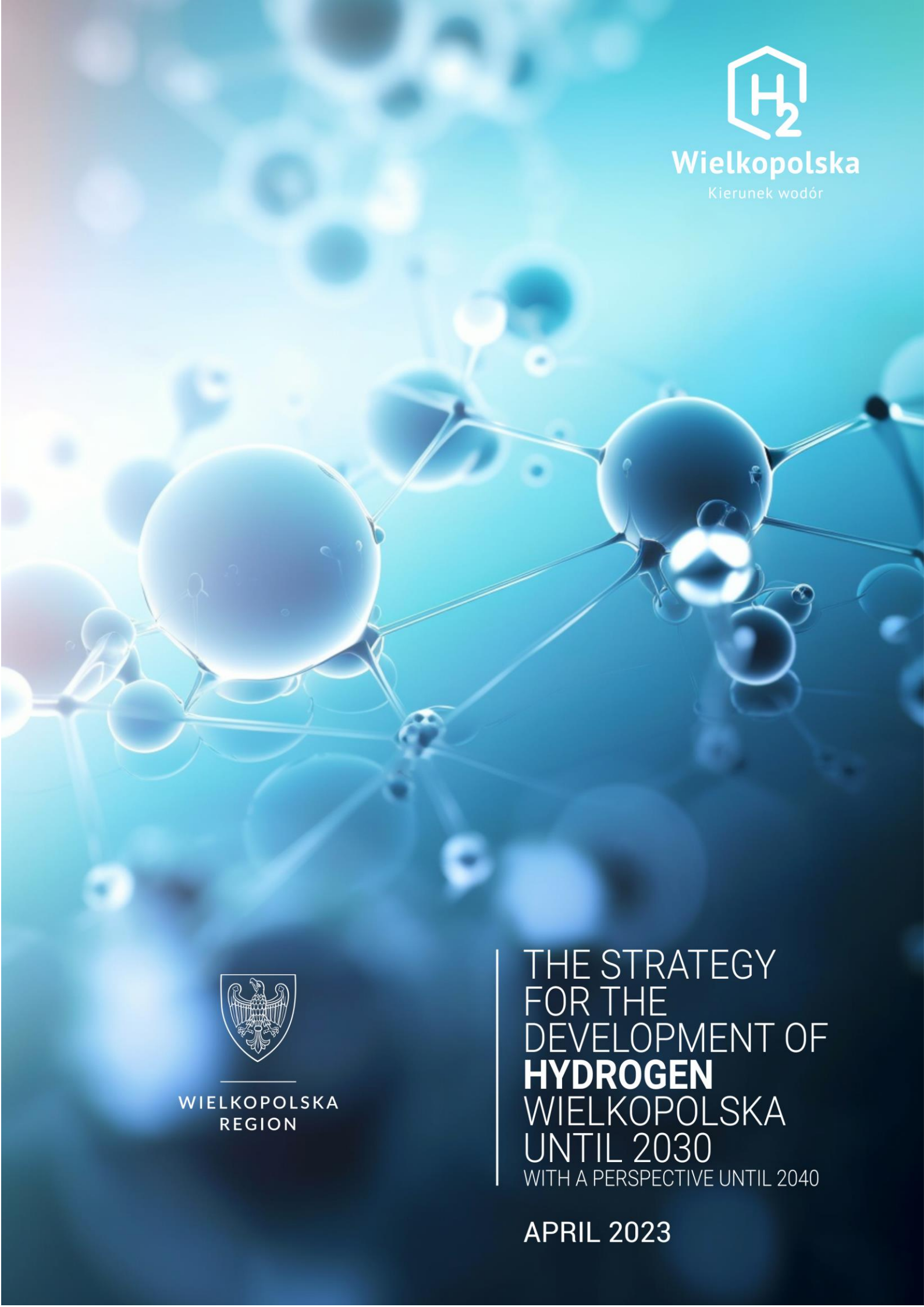

Wielkopolska
Kierunek wodór

WIELKOPOLSKA
REGION

THE STRATEGY FOR THE DEVELOPMENT OF **HYDROGEN** WIELKOPOLSKA UNTIL 2030

WITH A PERSPECTIVE UNTIL 2040

APRIL 2023

The strategy for the development of Hydrogen Wielkopolska until 2030, with a perspective until 2040, hereinafter referred to as the Wielkopolska Hydrogen Strategy 2030 ($SRWH_2$ 2030) was developed by:

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1. SUMMARY

Context of the creation of the Hydrogen Wielkopolska 2030 strategy

The world is facing global warming. Based on historical measurements and analyzes of geological material, scientists are able to show that the currently observed rate of increase in average temperatures in the world was unprecedented. On the other hand, the strong correlation of temperature changes and the level of CO2 in the atmosphere points to the direct culprit - human economic activity.

The European Union is the third largest emitter of greenhouse gases in the world (2,710 Mt CO_2[1], following China - 11,472 Mt CO_2 and the United States - 5,007 Mt CO_2). In turn, Poland, along with Germany, France, Italy and Spain, belongs to the top five emitters in the European Union.

Reducing greenhouse gas emissions has become a necessity. The adoption of the European Hydrogen Strategy in 2020 was an expression of the EU's efforts in the field of climate protection. Individual EU countries have developed and adopted national strategies for the development of a hydrogen economy. A number of regional hydrogen strategies have also been developed.

The Wielkopolska Hydrogen Strategy 2030 (hereinafter referred to as the "Strategy") is a response of local government authorities to the need to include the widest possible group of stakeholders in the stream of activities aimed at decarbonizing the economy in order to stop the ongoing climate change.

Following the analysis, the Strategy attempts to identify the elements that make up the region's potential in building the hydrogen economy chain, and to estimate this potential both for the demand and supply.

The strategy takes into account the intentions of the European Union related to developing the hydrogen economy as well as national plans, including the Polish Hydrogen Strategy, and regional plans (including the Strategy for the Development of the Wielkopolska Region until 2030). As a result of the work carried out, a vision, mission and strategic goals were formulated.

Analysis of the region's resources - conclusions

Development of strategic goals was preceded by an analysis of the region's resources in terms of the possibility of entering the hydrogen economy chain. The main conclusions from are:

- Significant potential for entering the hydrogen economy, resulting from, among others:
  - relatively favorable conditions for the location of renewable sources,
  - high potential for the supply of biogas and biomethane - a semi-finished product for the production of hydrogen,
  - a highly developed automotive industry and the position of other industries, as compared to the country: production of furniture, beverages, textiles, electrical equipment, a large number of entities from the logistics industry (TSL),
  - geographical location - at the point of contact of the main communication routes and the planned hydrogen transmission routes,
  - local government activity in the field of hydrogen - creation of the Wielkopolska Hydrogen Platform as a channel for knowledge transfer and "hydrogen" communication, the "Hydrogen School" project - addressed to teachers and students of secondary schools, students of high schools and other recipients.

[1] Climate Watch. Data for 2021. www.climatewatchdata.org

- The region's weaknesses include:
  - no large domestic consumers of hydrogen,
  - no raw material resources for the production of important components of hydrogen technologies - fuel cells, electrolysers,
  - administrative and regulatory barriers.
- Among the opportunities for the development of the hydrogen economy in the region, the following are perceived:
  - inevitability of changes in the climate and energy policy of the EU and Poland towards limiting the negative impact on the environment,
  - availability of programs financing investments in the area of hydrogen technologies,
  - increased social expectations related to the need to reduce CO_2 emissions.
- The following are threats to the development of the hydrogen economy:
  - no clear EU regulations on qualifications and the required share of zero- and low-emission hydrogen,
  - high dependence on the pace of development of renewable energy sources (RES), lack of development of renewable energy sources (wind farms),
  - no liberalization of the biogas market,
  - risk of overregulation of the domestic hydrogen market.

Potential participants in the hydrogen economy chain in the region

The development of the hydrogen economy to the full extent is related to the construction of individual elements of the entire value chain, i.e. both for hydrogen supply and its use (demand).

In addition to the RES installations already operating in the region and planned, being suppliers of "green" energy, the surplus of which could be used to produce hydrogen (as an energy storage), for hydrogen supply, participants in the hydrogen economy may include entities that, due to the subject of their activity, have competences, willingness to establish cooperation with innovative partners, would be able to contribute to the construction of individual links in the chain.

As part of the previously conducted - commissioned by the Local Government of the Wielkopolska Region - analyzes, the following PKD divisions were selected, from which companies could participate in the value-building chain of the hydrogen economy:

- producers of rubber and plastic products (Division 22),
- metal production (Division 24),
- manufacture of finished metal products, excluding machinery and equipment (Division 25),
- manufacture of computers, electronic and optical products (Division 26),
- manufacture of electrical equipment (Division 27),
- manufacture of machinery and equipment n. e. c. (Division 28),
- specialized construction works (Division 43),
- warehousing and storage of goods (Division 52),
- architectural and engineering activities; technical research and analysis (Division 71).

Entities whose business is run within one of the above-mentioned departments could participate, among others, in the following areas of activity, building a hydrogen economy in the region:

- production of compressors and new type of compressors (electrochemical),
- production of components for cooling systems: cryogenic pumps, pipes, wires, valves, monitoring sensors,

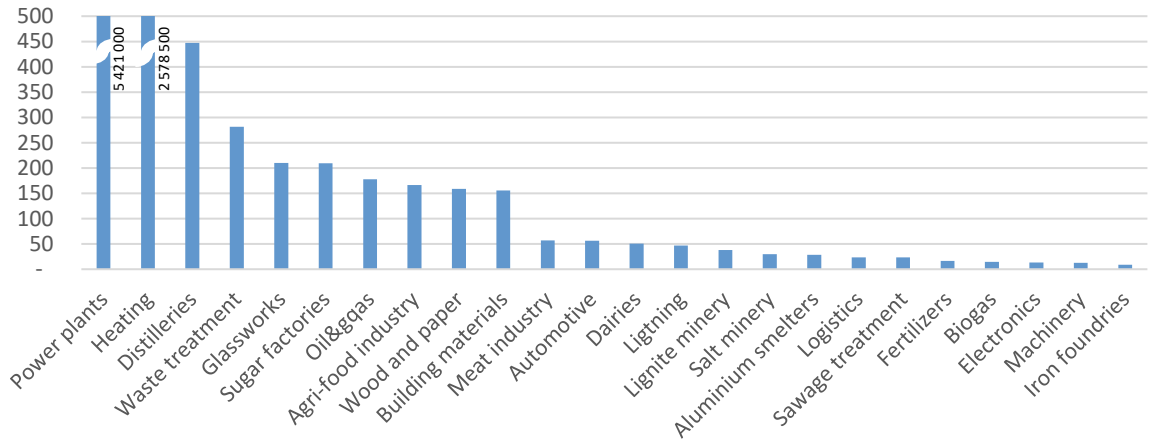
- pump production,
- production of hydrogen storage facilities: above-ground pressure tanks as well as large-size and high-pressure tanks,
- infrastructure accompanying hydrogen storage facilities (compressors, heat exchangers, connectors and valves),
- parts for hydrogen refueling stations, including parts for the construction of high-pressure elements (e.g., high-pressure polymer elements for hydrogen),
- polymer materials - gas seals, hydrogen refueling lines (hoses), connectors,
- production of pipes and connectors,
- production of gas cylinders (tanks) from lightweight composite materials,
- production of electric motors to drive pumps and compressors,
- measurements and control – hydrogen sensors – companies producing gas sensors, analyzers for the chemical, food and energy industries.

It should be noted that a large part of the competences required in the hydrogen economy is concentrated around companies producing for car and other vehicle manufacturers. Due to the high concentration of this type of enterprises in the Wielkopolska Region, focusing their development on hydrogen issues may be a starting point for building a strong industrial center in this field.

Potential demand for hydrogen will be generated by industries predisposed to decarbonization in the first place, in accordance with the directions of action taken by the EU - energy, heating, glass and metallurgy, transport.

When analyzing the data on registered CO_2 emitters, with emissions exceeding 1,000 tons per year, it is possible to identify the main industries responsible for the majority of emissions in the region. The group of the largest CO_2 emitters in Wielkopolska classified in this way includes 370 entities, and their total emissions are responsible for 95% of all emissions registered in the region.

CHART 4
List of groups of the largest CO_2 emitters in Wielkopolska based on data for 2021



Source: NEXUS Consultants study based on KOBiZE data.

In addition to the largest groups of emitters, such as power plants or heating plants, whose annual CO_2 emissions exceed 5.4 and 2.6 million tons per year, respectively, significant groups of emitters in Wielkopolska include:

- distilleries (over 400,000 tons of CO_2 per year),
- waste treatment plants (nearly 300,000 tons of CO_2 per year),
- agri-food industry, food processing and meat industry (in total nearly 300,000 tons of CO_2 per year),
- glassworks (over 200,000 tons of CO_2 per year),

- sugar factories (over 200,000 tons of CO_2 per year),
- oil & gas sector (nearly 200,000 tons of CO_2 annually);
- wood and paper industry (nearly 200,000 tons of CO_2 per year);
- construction processing (165,000 tons of CO_2 per year).

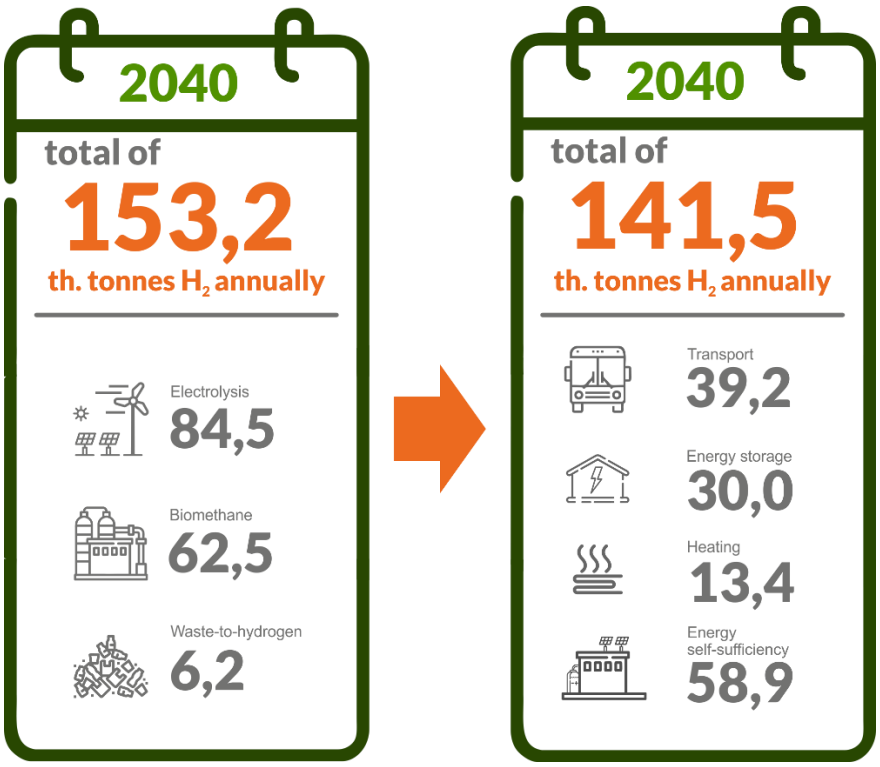
It should be noted that the list does not include such emission sources as transport or households. However, based on data on emissions from fuel combustion, it can be assumed that both groups of emitters are responsible for emissions of up to 10 million tons of CO_2 per year.

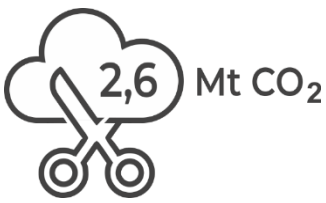
Potential of the region: supply - demand

The analyzes carried out indicate that the potential of Wielkopolska for the production of low-emission hydrogen is about 500,000 tons per year. At the same time, the use of this potential will depend to a large extent on overcoming regulatory and administrative barriers.

The assumed production volume of low-emission hydrogen in the region will amount to nearly 40,000 tons in 2030 and over 150 thousand tons in 2040. On the other hand, demand will be stimulated, in the initial period, by requirements for the use of zero-emission public transport vehicles. There are also opportunities to use hydrogen in the energy and heating sectors. Small and medium-sized enterprises are an important link in the hydrogen market, they see hydrogen technologies as a method to increase energy self-sufficiency.

Estimated hydrogen production by 2040 and its expected consumption.





Implementation of the hydrogen economy in the indicated areas of application may reduce CO_2 emissions to the atmosphere at the level of 2.6 Mt per year.

Conditions for the development of the hydrogen economy

Regulatory environment

The development of the hydrogen economy in the region, and more broadly - in the country, must be supported by the legal and regulatory environment supported by financial resources supporting "hydrogen" initiatives.

Poland joined the development of the hydrogen economy by adopting the hydrogen strategy in 2021. The priority should be to ensure a stable and friendly legal environment for the development of an energy carrier in the form of hydrogen. Among the specific objectives assumed in the strategy - objective no. 6 - is to create a stable regulatory environment. The government is working on the "Constitution for Hydrogen".

It is important to implement regulations and EU provisions into national regulations - the Green Deal, the EU Hydrogen Strategy, the Fit-for 55 program, the RepowerEU program, the Net-Zero Industry Act and others. Implementation of the hydrogen and gas market decarbonisation package ("gas package") is particularly important, together with the regulations on methane emissions and energy performance of buildings of 15 December 2021. In addition to the above-mentioned acts, it is important to implement:

- the revised Renewable Energy Directive (RED),
- Energy Taxation Directives (ETD),
- EU taxonomy,
- regulation on the development of alternative fuels infrastructure (AFIR),
- the Regulation on Trans-European Networks (TEN-T, TEN-E) and the State Aid Guidelines (CEEAG).

All of the above-mentioned regulations will be directly applied or transposed into Polish law, thus their impact on the development of the Polish hydrogen market will be significant.

A number of legal acts have already been developed, but decisions are still needed regarding, for example:

- the use of biomethane and/or hydrogen, which can be injected into the hydrogen network or gas network. This applies to both quality issues and guarantees of origin. The solutions should be fully harmonized with arrangements at the level of European countries due to the potential cross-border exchange of biomethane, hydrogen or natural gas with an admixture of hydrogen,
- the hydrogen package, which is a legal framework that takes into account the cross-sectoral possibilities of using hydrogen,
- systemic support mechanisms for conducting research and development activities of projects in the field of hydrogen technologies,
- simplifying and shortening administrative procedures for investments in hydrogen, including prioritizing investments in hydrogen valleys, introducing facilitations in locating and developing new RES capacities, energy storage facilities, including hydrogen storage facilities, solving problems with connecting RES installations to the grid.

However, the most important issue is to ensure financing of hydrogen initiatives based on national and European funds. Full activation and launch of financing programs by the National Fund for Environmental Protection and Water Management is needed. At the same time, it should be possible to finance elements of technical infrastructure used by public transport operators.

Development of technology, knowledge, staff

At present, it is difficult to predict whether and which hydrogen technologies will dominate the market in individual links of the hydrogen economy chain. The search for optimal solutions is continued. According to the International Energy Agency (IEA), approximately 30% of mature technologies necessary to achieve climate

neutrality in 2050 are currently available. The remaining 70% consists of technologies that are in the prototype or demonstration phase (30%) and technologies that have not been yet implemented on a massive scale (40%)[2].

In this context, research and development works aimed at increasing the technological readiness of the solutions taken in the area of hydrogen production, storage and distribution become important. Pilot and implementation projects will be an important source of knowledge about the course of processes, the possibility of scaling installations, directions of technology development.

Looking through the prism of the entire hydrogen economy chain, at the moment of developing the strategy (2023), the research and development effort should be directed to:

- the area of materials used in the construction of: devices, control, control and measurement equipment, storage and transmission infrastructure, including:
  - materials used in distribution systems: polymers, new materials for devices for liquid hydrogen,
  - searching for cheaper, more accessible substitutes for precious materials currently used in electrolysers, fuel cells and other devices, including substitutes based on biotechnology,
  - recycling materials from recycled devices used in the hydrogen economy, in order to recover critical raw materials,
  - metal coating technologies, gas-permeable surfaces,
- the area of development of technologies, devices, production installations, storage and transmission infrastructure, including:
  - development of high-temperature SOEC electrolysers (cells) on a larger scale,
  - examining the possibilities and potential of hydrogen storage in salt caverns in the region,
  - identification of opportunities to adapt/build gas infrastructure in the region for hydrogen distribution,
  - works on the use of hydrogen in the glass industry - new designs of furnaces and burners using hydrogen,
  - alternative methods of hydrogen production: photosynthesis, bioreactors/dark fermentation,
  - technologies for the production of advanced biofuels and synthetic fuels,
  - implementation of methane (biomethane) pyrolysis technology to hydrogen and coal in solid forms,
  - implementation works and construction of a pilot plant for processing municipal waste and plastics into hydrogen,
  - water treatment/purification technologies for the electrolysis process; including ozonation of water using oxygen from electrolysis,
  - works on IV-V type high-pressure tanks (e.g., on the possibility of using basalt fibers),
- the area of application development, hydrogen applications, including:
  - production of synthetic fuels based on hydrogen,
  - hydrogen conversion to ammonia,
  - vehicle hydrogen drive technologies, including participation in the e-VAN delivery vehicle construction project,
  - technologies for the electrification of agricultural machines and power transmission systems in tractors and off-road vehicles, including those with fuel cells,
- the area of IT systems development, including:
  - development of programs for managing the operation of RES with different characteristics (hybrid installations, energy storage), integrating energy supply into a homogeneous, predictable stream,

[2] Analysis of the potential of hydrogen technologies in Poland until 2030 with a perspective until 2040, p. 467

- specialized, intelligent electrotechnical and electronic instrumentation to ensure safety and its continuous monitoring.

The hydrogen economy is a highly innovative economy, requiring specialists in many fields, strongly influencing the environment, which must be prepared for the emergence of hydrogen in common use.

In addition to specialists with "technical" knowledge about hydrogen, its properties, possible applications (current and future), production technology, people with "soft" skills and interdisciplinary knowledge will be needed, enabling a combination of individual links of the hydrogen economy chain into one efficiently functioning system operating in a favorable regulatory and social environment.

From the point of view of the emerging hydrogen economy, the following will be needed:

- **specialists with technical knowledge** – due to the variety of production technologies and the multitude of possible applications of hydrogen, specialists in the field of hydrogen technologies will be needed, they will deal with technological consulting, audits, configuration of installations, selection of devices, selecting and operating them, creation of development plans for enterprises, as well as the development of domestic production of devices, components, parts, components of hydrogen production installations,
- **software specialists, computer scientists** – integration of hydrogen into the energy system requires integration, as the optimal production of hydrogen and its use to power the system must be harmonized; automatic operation of the entire installation requires an appropriate IT system equipped with individual software, building an energy management system (EMS - Energy Management System),
- **specialists with legal knowledge, advisors** – installation designs will have to be adapted to the applicable legal standards, while shaping the standards, analyzing the directions of changes in Europe and in the world, and adapting them will also require appropriate competences,
- **specialists with soft skills**:
  - commercialization of hydrogen concepts, ideas and projects will require personal skills and abilities, they can also develop the hydrogen economy,
  - no social acceptance for hydrogen projects will require advertising campaigns dedicated to energy transformation,
  - due to the fact that hydrogen is a potentially dangerous gas, it will be necessary to train in the operation of devices and installations, both for direct users (transport and municipal companies), as well as institutions and entities indirectly related to hydrogen, i.e. public administration that shapes conditions functioning in the immediate vicinity, and services responsible for fire safety, environmental protection, civil security,
- **financial engineering specialists, analysts**, they know the specifics of energy production from RES, they will support entrepreneurs in making investment decisions by developing feasibility studies, business plans, looking for sources of financing for the planned project, preparing applications for the EU funds.

Development of the hydrogen economy requires, apart from material and financial resources, knowledge about hydrogen and technologies, it should be passed on at all levels of education. Universities should play an important role in shaping the potential.

In the scientific area, the key is the acquisition of knowledge and its transfer at various levels of education, supported by practice, preferably in entities operating in the hydrogen industry. From this perspective, it is advisable to create a field of study dedicated to the hydrogen economy - starting from the technical sphere, through economics, the sphere of regulation, to social communication (the need to decarbonize the economy). The solution may be a field of study within one university, or an inter-university field of study, postgraduate studies.

Practice should support hydrogen education. At the current stage of development, there are generally no entities in the region that are significantly involved in the hydrogen economy. ZE PAK is the leader - taking action to support the organizer of hydrogen studies, aimed at obtaining the possibility of conducting internships, would significantly strengthen the attractiveness of the new field of study.

At the level of primary, secondary and industry schools, it is advisable to introduce content related to the hydrogen economy to the core curriculum. This is a long-term activity, requiring cooperation of many institutions and entities, including, above all, the Ministry of Education and Science.

At present, no vocational teachers in some specialties is the problem, and in the case of people with knowledge about hydrogen that they could pass on to students, their number is negligible. As the hydrogen economy develops, demand will increase. The solution should be teacher training on hydrogen technologies and their significance, e.g. for climate protection, socio-economic development. The transfer of knowledge through the prism of environmental protection, innovativeness of the hydrogen economy, can be an effective channel to reach young people and make them interested in hydrogen issues also in terms of their professional career.

Teacher training may be supplemented by establishing cooperation with enterprises that, operating in the hydrogen economy chain, will be interested in delegating employees, their experts, to learn a profession, in the event of the expected dynamic development of the market.

Creating patronage classes, in consultation with local entrepreneurs, scholarships, employment guarantees on attractive terms, will strengthen interest in hydrogen. Vocational counseling should also play an important role in attracting people interested in professions related to the hydrogen economy.

Information and consultation points providing information, e.g. on hydrogen technologies, equipment manufacturers, directions of technology development, possibilities of new applications would facilitate the dissemination of knowledge on the hydrogen economy.

In addition to systemic activities, cyclical events organized by various entities, including the local government, e.g. Roadshow, Showroom, will support systemic activities related to expanding knowledge about hydrogen, its role in decarbonization, stopping climate change, and increasing innovativeness of the economy.

Vision, mission, strategic goals, indicators

This strategy is the first step in the approach to building the hydrogen economy in the region, which is reflected in the content of the mission, developed strategic goals and levels of measures monitoring the state of development of the hydrogen economy in the Wielkopolska Region. On the basis of the analyzes carried out, the collected and analyzed views of the participants of public consultations, the approach of the Ordering Authority - the Local Government of the Wielkopolska Region - the following strategic goals, market development indicators and the vision and mission of the region in the field of hydrogen economy were assumed.

Vision of the Hydrogen Wielkopolska:

Wielkopolska is a region where hydrogen is a widely available energy carrier, replacing fossil fuels in the region's economy. Generated using low- and zero-emission technologies, safe to use and thus socially acceptable.

Hydrogen Wielkopolska mission:

Creating conditions, a framework for action for all participants in the hydrogen economy chain, enabling the maximum use of the existing potential of the region - resources, skills, geographical location - in the construction of individual links in the hydrogen economy chain in order to improve the level and quality of life in the region.

Strategic objectives:

#1	**Implementation of low- and zero-emission hydrogen production methods and - adequate to the scale of development of the hydrogen production market - development of storage and distribution systems**
#2	**Introduction of hydrogen to common, available applications, in particular in public transport**
#3	**Raising the level of knowledge about hydrogen and its importance in the energy transformation of the economy in order to prevent the negative effects of climate change, improve the level and quality of life in the region**
#4	**Wielkopolska as an important animator of the development of the hydrogen economy by creating a credible image of Wielkopolska in Europe and in the world as a region with high competence in selected links of the hydrogen economy value chain**

To assess the degree of development of the hydrogen economy in the region, a number of indicators have been proposed, monitoring the level of which will enable assessing the degree of development of the hydrogen ecosystem in Wielkopolska. Results of such monitoring may be a premise for updating the provisions of the Strategy, in particular in terms of specifying and modifying strategic goals and the manner of implementing them.

Due to the nature of the selected measures, the assessment of the degree of achievement of individual indicator values will be made in selected years - 2025, 2030, 2040. This is related to both the difficulty of obtaining data in selected areas where official statistics do not yet exist, and the fact that the hydrogen economy in Poland is at an early stage of development.

Strategic goal	Market development indicator	Unit of measure	2023	2025	2030	2040
#1 Implementation of low- and zero-emission hydrogen production methods and - adequate to the scale of development of the hydrogen production market - development of storage and distribution systems	Production capacity of low- and zero-emission hydrogen in the Wielkopolska Region	t/year	0	700	40 000	150 000
	Power of electrolysers dedicated to hydrogen production in the Wielkopolska Region	MW at the end of the year, cumulatively	0	5	250	1 000
	Number of installations for generating hydrogen in the Waste-to-hydrogen technology	pcs. at the end of the year, cumulatively	0	1	2	5
	Number of hydrogen generation installations in systems integrated with biogas plants in the Wielkopolska Region	pcs. at the end of the year, cumulatively	0	1	5	20
	Number of feasibility studies for investments in new hydrogen generation sources	pcs/year	0	2	2	2
	Number of hydrogen valleys[3]	pcs. at the end of the year, cumulatively	0	1	2	3
	Number of initiated R&D&I projects in the area of hydrogen production, transmission and storage technologies	pcs/year	5	10	20	20
Strategic goal	Market development indicator	Unit of measure	**2023**	**2025**	**2030**	**2040**
#2 Introduction of hydrogen to common, available applications, in particular in public transport	Number of hydrogen-powered buses in the cities of the Wielkopolska Region	pcs. at the end of the year, cumulatively	1	30	100	300
	Share of zero-emission trains, including hydrogen trains, in the fleet of the Local Government of the Wielkopolska Region	%	67	75	75	95-100
Strategic goal	Market development indicator	Unit of measure	**2023**	**2025**	**2030**	**2040**
#3 Raising the level of knowledge about hydrogen and its significance in the energy transformation of the economy in order to prevent the negative effects of climate change, improve the level and quality of life in the region	Number of hydrogen initiatives undertaken by CSG	pcs. at the end of the year, cumulatively	2	5	10	20
	Number of post-graduate studies and specializations related to hydrogen	pcs. at the end of the year, cumulatively	0	2	4	5
Strategic goal	Market development indicator	Unit of measure	**2023**	**2025**	**2030**	**2040**
#4	Number of events dedicated to hydrogen technologies attended by	pcs./year	2	5	5	5

[3] Hydrogen valleys defined as local initiatives covering a wide spectrum of the hydrogen economy value chain (generation, distribution, use) and having a feasibility study.

Wielkopolska as an important animator of the development of the hydrogen economy by creating a credible image of Wielkopolska in Europe and in the world as a region with high competence in selected links of the hydrogen economy value chain	stakeholders of the regional hydrogen economy.					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