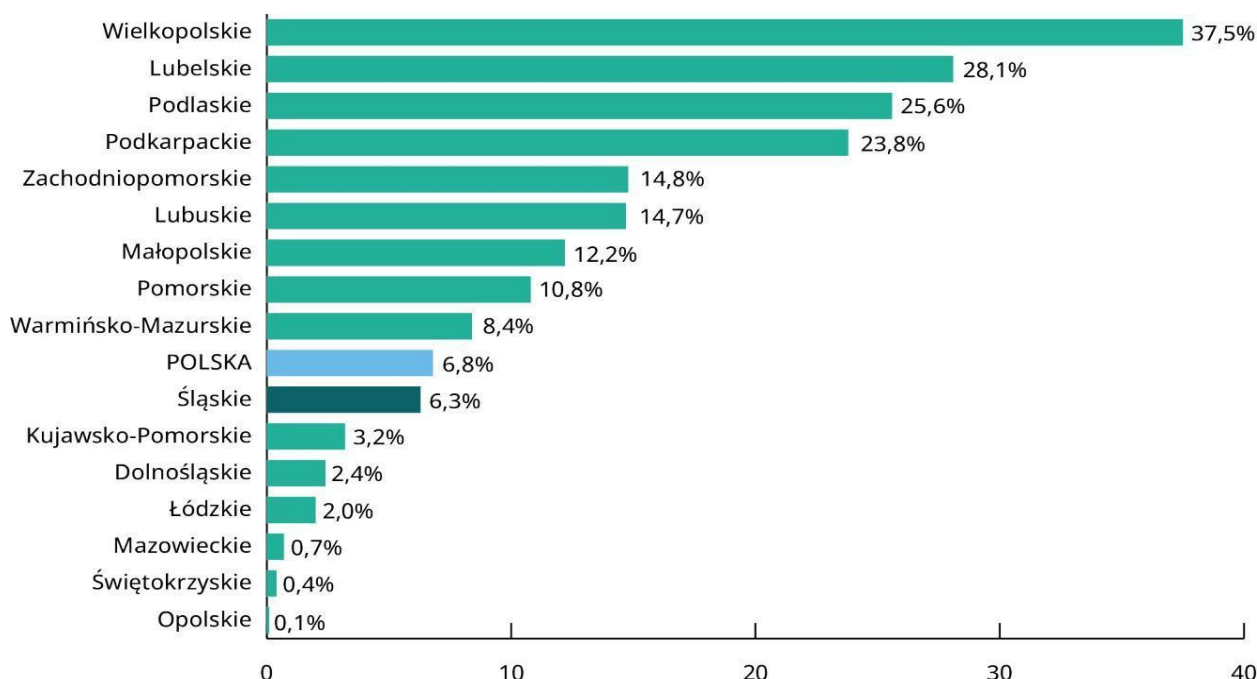
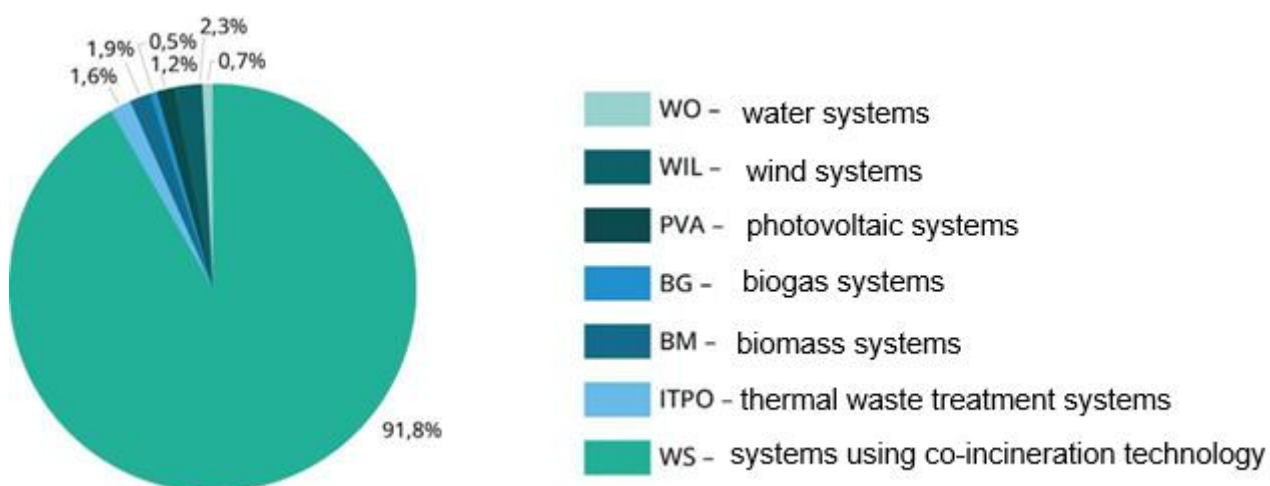


Chart 10. Change in the share of renewable energy in electricity production by province, 2017–2022

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].

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 installations) is dominated by installations burning biomass, bioliquids, biogas, or agricultural biogas with other fuels (91.8%).

Chart 11. Structure of renewable energy sources in the Silesian Province as at 30 June 2023.

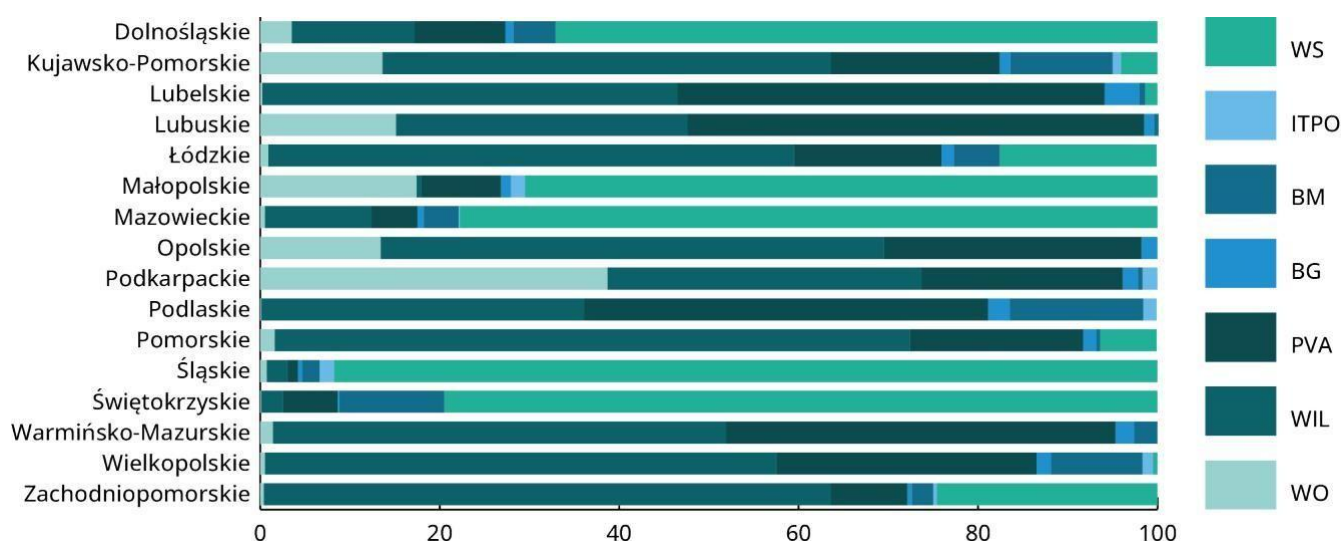


Note: Micro-installations, including prosumer installations, are not included in the published data.

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 12. 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)].

SOURCES

[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>.

[2] Statistics Poland, Local Data Bank; <https://bdl.stat.gov.pl/bdl/start>.

[3] International Energy Agency, *Renewables 2023. Analysis and forecast to 2028*, January 2024; https://iea.blob.core.windows.net/assets/96d66a8b-d502-476b-ba94-54ffda84cf72/Renewables_2023.pdf.

[4] Juszczak A., Pilszyk M., Miniszewski M., Kania K., Tomasiak T., Wiącek M., *The costs of not decarbonising the economy*, Polish Economic Institute, Warsaw 2023; <https://pie.net.pl/wp-content/uploads/2023/12/Dekarbonizacja.pdf>.

[5] Euro-Centrum Science and Technology Park, *Renewable Energy Market in the Silesian Province*, Katowice 2013; <http://pnt.euro-centrum.com.pl/files/post/830/Rynek-odnawialnych-zrodel-energii-w-wojewodztwie-slaskim.pdf>.

[6] Energy Regulatory Office; www.ure.gov.pl.

[7] Act of 20 February 2015 on renewable energy sources, Journal of Laws of 2015, item 478; <https://isap.sejm.gov.pl/isap.nsf/download.xsp/WDU20150000478/U/D20150478Lj.pdf> (consolidated text).

[8] Zabłocki M., *The conventional and renewable energy sources sector in Poland. Conditions and problems of development*, doctoral thesis, Poznań 2021; <https://www.wbc.poznan.pl/Content/506459/download/>.

Lesson ideas

1. Using the SWOT analysis (analysis of strengths, weaknesses, opportunities, and threats), analyse perspectives for the development of renewable energy sources in the Silesian Province. *The SWOT method presents the strengths, weaknesses, opportunities and threats of the analysed entity or issue in tabular form.*
2. Hold an Oxford debate on: “Renewable energy sources as an affordable source of electricity.”

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 table below. The differences mainly result from the technology used, which currently allows for higher energy efficiency.

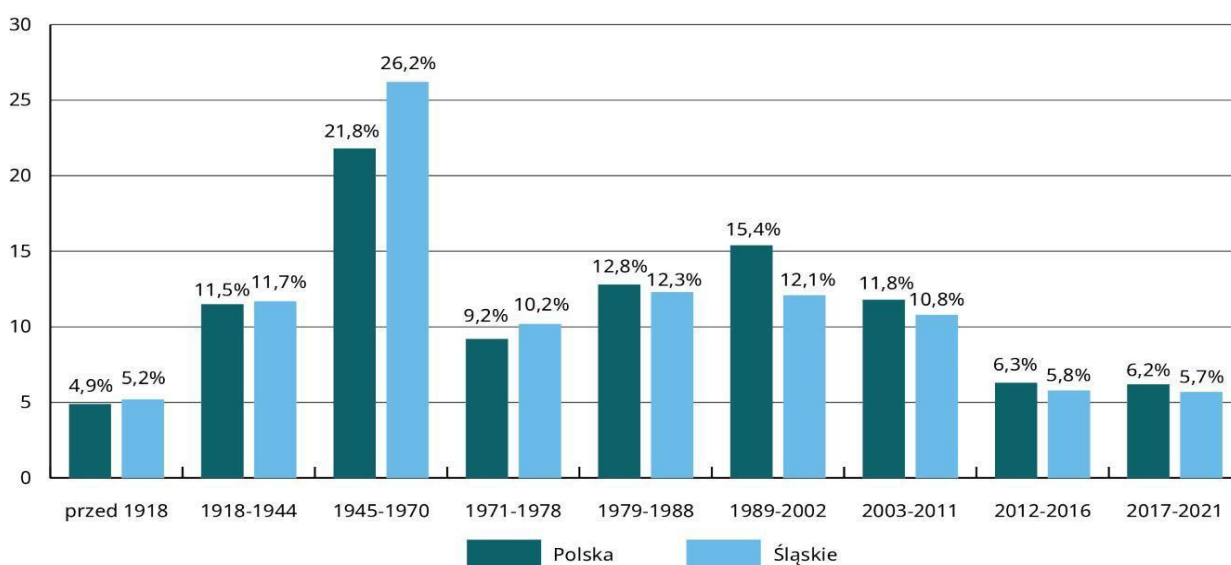
Table 14. Seasonal heat demand values depending on the building construction technology used

Year of construction	Heat demand index
	kWh/(m ² /year)
until 1966	350
from 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/Energoooszczedne_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 13. 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_swietl_e_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.

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).

2. 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.

3. 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.



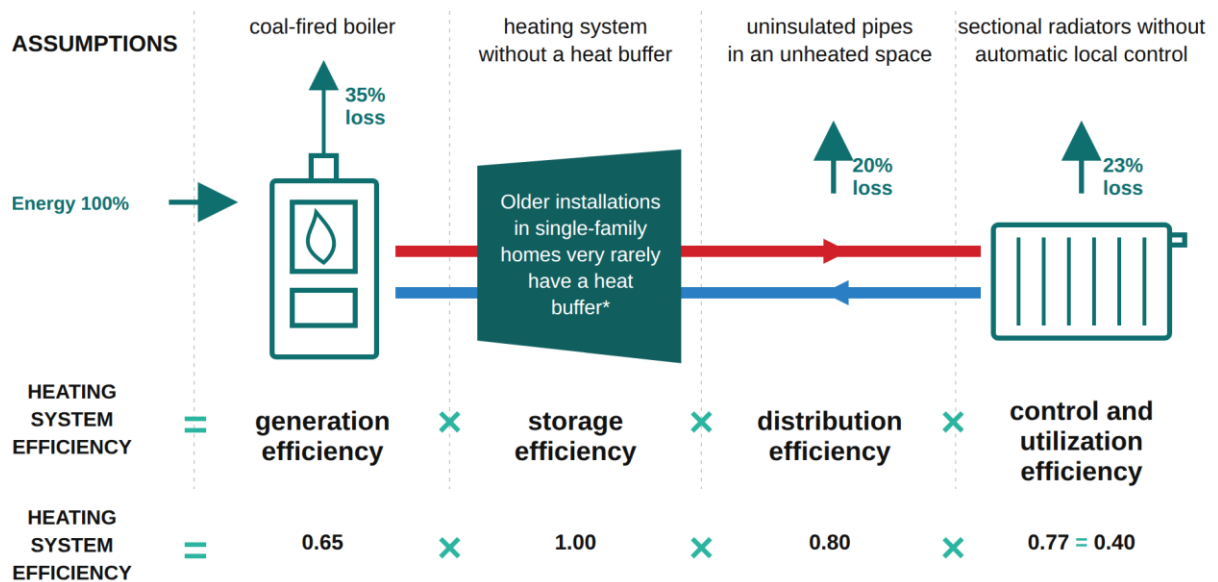
- **Ventilation** – in the process of removing polluted air (e.g. water vapour, carbon dioxide) from a room, air is supplied from the outside, which needs to be reheated in winter. Choosing the right ventilation system is crucial for minimising heat loss. A good alternative to classic gravity ventilation 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 the outside.

- **Roof** – the roof is usually the largest external partition in terms of surface area. 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. Walls in 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.

The infographic below presents an example heating system for a single-family house from the 80. 20th century that is characterised by its low efficiency. Only 40% of the energy contained in the fuel used to heat a building is converted into heat emitted by radiators.



**In the past, little attention was paid to energy efficiency. The current approach is different; the advantages of using a heat storage tank (buffer) are widely recognized—including efficient fuel combustion, less frequent firing, and lower building heating costs*

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

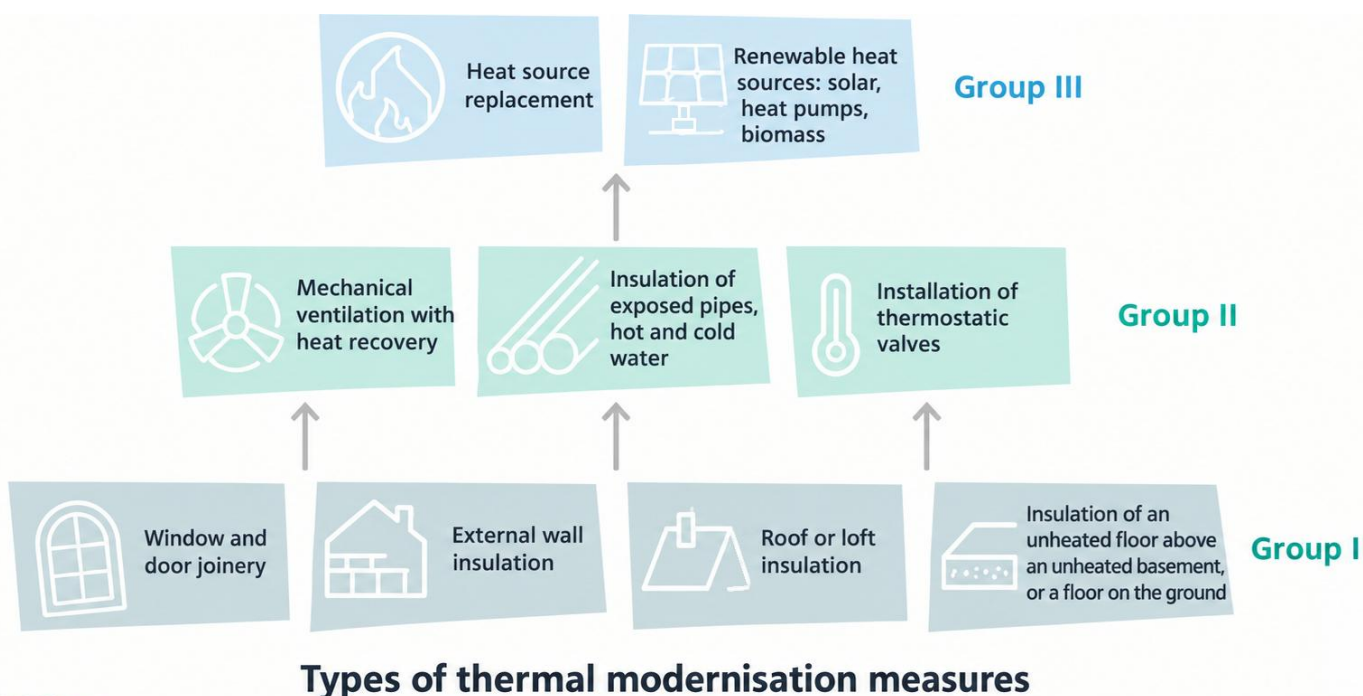
Thermal modernisation of a building can be carried out in various ways, as shown in the table below.

Table 15. 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://termomodernizacjadowow.pl/wp-content/uploads/2020/06/KOMPLEKSOWA.pdf>.

The path to comprehensive thermal modernisation involves the implementation of three groups of measures, as shown in the infographic below.



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 standard, below class 3 and not suitable to be assigned to any class, in the Silesian Province (according to information from declarations submitted in). The highest number of furnaces of this standard was recorded in the poviats of Częstochowa (13,099), Żywiec (9,919) and Cieszyn (9,698).

Table 16. Number of solid fuel furnaces in districts of the Silesian Province according to the furnace class (as at 25.04.2024)

District	Ecodesign*	Below class 3 or no information	Class 3	Class 4	Class 5
będziński	326	5 829	2 889	1 513	3 019
bielski	380	7 734	4 127	3 274	4 500
Bielsko-Biała	152	2 490	1 309	829	1 345
bieruńsko-lędzki	256	1 933	1 498	1 234	3 084
Bytom	94	2 906	614	391	784
Chorzów	30	1 560	198	151	336
cieszyński	575	9 698	3 497	2 793	4 526
Częstochowa	223	6 036	2 092	1 490	2 634
częstochowski	592	13 099	5 089	3 832	5 392
Dąbrowa Górnicza	94	2 020	981	512	1 163
Gliwice	97	2 450	758	473	1 295

gliwicki	474	4 810	2 155	1 392	4 962
Jastrzębie-Zdrój	100	962	585	529	1 614
Jaworzno	305	2 470	1,403	1,198	2,455
Katowice	194	3 483	841	506	1,436
kłobucki	748	8 826	3,792	3,027	4,711
lubliniecki	517	5 856	2,189	2,077	4,060
mikołowski	441	3,433	1,811	1,825	4,150
Mysłowice	120	1,274	785	626	1,416
myszkowski	271	4,994	3,130	1,799	3,418
Piekary Śląskie	118	1,721	1,005	358	866
pszczyński	300	3,722	1,826	2,144	3,775
raciborski	443	4,440	2,532	1,221	3,807
Ruda Śląska	137	3,317	810	544	1,296
rybnicki	804	2,587	2,469	1,231	6,248
Rybnik	491	1,913	2,386	992	6,375
Siemianowice Śląskie	28	699	205	106	184
Sosnowiec	146	2,932	738	503	985
Świętochłowice	16	1,195	130	65	153
tarnogórski	520	5,946	2,842	1,836	4,393
Tychy	93	514	443	360	1,657
wodzisławski	923	5,532	4,054	2,161	9,331
Zabrze	142	4,376	972	620	1,417
zawierciański	384	7,395	4,826	2,358	3,456
Żory	54	834	500	330	1,014
żywiecki	690	9,919	7,124	4,909	8,561
TOTAL	11,278	148,905	72,605	49,209	109,818

* Ecodesign is a European Parliament directive that came into force on 1 January 2020, which concerns energy and emission requirements for all heating equipment sold on the market. Source: data from the Central Register of Building Emissions

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 a subsidy to carry out a comprehensive thermal modernisation, resulting in the decrease in energy demand

to 80 kWh/(m²*year) or the decrease in energy demand by at least 40%, which imposes higher application requirements in the form of the need to conduct an energy audit of the building or residential premises.

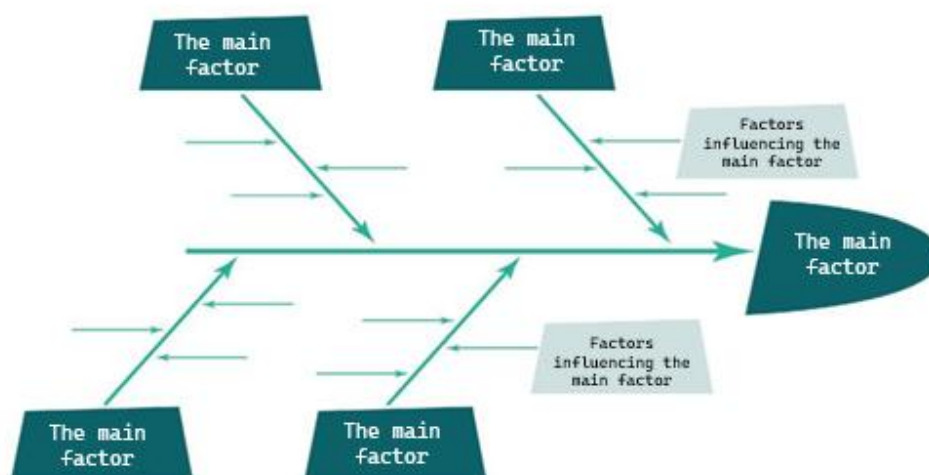
SOURCES

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- [2] 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_wy-nikow_nsp_2021.xlsx.
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Lesson ideas

1. Using the fishbone diagram, discuss the causes and results of the problem of low energy standard of residential buildings and flats in the Silesian Province.

The fishbone diagram (known also as the Ishikawa diagram) is a method of creative thinking that makes it possible to see the problem complexity by identifying and illustrating cause and effect relationships. The starting point is a horizontal axis pointing to the right, which is the specifically determined problem (effect) and which connects the main categories of causes in the form of inclined arrows leading to the phenomenon examined (big bones) and their sub-causes (small bones).



2. While working in groups, using the priority pyramid, create a list of priorities for measures related to the thermal modernisation of a single-family house with limited budget.

The priority pyramid is a method of prioritisation that teaches how to organise and evaluate information of greater and lesser importance according to specific criteria. Priorities should arise in the course of discussions among group members, with the highest priority



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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