

Smart strategies for the transition in coal intensive regions

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Abbreviations

DIHs	Digital innovation hubs
EU ETS	European Emissions Trading System
ITS	Intelligent Transportation Systems
OGs	Operational goals
NECP	National energy and climate plan
TPJT	Territorial Plan of Just Transition
PEP 2040	Polish Energy Policy 2040
RES	Renewable Energy Sources
R&D	Research and Development

ROP Silesian Voivodship - the Regional Operational Programme of the Silesian Voivodship

Executive summary

The Śląskie Voivodeship, in particular its seven mining sub-regions, make up the largest mining area in Europe, which is facing a huge challenge, which is the implementation of EU climate policy [1].

The main area of activity in the Śląskie Voivodeship related to the implementation of the provisions of the NECP is the energy transformation and the associated reduction of the use of coal for the production of electricity and heat [1].

In the voivodeship, this will translate into the gradual closure of mines due to the decrease in demand for coal-based steam generation in all sectors of the economy and the restructuring of the conventional energy sector by decommissioning obsolete power units put in operation in the 1970s and 1980s and by replacing them with modern infrastructure, friendly to the environment and residents [1].

Complementary measures will be taken in order to develop new energy sources, improve energy efficiency and develop zero-emission transport [1].

The next stage of transformation will be the reduction of emissions in sectors not covered by the ETS [1;2].

1. Upper Silesia' common vision statement

Upper Silesia - a modern European region with a competitive economy as the result of a responsible transformation.

The energy transformation process of the Upper Silesia region will require changes in the production structure and development of the energy sector. Renewable energy sources should play an important role in the region's energy system in the future. Due to the fact that the Upper Silesia region is the largest hard coal consumer in the country, it is necessary to support this type of investment in the regional policy [1].

Among the main challenges for Upper Silesia is the improvement of air quality through the implementation of investments enabling the transition to a zero-emission economy. Another challenge for the region is the significant share of industrial and post-industrial areas as well as areas where the effects of mining have occurred or will occur. A significant problem is the post-mining land reclamation and revitalization, as well as the retraining of employees leaving the mining sector. When planning economic development, it is recommended to take into account the need to ensure the possibility of operation for companies from the mining-related industry or their re-industry. This industry sector currently employs from 96,000 up to 400,000 workers depending on the adopted methodology for estimating. Liquidation of the mining sector in the analyzed area will weaken the pace of economic development and the taxes revenues for municipalities. Until now, some mining municipalities still bear the social and economic costs of the restructuring of the mining sector carried out in the 1990s [3].

For these reasons, a just transition of the region should take into account goals in three thematic areas: economy, environment and society [2;4].

In the area of economy, it is necessary to build an innovative and high-tech industry, a diversified, resource-efficient and energy-efficient economy by increasing the number of companies and creating jobs in sectors alternative to mining and conventional energy [2;4].

In the area of environment, it is necessary to build a balanced energy based on alternative energy sources, effective use of post-industrial areas for economic, environmental and social purposes, an effective system enhancing the mobility of the region by reducing the emission of transport and improving communication [2;4].

In the area of society, the goal should be to build an attractive and effective education system and to raise qualifications, the labor market support system and social activation, and the transformation management system. [2;4]

2. Upper Silesia' projection of the energy mix

The Silesia Voivodeship, through the implementation of, for example, the provisions of the Territorial Plan of Just Transition (TPJT) [1], will directly contribute to achieving the objectives set out in the document in the area of energy security, lowering carbon dioxide emissions, increasing energy efficiency and development of the R&D sector, which contributes to increasing the level of innovation in the economy. Due to the fact that the Silesian Voivodeship is one of the regions with high levels of electricity production and consumption (respectively in the 3rd and 2nd position compared to other voivodships in Poland), the activities undertaken in the area of transformation are necessary to achieve the objectives set out at the national level. Measures implemented in Upper Silesia will include the gradual closing and restructuring of mines and decommissioning of obsolete power plants (built in the 1970s and 1980s), and replacing them with modern, environmentally and socially friendly infrastructure [1;2].

The energy transformation process of the Upper Silesia region will require changes in the production structure and development of the energy sector. Renewable energy sources must play a key role in the region's energy system in the future. Due to the fact that the Upper Silesia region is the largest hard coal consumer in the country, it is necessary to support this type of investment in the regional policy. The Upper Silesia region produces ca. 19% of the domestic electric energy. The installed power in the region is ca. 7,300 MW. The share of renewable sources in electric energy produced in the Upper Silesia averages ca. 6%. The major potential renewable energy sources in Upper Silesia include hydropower, wind, solar energy and biomass. However, the region has average natural conditions for renewable energy production. A strategy for reducing the emissivity of the economy has been developed for Śląskie voivodship. The assumptions of this strategy are presented in the document "Low-emission economy policy for the Śląskie voivodeship" [5]. This document adopted by the voivodship board presents a development strategy towards a low-carbon economy. Particular attention has been paid to the elimination of so-called low-stack emission, which is the main cause of poor air quality in the Silesia region [5]. In a region where coal is the main power source and some deposits have not been mined yet, it is unlikely that it will be possible to eliminate power from coal-based installation. Therefore, all four scenarios of energy production (referred in the document as "business as usual", "present", "changes" and "extensive") in the above-mentioned document contain a considerable share of energy production from coal. The "changes" scenario was developed based on a compilation of market, social and global trends, including adopted strategies and policies at the international level, and the overlay of changes resulting from the implementation and extension of specific policies and strategies. It is the most probable scenario for energy production in Silesia in 2030. The scenario predicts that the volume of coal-fired power generation will decline with 30.8% by 2030. Among renewable energy sources, it predicts that the largest increase in new capacity will use photovoltaics and biomass. Also important is the significant projected increase in the amount of energy produced from municipal waste. Under this scenario, it is projected that by 2030 there will be a significant decrease in electricity production in the Silesian province, with a significant increase in demand. The largest increase in demand for electricity is projected in the transport sector (development of electromobility) and in households (replacement of coal stoves with electric ones). In consequence in 2030 the region will become a net energy importer [1].

According to the "changes" scenario coal will remain a dominating energy source in Silesia, but its share will decrease from 85.2% nowadays to ca. 62.8% in 2030 (Figure 1). The share of gas-based energy production (including methane from coal mines) will increase from ca

10.8% at present to 29.0%. The share of energy from RES will also increase to ca. 7.3% (Figure 1, Table 1).

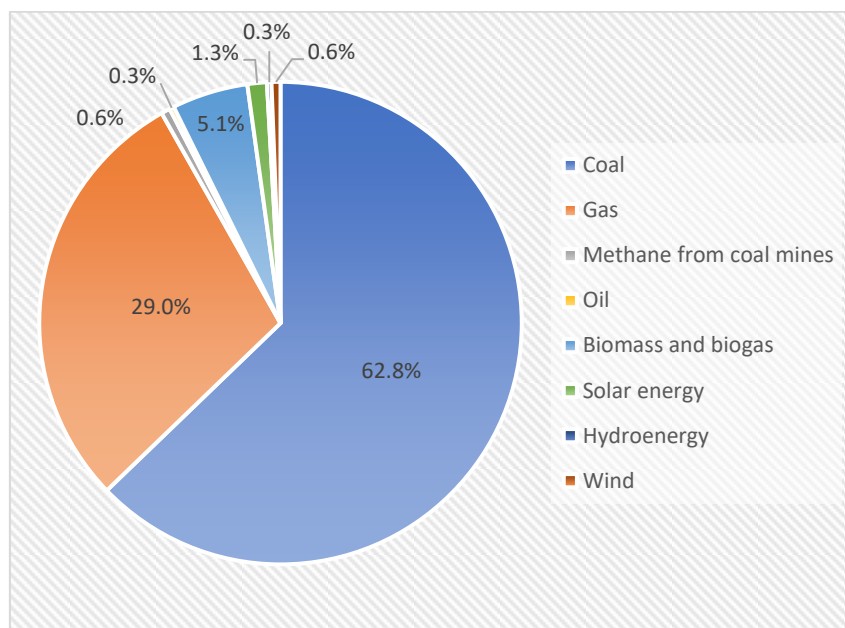


Figure 1. Shares of different sources in energy production mix in Upper Silesia in 2030 according to “changes” scenario [6].

Table 1. Projection of electricity production in the Śląskie Voivodeship (GWh) (Marshal’s Office, 2022)

Source of energy	2017	2025	2030	2040	2050
Coal	26 300	25 997	18 201	2 460	2 460
Gas from MMC (mine methane capture)	54	74	67	55	36
Coke oven gas	187	187	164	98	59
Natural gas	504	5 564	6 901	7 254	7 625
Biomass - co-combustion	389	0	0	0	0
Water	187	506	506	506	506
Biogas	97	161	201	245	298
Biomass - dedicated boiler rooms	52	852	1 352	1 493	1 650
Wind	39	249	424	775	1 125
Photovoltaics	26	165	349	687	1 001
Municipal waste	3	17	17	17	17

A timeline (2017-2050) of Upper Silesia energy (electricity and heat) generation mix forecasting, by type of fuel, is graphically presented in the Annex to this current Report “Blueprint Benchmark of Upper Silesia”.

In order to achieve emissions at the level required by the European Union, the power plants will use CCS/CCU technologies, which can reduce CO₂ emissions by up to 91% compared to 1990. Another possibility are steam power plants with supercritical parameters and power plants using IGCC technology, low emissivity. In the case of heating plants and combined heat and power plants using biomass, the largest share will probably be biogas, which emits fewer solid particles when burned [1;4].

In the next decades (especially after 2029) a significant part of the currently operated coal-fired units will be withdrawn from the system. According to forecasts, in 2040 the share of coal in electric power generation in Poland will be from 28% to even 11% in the high-price scenario. Coal will be replaced mainly by renewable and nuclear energy [1]. Some of the analyses carried out on the basis of historical trends and detailed forecasts of the profitability of mining in Upper Silesian mines indicate that by 2050 the production of energy coal in the region will have ceased. Only the most efficient coking coal mines have a chance to survive

in the mid-century, but they will also have to improve efficiency and significantly reduce employment [4;7].

There is no official strategy for energy production neither in Silesian Voivodship nor in Poland until 2050. The only official document that describes energetic policy at the country level is Polish Energy Policy 2040 (PEP 2040) [6;7]. The objective of the national energy policy is energy security while ensuring the competitiveness of the economy, energy efficiency and reduction of the impact of the energy sector on the environment with optimal use of own energy resources. According to this document Poland's power generation source mix in 2050 will be significantly impacted by the planned implementation of nuclear energy in 2033. The first unit of a nuclear power plant in Poland (with a capacity of approx. 1-1.5 GW) will be commissioned around 2033. Another 5 units with a total capacity of 5 7.5 GW will be launched every 2-3 years [1;4].

The action plan for the development of nuclear energy in Poland according to PEP 2040 has been described in Table 2.

Table 2. Actions and dates envisaged for the introduction of nuclear energy into Polish energy system [7].

Action	Date
Implementation of legal changes limiting delays of the NPP construction project due to non-technical (formal) reasons	2019
Final site selection for the first nuclear power plant unit - Kopalino / Żarnowiec (subsequent site selection for subsequent units)	2020
Final selection of technology and general contractor for first nuclear power plant	2021
Developing (and implementing) a Human Resources Development Program for Nuclear Power	2019 (2030)
Organization of technical support for nuclear supervision - consolidation of research institutes, establishment of the National Nuclear Energy Laboratory	2019
Commissioning of a new low- and intermediate-level radioactive waste repository	2027
Construction and commissioning of nuclear units:	2024-2043
- first nuclear unit;	(to 2033)
- five more nuclear units (every two years).	(to 2043)

The first nuclear power plant in Poland is to be built in Pomorskie Voivodship. Next units according to PEP 2040 are to be built in Łódzkie Voivodship and Wielkopolskie Voivodship. At present there is no localization for NPP in Silesian Voivodship. However, there is a possibility that some private entities will build a small modular reactor power plant in the city of Oświęcim in Silesia.

PEP 2040 includes also development of RES as the share of energy from this source is to increase from ca.20% now to 32% in 2030. Table 3 presents actions envisaged at the country level to develop energy production from RES.

Table 3. Actions and dates envisaged for the introduction of renewable energy into Polish energy system [7].

Action	Date
Ensuring conditions for achieving 21% of RES in gross final energy consumption in 2030, including:	2020 / 2030
- in the heating and cooling sector - an annual increase in the share of RES by 1-1.3 percentage points,	

Action	Date
- in power generation - an increase in the share of RES in electricity production, especially after 2022 (due to increased profitability of certain technologies), - in transport - reaching a 10% share of RES in 2020 and 14% in 2030, including increased use of advanced biofuels.	
Ensuring conditions for balancing renewable sources - introducing an obligation to connect unstable RES with an energy storage facility or other form of power reserve	2030
Providing conditions for the development of sustainable energy areas at the local level (energy clusters, cooperatives) - about 300 in 2030.	2030
Maintaining financial support for RES and improving its existing forms, taking into account the role of technologies in the NPS (until economic maturity).	2040

3. Upper Silesia' available options meeting the planned energy transition

The Development Strategy of the Silesian Voivodship is a document that takes into account several key directions of development. One of them is energy transformation related to the gradual transition from fossil fuels [1]. The Silesian province's energy transformation strategy is described in the "Low-emission economy policy for the Silesian voivodship" strategy. The general goal of this strategy is to increase the energy security of the Silesian province and ensure energy efficiency, while reducing the negative impact of human activity on air quality, including in particular the reduction of low emissions. The strategy identifies four operational goals (OGs):

OG1. High energy standard of the region's residential, business and public buildings.

OG2. Energy security of the Silesian region and development of the clean energy sector.

OG3. Clean public and individual transportation system.

OG4. Proactive management in the area of air quality.

OG1. addresses one of the main challenges facing the Silesian region, that is, reducing low emissions. Individual households and local coal-fired boiler houses are the main producers of dust and harmful gases in the region. Actions taken should include replacing heat sources with more environmentally friendly ones, as well as raising the energy standard of the housing sector. Ensuring energy security (OG2) is one of the basic tasks without which economic and civilizational development is not possible. Ensuring continuity of energy supply is particularly important for a region with the largest population and characterized by an accumulation of industrial plants. In order to maintain the high position of the region on the energy map of the country, it is necessary to carry out activities related to the modernization of the infrastructure of the electric power system and the reorganization of the generation system (with particular emphasis on high-efficiency cogeneration, renewable energy sources and biodegradable waste). A great opportunity for the region in the implementation of new, innovative technologies is the activities undertaken within the framework of smart regional specialization in the field of energy. OG3 takes into account the significant impact of transportation on air quality in the Silesian voivodship. In a region with one of the highest traffic volumes and the highest density of highways and expressways, an opportunity to reduce the negative impact on the environment and the quality of life of residents is to support the development of environmentally friendly transportation along with the development of the necessary infrastructure. OG4 results from the fact that the Silesian Voivodeship is one of the regions with the highest emissions of gaseous and particulate pollutants. Sustainable development of the region will be possible by building an economy that makes efficient use of the region's resources and potentials and supports the

development and use of innovative environmentally friendly technologies. An important aspect in the initiatives taken to improve air quality in the region is to take into account in spatial planning the conditions for ventilation of city centers and to ensure the adequate area and proper functioning of green areas [6].

Implementation of the operational goals requires taking action in specific directions. For **OG1**, the strategy provides the following directions for action:

1. Supporting the replacement of heat sources with equipment that meets the requirements of the "anti-smog" resolution;
2. Supporting and promoting the connection of individual households to the collective energy, gas and heat supply system;
3. Raising the energy standard of existing and newly constructed buildings, including support for comprehensive thermal modernization measures in individual and public buildings, as well as energy-efficient and passive construction;
4. Promotion of energy production for household needs using renewable sources;
5. Implementation of energy management systems in residential resources and public buildings;
6. Support of measures to reduce energy poverty;
7. Promotion of activities that increase the environmental awareness of the region's residents, including technological changes in the energy market;
8. Promotion of sustainable energy consumption patterns.

OG2. provides for the following lines of action:

1. Support long-term activities aimed at changing the energy profile of enterprises, taking into account the potential of the region;
2. Modernization of generation and network infrastructure, including reduction of energy transmission losses;
3. Expansion of existing distribution and transmission networks and taking measures to eliminate "white spots";
4. Lowering the energy intensity of industry;
5. Support for solutions using high-efficiency cogeneration technologies;
6. Support system for investments in renewable energy sources, taking into account energy storage;
7. Increasing security of supply and handling of fuels;
8. Increasing local energy security through support for cluster initiatives, energy cooperatives and prosumers;
9. Development of facilities to use biodegradable waste for energy production (organic recycling);
10. Support activities that encourage the development of a closed-loop economy;
11. Support for research in smart regional specialization in the field of energy, including the development of high-energy fuels and technologies for coal mining;
12. Creation of a regional database listing sources of electricity and heat;
13. Support for measures to reduce the use of electricity in municipalities, including energy consumption in public buildings and for street lighting.

Actions for the operational goal **OG3**. include:

1. Promotion of environmentally friendly transportation;

2. Development of infrastructure to facilitate the use of environmentally friendly vehicles, including those with electric and hydrogen propulsion;
3. Modernization of infrastructure and replacement of public transportation rolling stock with low-emission and energy-efficient vehicles and improving the quality of transportation;
4. Increasing the attractiveness and promotion of public transportation;
5. Development of multimodal transportation, including the construction of Park & Ride systems;
6. Implementation of intelligent transportation systems (ITS);
7. Development of new technologies that reduce fuel and energy consumption in transportation;
8. Support of social behaviour in the field of sustainable transportation;
9. Development and promotion of bicycle infrastructure;
10. Reducing the negative impact of the transportation system on air quality, including the promotion of measures to reduce secondary emissions.

Realization of **OG4**. operational goal requires the following actions:

1. Supporting the activities of local government units that reduce the impact of the economic sector on air quality;
2. Supporting investments related to the installation of equipment to improve air quality;
3. Development of the air quality monitoring system;
4. Responsible shaping of spatial order, including the creation of "green" city centers and "clean" transportation zones;
5. Supporting cooperation of scientific, economic and administrative communities in the creation and implementation of innovative solutions to reduce emissions;
6. Reduction of emissions from the economic sector, including from particularly troublesome plants;
7. Development of a system of advisors on environmental auditing and low-carbon technologies;
8. Support activities promoting the idea of a green economy;
9. Dissemination of the principle of green public procurement.

Key partners in the implementation of the above-mentioned tasks are R&D units, local government units, government administration, and business environment institutions, entrepreneurs, NGOs, energy clusters, energy cooperatives and prosumers [7].

4. Upper Silesia' high priority measures and concrete actions

As highlighted in TRACER-D6.1 report on "Projections for the transition to 2030 / 2050 in the target regions", for implementing the provisions of "Low-emission economy policy for the Silesian voivodship" strategy it is important to implement certain types of projects. Taking into account the socio-economic conditions of the region and its specificity in terms of geography, it is advisable to support the following types of projects in order to achieve the assumed objectives described in the above strategy [1]:

1. Comprehensive thermal modernization measures.

2. Giving new functions to infrastructure and post-mining and post-industrial areas.
3. Support for the development of environmentally friendly transportation.
4. Expansion of the network of measuring stations for air quality monitoring.

However, "Low-emission economy policy for the Silesian voivodship" strategy describes only a single aspect of the regional development. Silesian voivodship has a large population and diverse economy that includes not only coal mining and energy production, but also metallurgy and the electrical machinery, chemical and food industries. The voivodship has the largest share in the production of cars and crude steel in Poland and is the place where large international companies such as FIAT, General Motors Corporation, ING Group N.V., Danone, Philips, HP etc. locate their investments. Therefore, development strategy of Silesian Voivodship does not focus solely on energy production but includes several other aspects [6].

Major strategic objectives of the development of Silesia Voivodship have been described in the- Strategia Rozwoju Województwa Śląskiego "Śląskie 2030" – Zielone Śląskie (Development Strategy for the Silesian Voivodship "Silesia 2030" – Green Silesia) document [2], hereafter referred to as Silesia 2030. This is the official strategic plan for the general development of the Silesian Voivodship, synthetically presented also in TRACER D6.4 report "Roadmap for Upper Silesia", in which all aspects of development in Silesia are described up to 2030. This key document defines the objectives for regional development and the instruments for their implementation with an achievement goal of 2030. The growing importance of ecology, demographic trends and an ageing society, as well as the fourth industrial revolution – including the several changes that will accompany that were identified as the key trends for the coming years.

There are four strategic objectives identified in the document:

- SG1) Silesia as a region of responsible economic transformation;
- SG2) Silesia as a resident-friendly region;
- SG3) Silesia as a region with a high-quality environment; and
- SG4) Silesia as an efficiently managed region [2].

First three of the strategic goals include challenges of the energy and environment sectors. For each strategic goal several operational goals have been formulated to be achieved by 2030.

The most important operational goals include:

- Diversification of the economic structure and development of economy 4.0 and strengthening of the competencies of current and future industry personnel.
- Development of infrastructure facilitating the location and conduct of business activities.
- Support for traditional sectors in terms of increasing their competitiveness, inter alia, through the modernization of technological processes, improvement of work safety, reducing negative impact on the environment and the development of human resources.
- Promotion and implementation of circular economy.
- Development and activation and attraction of human resources, especially in the areas of smart specialization and creative industries.
- Support for universities, research institutions and organizations, including the development of staff potential in the development of innovative and creative solutions, including patents and their commercialization in cooperation with the economic sector.
- Support for the participation of regional entities, especially universities, in the European and global research space.

- Support for the creation of new and the development of existing companies, including start-ups, based on the potential of the region and using technologies developed in the region, especially in the areas of regional and smart specialization and creative industries.
- Increasing the quality and improving access to modern educational offer at all levels of education, responding to social and economic challenges, including the labour market.
- Strengthening education of key skills and competences of students, including emotional and social skills necessary to move freely on the labour market.
- Supporting implementation and enforcement of solutions improving air quality.
- Counteracting the effects and reducing the negative impact of mining operations on the environment, including cities.
- Reclamation and revitalization of degraded areas and development of post-industrial sites and facilities for environmental, economic, cultural, recreational purposes, among others.
- Development of pro-ecological infrastructure for generation, storage and transmission of electricity and heat, including development of RES.

The Strategy highlights a group of projects which are a set of tasks and activities of the local authorities. Their realization will be a practical implementation of the Strategy in terms of its objectives and directions. Table 4 presents the projects included in the strategy that are related to environment and energy.

Table 4. Projects related to environment, energy and education/reskilling to be realized within the framework of Development Strategy for the Silesian Voivodship “Silesia 2030” – Green Silesia [8, 9]

Name	Reindustrial Silesia
Extent	1. Monitoring the condition and potential of industrial and brownfield sites. 2. Management and coordination of activities related to the transformation of brownfields and giving them new functions. 3. Development of industrial parks and attracting and servicing investors on post-industrial sites. 4. Diversification and development of modern branches of economy in place of traditional ones, e.g. through support of the business sector on post-mining sites.
Expected results	Program, coordinate and accelerate the development of brownfield sites for economic, social and environmental purposes, taking into account their potentials and regional policy objectives.
Name	Innovative Silesia, Highway of the Future Companies
Extent	1. Investments in highly specialized, integrated industrial and research centers (technology parks in the area of smart specialization - regional network, universities and research centers of higher education institutions, R&D centers, scientific and research units, research institutes). 2. Support for the development and cooperation of companies operating in the areas of smart specialization. 3. Support and development of activities of the Digital Innovation Hubs (DIH) operating within the one-stop-stop model. 4. Support of clusters as a tool for the development of cooperation between companies, universities, research institutes 5. The support of companies in the export activity. 6. development of financial and organizational instruments in the field of

Name	Reindustrial Silesia
	creation and support of companies implementing new technologies and high-risk companies. 7. The development and complex support of patenting process and implementations.
Expected results	Increase the level of innovation in the region's economy, in particular in the areas of smart specialization.
Name	Educational Silesia
Extent	1. Development of educational and peri-educational infrastructure, including universities. 2. Development of an effective system of vocational education and professional reorientation, including a greater inclusion of entrepreneurs and individualized approach to vocational guidance 3. Development of new models of education with the use of innovative technologies, including ICT. 4. Development of a regional knowledge platform which enables the growth of competencies of teachers and vocational advisors. 5. Promotion of international cooperation in the education system.
Expected results	Increase in the level of competence and education of the population translating into the process of economic transformation of the region.
Name	Low-emission Silesia
Extent	1. Support for comprehensive thermo-modernisation and energy-efficient and passive construction. 2. RES development, including prosumers and energy clusters support. 3. Development of environmentally friendly transportation, especially mass transport. 4. Support and promotion of connecting individual households to the collective energy, gas and heat supply system.
Expected results	Increase the quality of life for residents by improving the quality of the environment, especially the air.
Name	Eco-Silesia
Extent	1. Shaping and protection of naturally valuable areas, including forest resources. 2. Development of nature tourism, including the creation of Nature Trail. 3. Shaping of space taking into account adaptation to climate change and protection against emission of noise into environment. 4. Shaping of ecological awareness, including support for ecological education. 5. Development and implementation of the concept of protection and integration of the natural systems of cities and their surroundings, including around the Upper Silesian Metropolis. 6. Shaping the green image of the region. 7. Formation of rational water management, improvement of water quality and promotion of the Upper Silesian Lake District. 8. Restoration of natural functions of degraded areas, including afforestation.
Expected results	Improvements of environmental quality, preservation of environmentally valuable lands, and strengthen urban resilience to climate change.

Another document describing development strategy, high priority measures to be undertaken and necessary actions is the Regional Innovation Strategy of Silesia 2030 (hereafter referred to as RIS Silesia 2030) [8, 9]. This document describes the issues of innovation development in the Silesian region. The RIS Silesia 2030 is related to Silesia 2030 as it refers to the strategic objective “The Silesian Voivodship as a region of responsible economic transformation” (SG1).

The R&I activities in the region have been based on smart specialisations that were elaborated in 2013–2019 within the framework of two projects, namely the *Network of Regional Specialist Observatories* and the *Network of Regional Specialised Observatories in the Entrepreneurial Discovery Process*.

Based on the EDP and analyses carried out, as described above, the following smart specialisations were proposed for the Silesian Voivodship:

- energy;
- medicine;
- ICTs;
- the green economy; and
- emerging industries.

Two of these—energy and the green economy—are closely related to the transition of coal intensive regions.

After performing a strategic balance and SWOT analysis for the Silesian Voivodship, four specific objectives were set:

- G1 – Increase the capacity of regional innovation ecosystem actors to generate and implement innovations and modern technological solutions;
- G2 – Ensure inclusive digital transformation in the region’s economy and society;
- G3 – Support the competitiveness and successful transformation of regional innovation ecosystem actors into national and international champions; and
- G4 – Develop competencies of employees and actors of the regional innovation ecosystem for smart specialisations, digital transformation and innovative entrepreneurship

Each of the objectives listed above corresponds to one of the challenges defined by the SWOT analysis. Objective G1 responds to the challenge “Improving the level of innovation of the region’s economy compared to Europe”. Objective G2 meets the challenge “Digital transformation in economy and society minimising the risk of digital exclusion”. Objective G3 responds to the challenge “To reduce the atomisation of the economic structure in conditions of growing pressure from international competition and legal requirements on the functioning of small companies”, while Objective G4 deals with the challenge “To increase the integration of the innovation ecosystem supporting the development of competencies in the economy of the Silesian Voivodship” [1, 2].

To achieve each of these objectives, appropriate actions were provided. The actions for Objective G1 included supporting development processes in smart specialisations (A1.1), implementing innovation in enterprises (A1.2) and strengthening research infrastructure for regional partnerships between science and business (A1.3). Objective G2 will be achieved through supporting an end-to-end digital transformation of SMEs (A2.1) and creating smart public-sector products and services to address societal challenges (A2.2), while Objective G3 provides for comprehensive support for start-ups (A3.1), the activation of cluster environments (A3.2) and support for the transformation and internationalisation of regional innovation ecosystem entities (A3.3). Finally, the actions for achieving the specific goal of Objective G4 will involve developing employees’ competencies for the competitiveness of the regional economy (A4.1), strengthening the regional innovation ecosystem (A4.2) and

strengthening competencies for the internationalisation of regional innovation ecosystem entities (A4.3) [1, 2].

In order to implement the planned actions, a strategy of implementing actions and flagship projects was foreseen [8, 9].

Actions [8, 9]:

Goal	Increase the capacity of regional innovation ecosystem actors to generate and implement innovations and modern technological solutions (G1)
Actions	
Supporting development processes in smart specialisations (A1.1)	The actions taken to strengthen the innovation potential of entities in smart specializations in 2014-2020 need to be continued to move from the phase of supporting investments in research and implementation infrastructure towards the implementation of research and development projects. On the one hand, support for individual projects will contribute to strengthening the competitiveness of Silesian companies in the international arena, while on the other hand, dedicated activities related to entrepreneurial discovery processes will be translated into specific research agendas, which will allow to launch joint support initiatives on the line of the voivodship self-government -National Centre for Research and Development. It is assumed that regional consortia within the framework of smart specialization, as a result of joint activities undertaken, will be perceived by international organizations as appropriate partners in the implementation of European research agendas.
Implementing innovation in enterprises (A1.2)	Small and medium-sized enterprises struggle with the transition from research projects that create new technological solutions to the introduction of innovative products and services to the market. Bearing in mind: the increasingly demanding legal regulations (European directives, international treaties) and market regulations (sectoral norms and standards), the specificity of innovation projects (the need for new competence and infrastructure), as well as the role of intellectual property in securing a position on the international arena, it is necessary to provide support for development and implementation projects together with support for the development of R&D infrastructure of enterprises and with a component on securing intellectual property and obtaining the necessary certificates. Enterprises going through this process will benefit from support related to scaling up the implementation of innovative products, under which they will have the opportunity to expand technical infrastructure, hire specialists, as well as expand the scope of intellectual property protection and obtain the necessary certification in selected international markets. The role of large enterprises is not without significance as they can include solutions from regional SME in their own innovation processes in the value chains. Therefore, the possibility of supporting large enterprises in the field of research and development works and implementation of innovative solutions, including those provided by SME, is assumed.
Strengthening research infrastructure for regional partnerships	Universities and scientific and research entities have undergone significant substantive and organizational transformation processes in the period 2014 - 2020. Consolidation activities within the Łukasiewicz Research Network and special support directed to selected research universities have contributed to organizing

between science and business (A1.3)	specialization and strengthening competencies around competitive advantages of individual entities in the research and development sector. Also business environment institutions, including technology parks, incubators and clusters, strengthened their role as integrators of innovation services based on R&D infrastructure, which contributed to intensification of cooperation with enterprises and identification of their development needs. Thus, areas requiring further support for the development of research infrastructure have been highlighted. It will be launched in order to improve the offer of cooperation of business environment institutions, universities and research and development units with enterprises in the region and beyond. In addition, the modernization of infrastructure and related activities aimed at increasing competencies in the commercialization of research results and cooperation with enterprises will help entities from the research and development sector to strengthen their activity within international consortia and research and development projects.
Goal	Ensure inclusive digital transformation in the region's economy and society (G2)
Actions	
Supporting an end-to-end digital transformation of SMEs (A2.1)	In order to ensure the uptake of information and communication technologies by micro-, small and medium enterprises on the widest possible scale, the topic of digital transformation in enterprises should be approached holistically, taking into account all aspects of digitalization, including but not limited to: Internet of Things platforms, mobile devices and applications, advanced human-machine interactions, automated and robotic systems using smart sensors and artificial intelligence, augmented and virtual reality, big data management systems, blockchain, prosumer business models, websites, online stores, customer communication platforms and social media activity and use of cloud services, instant messaging, conferencing platforms or remote working software. This approach helps convince companies to embrace digital transformation regardless of scale, type of business or level of technological sophistication. Support for investments in information and communication technologies will be preceded by information, training and advisory activities, including within regional/national and thematic digital innovation hubs. Due to the different needs of companies of a service nature and typically industrial companies, it is assumed to differentiate the instruments of support for IT investments for companies in the scope of implementation of digital technologies. At the same time, measures to make companies and the public sector aware of cyber security issues and investment support, related to securing network infrastructure, technical infrastructure, smart devices as well as data, should be of key importance.
Creating smart public-sector products and services to address societal challenges (A2.2)	The specific urban layouts, in the agglomerations of the Silesia Voivodeship, as well as historical and socio-economic factors are the basis for a number of calls formulated in the strategy "Silesia 2030". By integrating activities related to data collection, processing and reuse, as well as by implementing smart solutions in the field of transport, education, health, culture or media and environment management, the public sector can improve the quality of its services and increase the efficiency and effectiveness of its activities. For some problems there are already solutions that can be bought on the market. However, other problem areas require a specific approach, including research and development work on the part of enterprises

	in order to develop dedicated solutions and demonstration activities on a smaller scale on the part of public entities, before their implementation on a larger scale. Therefore, building consortia of enterprises and cities will be promoted in the context of smart cities projects, in which research, development and demonstration activities on the part of enterprises and investment projects on the part of cities will be implemented. In the first place, they may concern intelligent devices, artificial intelligence and methods of analysing large data sets that meet problems and challenges faced by various social groups or help to build awareness of the impact on the environment and solve selected environmental problems. Investment support aimed at developing and testing in specific environments digital innovations for society, including those based on a prosumer approach, can contribute to solving problems that the public sector or local NGOs are currently unable to cope with. The challenge may be to ensure consistency with the Public Procurement Law and regulations on public-private partnerships. Therefore, in parallel to work on support instruments, actions will be taken to develop good practices in the interpretation and application of legal provisions related to the organization of joint innovative projects between local government and business.
Goal	Support the competitiveness and successful transformation of regional innovation ecosystem actors into national and international champions (G3)
Comprehensive support for start-ups (A3.1)	In the Silesia Voivodeship there are many initiatives promoting the establishment and development of technology companies. Various public and private institutions engage in pre-incubation activities, offering advice or organizing competitions of business plans and presentations of ideas, helping the originators to build a community of suppliers, partners and potential customers around a given venture. Ensuring a smooth transition from the concept phase to the reality of business operations requires further strengthening of the environment of providers of seed funding and subsequent investment rounds, both from public-private and private sources. The provision of venture capital assumes funding for existing and new funds that guarantee funding of the scale of a single investment. These funds should develop partnership relations with the animators of start-up environments and together with them build a coherent message and prepare the most interesting ideas in the pre-incubation phase. An important role will be played by science and technology parks, incubators, business accelerators and special purpose vehicles and their networks, which comprehensively provide young companies with access to infrastructure, knowledge, capital and scientific-research and business contacts within their ecosystems. In addition, given the important role of medium and large enterprises in the regional economy, it is important to engage these companies in scale-up projects that ensure implementation of innovative solutions of start-ups from the region on a larger scale.
Activation of cluster environments (A3.2)	Animating cluster initiatives involves a lot of commitment and requires consistency and persistence. An example of this can be several regional clusters that have established their position on the national stage and within the National Key Clusters system benefit and will benefit from support at the central level. In order for more business communities to take advantage of industry or value chain synergies, the region will support the development of seed-stage (year 1-3) cluster initiatives with themes related to smart specializations.

	Existing cluster initiatives with several years of experience can in turn benefit from support for the implementation of a new service.
Support for the transformation and internationalisation of regional innovation ecosystem entities (A3.3)	Continuous transformation is a natural process of any regional economy. Changing conditions and new opportunities appearing on the horizon require from companies' constant adjustments (including changes in business models, which result from the growing importance of digitalization, providing products as services or prosumerism) and increasing the scale of activity. In these activities, SMEs in the region will be supported by a system of vouchers for services implemented by business support institutions, as well as by repayable financial instruments and guarantee and suretyship schemes. Regional product brands and regional specialisation products will also be supported in the field of export promotion or building a presence in international supply chains. Business support institutions, whose regional network will be strengthened in terms of infrastructure and resources, will become the backbone of SME's transformation. Support will also be given to preparation of investment areas, giving space for development to companies from the region, but also to external investors, including the Silesia Voivodeship in their activity. The technological race in the world forces also higher education and science entities to make organizational and competence transformations. Support for these entities in the transformation processes should contribute to strengthening their position in the field of diffusion of innovation (commercialisation of R&D results) and to intensifying their activity on the international arena.
Goal	Develop competencies of employees and actors of the regional innovation ecosystem for smart specialisations, digital transformation and innovative entrepreneurship (G4)
Actions	
Developing employees' and enterprises competencies for the competitiveness of the regional economy (A4.1)	Previous experience in the functioning of the system of co-financing the so-called soft services for companies in the Development Services Base with the active participation of operators (Entity Based Financing System) indicates the legitimacy of continuing this approach, aimed at improving the competence of employees in the regional economy and increasing adaptability of both themselves and companies. From the perspective of digitization, it is important to support the development of digital competencies of employees for efficient functioning of both business and modern administration. It is necessary, among others, to focus on advanced competencies in the field of cyber security and data economy. Undertakings undertaken in this area will be complemented by direct support for the managers of cluster initiatives, in response to the need for further professionalisation of their activities. Training and advisory activities for the development of competencies and improvement of scientific staff in higher education and science, both in their areas of specialization, as well as in the field of research infrastructure management or commercialization of the results of research and development work and cooperation with business, are not insignificant for the strengthening of cooperation within smart specialization.
Strengthening the regional innovation ecosystem (A4.2)	The Silesia Voivodeship will continue the initiatives for the regional innovation ecosystem through further activities of the Network of Regional Specialised Observatories (SO RIS) and dissemination of the idea of regional digital innovation hubs. In the first case, support

	will be directed to networking of enterprises and scientific units for smart specialisations. In the second case, support will be provided for operating costs and information, training and advisory activities addressed to SMEs within the framework of hub activities. There will also be an investment component for demonstrators. The activity of both types of entities will ensure continuity of entrepreneurial discovery processes, networking and brokerage activities within smart specialisations in the region.
Strengthening competencies for the internationalisation of regional innovation ecosystem entities (A4.3)	So far, selected business environment institutions and entities of higher education and science, and together with them the cooperating enterprises, have taken advantage of the possibility of international cooperation co-financed by European funds within the framework of programmes supporting research and development activity, development of companies or improvement of regional policy instruments. The experience gained in this way inspire to build international business relations and make changes in business models. In the region, building openness to new technological and market trends will be promoted by supporting the preparatory process for the participation of SMEs, business environment institutions and higher education and science entities in international programmes for the development of innovation. In particular, training and advisory activities will be supported in the development of qualifications of scientific and research teams, including in the context of strengthening their competencies towards diffusion of innovation in areas related to smart specialisation.

Flagships projects [8, 9]:

1. Eco-innovations in the region;
2. Silesian science and technology parks;
3. Silesia – the top Polish technologies for medicine;
4. A map of key regional research infrastructure;
5. Testing social and technological innovations;
6. Regional innovation vouchers;
7. Digital solutions for public services;
8. Digital innovation hubs (DIHs);
9. A platform of Silesian start-ups;
10. The incubation of technology companies 3.0;
11. A network of regional SOs;
12. A programme for improving and changing professional qualifications to fit the needs of green energy; and
13. A Laboratory for New Technologies in Żory.

Each of the planned flagship projects addresses one or more specific objectives, and some of them include R&I for the energy transition or development of a green economy.

Existing official development strategies for Silesian voivodship do not reach beyond year 2030. However, certain strategic activities related to Silesia are included in Polish Energy Policy to year 2040 (PEP 2040). According to this document the share of electric energy from coal in 2030 should be lower than 56% and the share of RES electricity should be 23%.

Decrease of energy production from coal is likely to affect coal producing regions including Silesia. According to PEP2040 special attention will be paid to the regions where the end of operation of an energy production unit or a mine is associated with the need to reformulate the labor market or economic importance - Silesia, Lower Silesia, Wielkopolska, Małopolska, Łódzkie Province and Lubelskie Province. Part of the labour market will be transformed naturally, but support will be needed to retrain workers, stimulate investment, and generate new jobs. This will be strongly supported by dedicated EU and national funds. The implementation of the transformation is not only a challenge but also an opportunity to take advantage of national and regional potential. The creation of new industries and jobs related to the development of civic energy, based on renewable energy sources, as well as perspective sectors, such as nuclear energy, electromobility, construction, thermo-modernization, decarbonized gas technologies (including hydrogen), energy storage, automation and digitalization, will be stimulated. It is estimated that about 300,000 new jobs will be generated in this way - this is more than three times the current employment in hard coal and lignite mining [1, 7].

Another official document related to coal phase-out in Silesia that reaches beyond 2030 is "Social Agreement on the transformation of the hard coal mining sector and selected transformation processes in the Silesian Province" from 28th of May 2021. The agreement establishes a system of financial support for gradually decommissioned mines and undertakes a number of other measures to mitigate the effects of the transition, in particular:

- construction of coal gasification facilities;
- construction of installations for the transport and storage of captured carbon dioxide from coal combustion;
- construction of underground CO₂ storage facilities;
- construction of coal gasification installations;
- construction of facilities to produce low-emission coal fuel, which will be permitted by 2045.

The agreement parties (government and trade unions) agreed to establish a special Silesia Transformation Fund.

As part of measures to diversify the local industry, the government side committed to build an electric car factory in Silesia (Jaworzno region) in a special economic area. The production start date was set for 2024. One of the most important parts of the agreement is a detailed schedule of mines closing. According to the agreement three mines employing ca. 5000 workers will be liquidated by year 2030, in years 2031 – 2040 closed will be four mines employing ca 13600 workers and in years 2041 – 2049 six last mines employing ca 17700 workers will be closed [6].

Instruments for implementation

In the 2030 perspective, in addition to the instruments being the responsibility of the voivodship government, an important role will be played by the mechanisms designed in the Strategy for Responsible Development and the National Strategy for Regional Development [1, 8, 9].

Taking into account the above conditions, the key instruments of the Strategy implementation process include:

- own projects of the voivodship self-government financed from the funds of the voivodship budget;
- civic budget - dedicated actions and examination of compliance with the Strategy;
- repayable financial instruments within the Regional Operational Programme of the Silesian Voivodship (ROP Silesian Voivodship);
- dedicated competitions within the framework of the ROP LSV or non-competition projects - preference for OSI;

- calls for proposals, grants and subsidies e.g. in the field of culture, tourism, sport, revitalisation, climate;
- territorial agreements (municipality - voivodship and municipality - government);
- programme contract (voivodship - ministry);
- sectoral contract (voivodship - ministries);
- giving opinions on strategic documents of municipalities;
- opinions on the division of the state budget reserve;
- lobbying activities in the field of national, regional and local investments, serving the implementation of the Strategy or shaping national policies, e.g. related to the transformation of the economy, transport, air quality, energy, education and culture.

A correlation between Upper Silesia region's high priority measures, concrete actions and technologies/systems recommended to be put in practice and scheduled on a proposed time-line (2022-2050), is presented in the Annex to this current Report "Blueprint Benchmark of Upper Silesia, Poland".

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ANNEX - Blueprint Benchmark of UPPER SILESIA, Poland

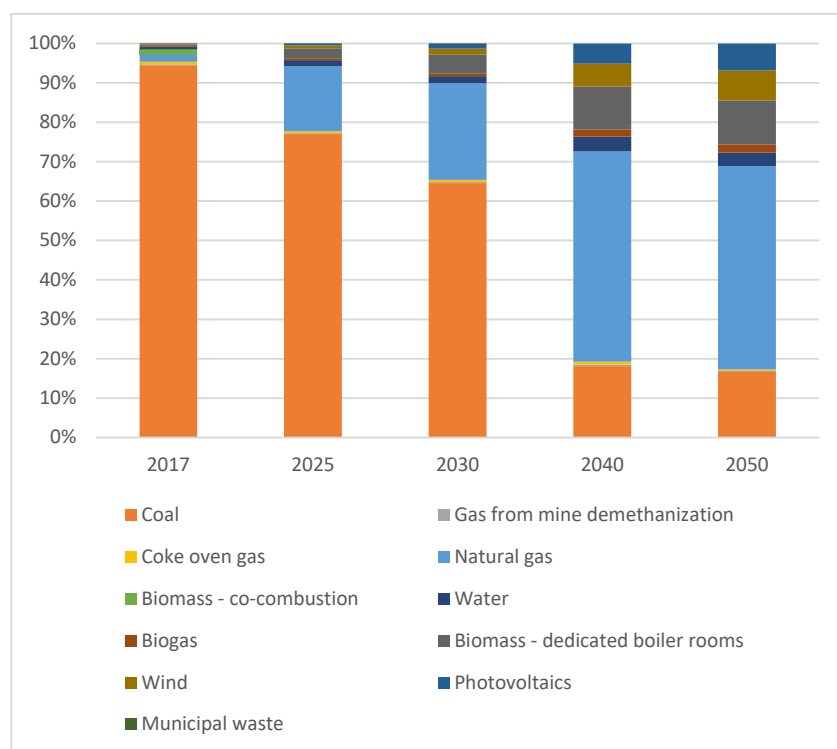
POLAND

Upper Silesia (PL22) [10-11]

	2021
SURFACE (km ²)	12,333.09
POPULATION (inhabitants)	4,492,330 (total)
GDP PER CAPITA (EUR)	12,871.49



	2022
DIRECT EMPLOYMENT IN THE COAL INDUSTRY (power and/or heat generation, mining) (pers.)	78,631
UNEMPLOYMENT (pers.)	73,727



TIME LINE OF UPPER SILESIA'S ENERGY PRODUCTION MIX FORECASTING

(energy, including electricity and heat, as % of total energy production in the region) [Marshal's Office, 2022]

JOB CREATION POTENTIAL DURING THE ECONOMIC TRANSFORMATION PROCESS [11]

TOTAL ESTIMATED JOBS CREATED TILL 2030	CONSTRUCTION	CAR INDUSTRY	RENEWABLE ENERGY	LAND RECLAMATION AND REVITALIZATION	LOGISTICS
23500-41000	11000-22000	6000-9000	2000-3000	500-1000	4000-6000

UPPER SILESIA ENERGY TRANSITION TIMELINE

Stages	High priority measures	CONCRETE ACTIONS	Technologies/Systems/Ser vices
Stage I: The Silesian Voivodship as a region of responsible economic transformation <i>Milestones: 2030 – end of current development strategy</i>	Increase the capacity of regional innovation ecosystem actors to generate and implement innovations and modern technological solutions	Supporting development processes in smart specialisations	-Internet of Things platforms. -Mobile devices and applications. - Advanced human-machine interactions. -Automated and robotic systems using smart sensors and artificial intelligence - Augmented and virtual reality. - Big data management systems. - Blockchain, prosumer business models, - Cloud services, instant messaging, conferencing platforms or remote working software. - Telecommunications and Information Technologies. - Geoinformation and its applications.
		Implementing innovation in enterprises	
		Strengthening research infrastructure for regional partnerships between science and business	
	Ensure inclusive digital transformation in the region's economy and society	Supporting an end-to-end digital transformation of SMEs	- Telecommunications and information technologies to support Industry 4.0. - Nanotechnologies and nanomaterials. - Industrial automation, automated production lines. - Design and manufacturing technologies in the automotive and aerospace industries
		Creating smart public-sector products and services to address societal challenges	
	Support the competitiveness and successful transformation of regional innovation ecosystem actors into national and international champions	Comprehensive support for start-ups	- Highly efficient energy technologies that reduce emissions of greenhouse gases and other pollutants into the environment - Generation of energy from renewable sources and improvement of efficiency of energy generation from RES - Smart and energy-efficient construction. - Technologies to reduce air emissions. - Technologies for environmental protection and remediation, energy, including biogeochemical engineering
		Activation of cluster environments	
		Support for the transformation and internationalisation of regional innovation ecosystem entities	
	Develop competencies of employees and actors of the regional innovation ecosystem for smart specialisations, digital transformation and innovative entrepreneurship	Developing employees' and enterprises competencies for the competitiveness of the regional economy	
		Strengthening the regional innovation ecosystem	
		Strengthening competencies for the internationalisation of regional innovation ecosystem entities	
	Develop low-emission economy	Comprehensive thermal modernization measures	
		Giving new functions to infrastructure and post-mining and post-industrial areas	
		Support for the development of environmentally friendly transportation.	
		Expansion of the network of measuring stations for air quality monitoring.	
Stage II: New development strategy for Silesian Voivodship – 2040 and 2050 <i>Milestones: 2049 – closure of the last coal mine</i>	Assessment of Stage I results	Monitoring of the implementation of the Strategy on the basis of available statistical data. Analyses at the region level.	- Indicator analysis with a general description of the socio-economic situation of the region. - Analysis of quantitative and qualitative indicators in relation to the set goals. - Smart and energy-efficient construction. - RES technologies.
	Update of existing policy according to new conditions	Evaluation of the progress of implementation of the established goals of the Strategy will enable decisions on the continuation or discontinuation of activities under the implemented projects, verification of the correctness of the identified objectives and directions of activities, as well as their effects in terms of the changing conditions of the socio-economic environment.	
	New/updated goals	New objectives for the strategies till 2040 and 2050 considering decreasing role of coal mining in the region will be elaborated.	