



HYDROGEN PROJECTS PORTFOLIO



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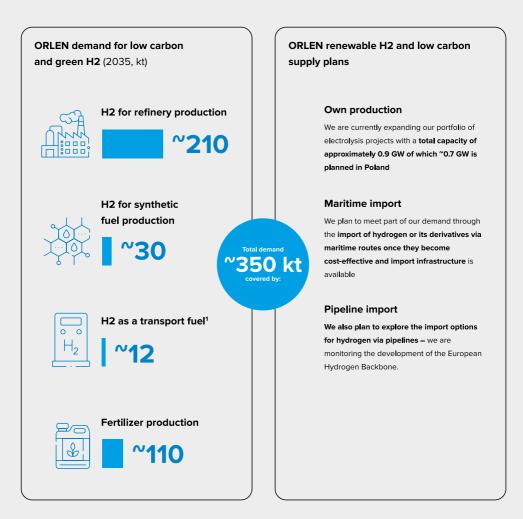
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Downstream - Hydrogen

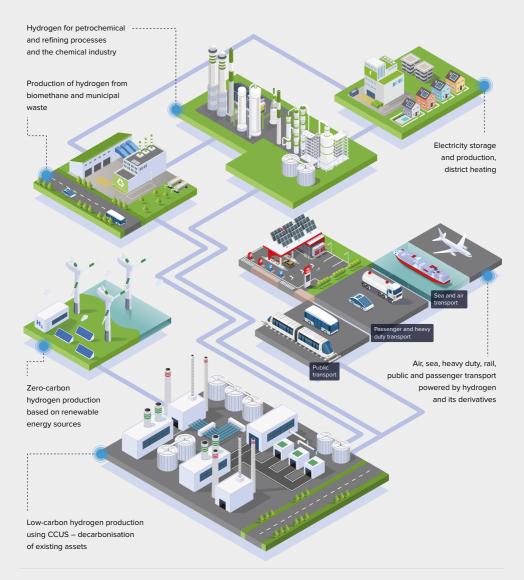
ORLEN plans to consume ~350 kt of renewable or low-carbon hydrogen per year, supplied from own production or imports



Note: Demand includes also import of hydrogen derivatives e.g. ammonia and own blue hydrogen production with CCS

1) Czech transport volumes included in "H, fo refinery production" as electrolyzer will be used for both purposes Source: ORLEN

Vision for the production and use of hydrogen at the ORLEN Group

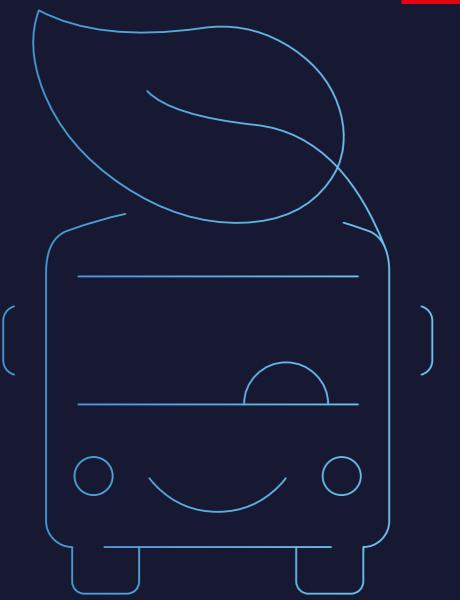




Hydrogen as a transport fuel

Hydrogen as a fuel in transport for buses, non-electrified railways, passenger cars, light and heavy-duty vehicles is response to the European Union's ambitions for climate neutrality. ORLEN Group aspires to emerge leader implementing hydrogen in Central Europe, supporting decarbonization of transport sector by supplying automotive hydrogen enabling reduction of greenhouse gas emissions throughout the fuel life cycle by at least 73.4 %.





HUB Trzebinia





In Trzebinia in 2021, ORLEN Group has launched a modern installation where it is produced propylene glycol. At the same time, the first Polish hydrogen HUB, which is part of the glycol complex, was put into operation. In the hydrogen HUB ca. 75 % will be intended for the production of glycol, and the remaining 25 %, after cleaning, as hydrogen fuel.

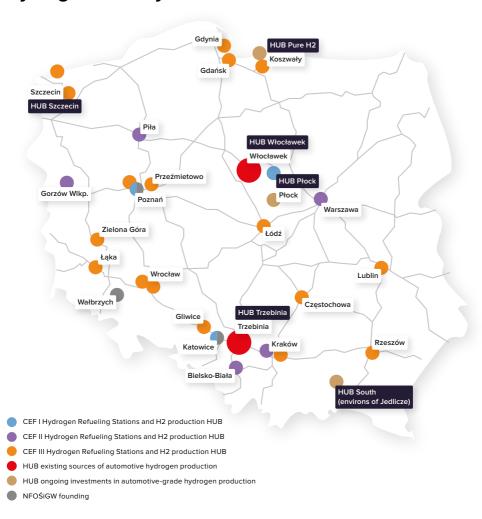
The HUB's production capacity is 350 t/year of automotive-quality hydrogen. As part of the project, the first mobile hydrogen refueling station in Poland was also launched. Since 2022, part of public transport buses in Kraków have been utilizing hydrogen from Trzebinia, refueling from a mobile refueling station.

- Use of hydrogen in glycol production and as a fuel;
- 350 tons per year of automotive quality hydrogen;
- Public transport in Cracow powered partly by hydrogen.



Clean Cities (Phase I, II & III)

Hydrogen mobility in Poland



Project "Clean Cities – Hydrogen mobility in Poland (Phase I)"

The scope of the project includes the construction of a low-emission automotive quality hydrogen* production facility (HUB Włocławek) and three public 24/7 hydrogen refuelling stations

- Funding from CEF Transport Blending Facility, eligible project cost: EUR 9,985,580.00,
- Grant amount: EUR 1.997.116.00.
- The hydrogen refueling stations in Poznań and Katowice were additionally financed through funds from the National Fund for Environmental Protection and Water Management as part of the priority program "Support for Electric Vehicle Charging Infrastructure and Hydrogen Refueling Infrastructure" (~ 20 million PLN). The hydrogen refueling station in Wałbrzych was also co-financed by the National Fund for Environmental Protection and Water Management Program.

Project "Clean Cities – Hydrogen mobility in Poland (Phase II)"

The project involves the construction of five publicly accessible 24/7 hydrogen refueling stations

- Funding from CEF Alternative Fuels Infrastructure Facility (AFIF), eligible project cost: EUR 25,591,265.00,
- Grant amount: EUR 12,795,632.00.

Project "Clean Cities – Hydrogen mobility in Poland (Phase III)"

The scope of the project includes the construction of an automotive quality hydrogen production facility (HUB Szczecin) and the construction of sixteen 24/7 hydrogen refuelling stations available to the general public

- Funding from CEF Alternative Fuels Infrastructure Facility (AFIF), eligible project cost: EUR 124,612,950.00,
- Grant amount: EUR 62,306,475.00,
- Construction of an automotive quality hydrogen production facility based on water electrolysis technology powered by renewable energy sources.

^{*} low-carbon hydrogen which enables a reduction in full life-cycle greenhouse gas emissions by at least 73.4 %, resulting in full life-cycle greenhouse gas emissions of less than 3t CO₂e/tH₂ [Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020]





HUB Włocławek – automotive-quality hydrogen production. The largest domestic HUB in Poland terms of the volume of high-quality hydrogen production from electrolysis process.

Starting in 2024, approximately 2,500 tonnes of automotive-grade hydrogen can be produced, with a modular design that allows for flexible production increases as demand grows, up to 4,500 tonnes.

Hydrogen purified in Włocławek is **produced** in an brine electrolysis process as a byproduct of the chlorine extraction process and has so far been used in the ammonia production plant.

- Hydrogen as a byproduct in chlorine extraction process and used as product in ammonia production and as a fuel:
- Polish public transport partly powered by hydrogen;
- First mobile hydrogen refuelling station in Włocławek;
- The HUB was built under the Clean Cities Programme (Phase 1) and cofinanced under the CEF Transport Blending Facility Call.







- This is the first publicly available 24/7 ORLEN hydrogen station in Poland;
- Dispensers for 350 and 700 bar allowing the refueling of eg. passenger cars and city buses;
- The station provides H₂ for public transport operator buses in Poznań city every day;
- HRS can provide fuel for 34 city buses within 12 hours;
- This is the largest hydrogen refueling station (HRS) of this type in Poland;
- Over a period of 15 years, ORLEN Group will supply 1.8 million kg of low-emission hydrogen fuel for Poznań's public transport;
- HRS was built under the Clean Cities
 Programme (Phase 1) and co-financed under
 the CEF Transport Blending Facility Call
 and the National Fund for Environmental
 Protection and Water Management priority
 programme "Support for electric vehicle
 charging infrastructure and hydrogen
 refuelling infrastructure";
- The station is open to the public from June 2024.







ORLEN Group actively collaborates with various Polish cities in the implementation of hydrogen-fueled buses, contributing valuable support and expertise. The company has helped organizing comprehensive tests in different urban settings, demonstrating its dedication to real-world application.

Bus tests have so far taken place in four Polish cities: Płock, Kraków, Poznań and Katowice.

As part of this collaborative effort, ORLEN Group commits to supplying the necessary hydrogen fuel for operation of buses and providing refuelling systems.

This collaborative approach ensures a seamless transition to zero-emissions public transport, underscoring ORLEN Group role as key partner in driving more sustainable solutions for urban mobility.







ORLEN Group in consortium with the Gdańsk Refinery, is implementing a project subsidized under the CEF Transport Blending Facility entitled "Pure H2 – Hydrogen Purifying Unit and Filling Infrastructure."

The project includes the construction of infrastructure for the production, distribution and sale of automotive-quality hydrogen that meets the requirements of standards for hydrogen fuel intended to power fuel cells and 2 public HRSes (350/700 bar).

- Construction of a hydrogen purification installation at the refinery in Gdańsk to the automotive quality hydrogen;
- Construction of a purified hydrogen*
 distribution station, i.e. an installation for
 filling the so-called battery vehicles; location
 of the installation vicinity of the refinery in
 Gdańsk;
- Construction of two publicly accessible hydrogen refueling, with a pressure standard of 700 bar for passenger cars and 350 bar for buses;
- Funding from CEF AFIF Eligible project cost: EUR 9,917,520.00;
- Grant amount: EUR 1,983,504.00.

- · Hydrogen purification installation;
- Purified hydrogen distribution station;
- Two publicly accessible hydrogen refuelling stations.

^{*}Purified hydrogen to the automotive quality





The project implementation assumes an annual RFNBO hydrogen production of approximately 2 400 t RFNBO H₂.

The project consists of a photovoltaic power plant with a capacity of approximately 60 MWp and a $\rm H_2$ hydrogen production unit (large $\rm H_2$ hydrogen storage facility, electrolyzer with a capacity of up to 30 MWe, hydrogen drying and purification).

The hydrogen production HUB is expected to start operating since 2028 gradually increasing production of renewable hydrogen. The project is intended to provide renewable energy (100% renewable) to cover potential production capacity of the electrolyzers.

The project is intended to provide the maximum amount of renewable energy to cover the maximum potential production capacity of the electrolyzer.

- RFNBO production located in Czech Republic;
- The innovation element: photovoltaic power plant (PVPP) with regulation of output power.







ORLEN Group has set ambitious goals to provide up to 28 hydrogen filling stations in the Czech Republic by 2030, along with two hydrogen distribution stations for rail transport in Litvínov and Neratovice.

- The first station in Prague-Barrandov was launched on March 10, 2023, and the second HRS station in Litvínov was launched on June 28, 2023. Both stations are publicly accessible and offer refueling facilities for buses, cars and trucks. Three more stations are under construction (another in Prague, Brno and Ostrava);
- The station features two dispensers that come equipped with specially designed nozzles that offer a pressure of 700 bar for cars and 350 bar for larger vehicles.
 Contruction of HRSes is supported under the Sectoral Operational Programme Transport financed by the Ministry of Transport of the Czech Republic.









ORLEN Group consistently develops hydrogen technology in transport. The concern purchased a modern locomotive from PESA Bydgoszcz, which is the first rail vehicle in Poland using hydrogen fuel. At the same time, its tests began. As part of operational tests, the locomotive's first run took place on the Gdynia - Hel route (17.09.2023).

The hydrogen-powered shunting locomotive will ultimately operate on a siding of the Production Plant in Płock.

The capacity of the locomotive's tanks is over five times larger than in hydrogen-powered buses and amounts to 175 kg. This enables the locomotive to operate 24 hours a day.

The locomotive's traction system includes two fuel cells with a power of 85 kW each, a battery and four traction motors.

- The first vehicle of this type in Poland;
- Possibility of zero-emission journeys on non-electrified lines when powered with green H_a;
- Use of the locomotive at the ORLEN facility in Płock;
- · Possibility of working 24 hours a day.







Hydrogen laboratory launched in Trzebinia & Włocławek by the ORLEN Laboratorium is equipped with research and measurement equipment enabling hydrogen quality tests to be carried out in accordance with the ISO 14687 Grade D standard.

As the only laboratories in Poland and one of the few in Europe; has become a facility with accreditation of advanced automotive-quality hydrogen research methods - it is able to test the quality of hydrogen in terms of the ppb level of contamination.

In order for fuel cells in vehicles to remain efficient and not undergo accelerated degradation, the hydrogen they will be powered by should have specific parameters and contain minimum concentrations of

components such as water, hydrocarbons, oxygen, helium, nitrogen, argon, carbon monoxide and dioxide, sulfur compounds, formaldehydes, ammonia, halogen compounds and particulate parts. The International Certification Organization has created the ISO 14 687 standard, which introduces international standards for hydrogen fuel and describes the impact of specific pollutants on the degradation of fuel cells. According to the standard, hydrogen fuel should have a minimum purity of 99.97 % mol (grade D).

In order to be able to control the quality of our hydrogen fuel in accordance with the standard, we have created a dedicated laboratory in Trzebinia & Włocławek.

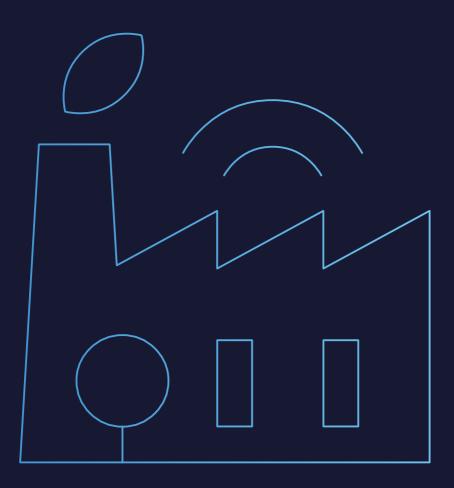


The use of hydrogen in the decarbonization of ORLEN Group production assets

In the pursuit of decarbonizing production assets, hydrogen emerges as a pivotal solution, notably evident in ORLEN Group strategic initiatives.

Through various projects, including those in industrial plants producing fuels, ORLEN Group wants to actively implement solutions based on renewable hydrogen, showcasing a commitment to reducing carbon emissions. These efforts underscore the critical role of hydrogen in reshaping industrial landscapes and advancing the decarbonization agenda across key sectors.









The Baltic Power offshore wind farm is a key project of the ORLEN Group and Northland Power, contributing to the energy transition of Poland.

The Baltic Power project, located approximately 23 km north of the coastline, near Choczewo and Łeba, is the most advanced investmented implemented in the Polish Exclusive Economic Zone of the Baltic Sea.

The installed capacity of 76 wind turbines under Baltic Power will be 1,140 MW.

The construction of offshore wind farms is a complex and multi-stage process. The onshore part of the farm, as well as the service base in Leba, is under construction since 2023. The start of offshore construction is scheduled for early 2025 and will continue until 2026.

The Baltic Power farm area of approx. 130 km² will feature 76 wind turbines, each of 15MW capacity.

These are currently some of the largest and most advanced turbines available on the market, and Baltic Power will be one of the first wind farms in the world to use them.

The height of the turbines will exceed 200 meters, and the operating area of each rotor is approximately 43,000 m².















The ORLEN Group has been developing renewables for a long time. The company has a complex portfolio of projects, including offshore wind farms in the Baltic Sea area belonging to Poland, as well as onshore wind farms and photovoltaic installations.

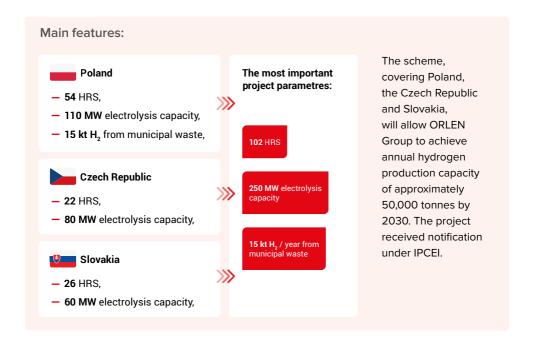
Our portfolio includes 45 hydroelectric power plants.

Currently, ORLEN has 1.3 GW of installed RES capacity. Our ambition is to increase this capacity to almost 13 GW by 2035, according to ORLEN's Strategy 2025-2035, available on www.orlen.pl.

Hydrogen Eagle



HYDROGEN EAGLE is an investment program to develop an international chain of hydrogen HUB's powered by renewable energy sources and build innovative facilities to convert municipal waste into zero- and low-emission hydrogen. The project also provides for the construction of more than 100 hydrogen refuelling stations for individual, public and cargo transport.



The program provides for the construction of six new RES-powered hydrogen HUB's: three in Poland, two in the Czech Republic, and one in Slovakia, including plans to build a hydrogen electrolysis plant to which electricity will be supplied from the RES. The capacity of the RES-powered electrolysis plants will ultimately total approximately 250 MW. The scheme also envisages the construction of three innovative plants for converting municipal waste into low-emission hydrogen, to be located in Poland and in the Czech Republic, as well as an international network of more than 100 hydrogen refuelling stations.

Green Hydrogen for Refinery Sector Program (1)

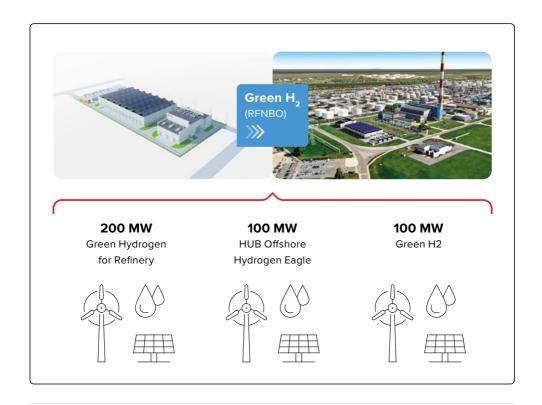
Program description:

Green Hydrogen for Refinery Sector program is part of the strategic initiative to decarbonize the fuel production in refinery using renewable hydrogen (RFNBO).

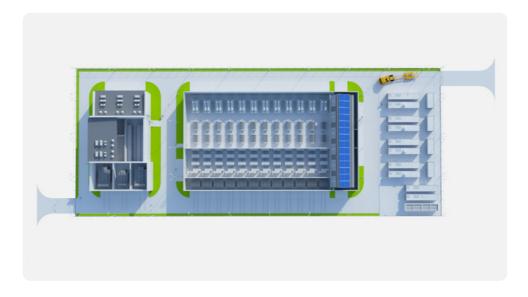
The aim of the program is to reduce the use of gray hydrogen in refinery processes by replacing it with renewable hydrogen of non-biological origin (RFNBO). At the same time, this initiative is key to the ORLEN Group's implementation of the RED III targets.

The program consists of the following projects: Green Hydrogen for Refinery (200 MW), HUB Offshore (Hydrogen Eagle) and Green H2.

In total, the expected installed electrolysis capacity of whole Green Hydrogen for Refinery Sector program is approx. 400 MW. It is assumed that investments within the Program will be cofinanced from national and EU funds.









Green H2 project's aim is to produce renewable hydrogen through water electrolysis using combination of AEL and PEM technologies. This renewable hydrogen will be used in the fuel production processes in ORLEN Group refinery in Gdańsk and in transport sector.

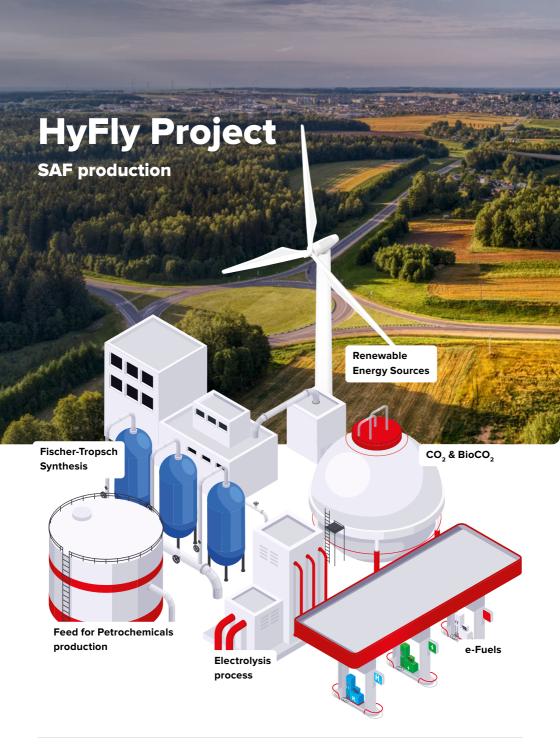
The electrolyser is expected to start full operating as of 2030 and to gradually increase its production up to $^{\sim}$ 8 500 tonnes of renewable hydrogen per year.

Implementation of the Project will significantly contribute to reducing CO₂ emissions and help achieve the targets set out in the RED II /RED III directives.

Hydrogen will be produced solely with electricity generated from renewable sources.

Main features:

- The installation of an electrolysers with a capacity of 100 MW and 20 MWh battery storage;
- Full operating from 2030;
- The project received notification under CEEAG.



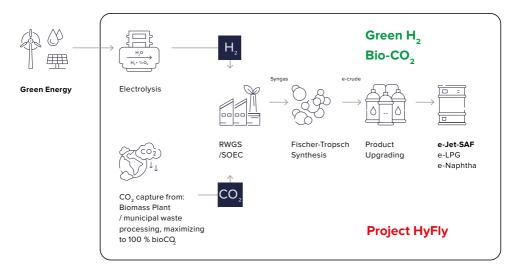
- E-Jet production (e-SAF) and other products that can be blended into existing infrastructure;
- Optimization of process towards liquid e-Fuels or valuable petrochemical feedstock (finally HVCh High Value Chemicals);
- Dedicated digital twin and an integrated optimizer for molecule management to ensure proper certification and utilization of molecules. To optimize operational efficiency to the fullest;
- Project contributes to the process decarbonisation of chemical & energy industry, as renewable hydrogen replaces grey hydrogen from steam reforming in a 1:1 ratio;
- Project shall utilize hydrogen from electrolysis processes powered by renewable energy sources and imported H₂ with diversified sources of bioCO₂ to maximize production.

Project assumption





Scope of planned e-Fuels plant



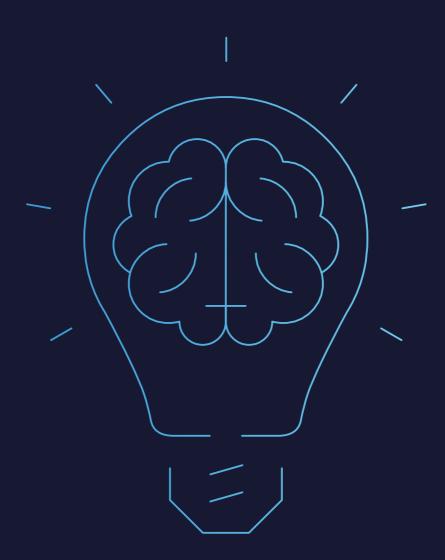


H2 Academy

The H2 Academy is an educational initiative by ORLEN. It stands as a testament to the company's commitment to nurturing a new generation of professionals dedicated to advancing the hydrogen future.

This program aims to promote and cultivate young talents who will play a pivotal role in shaping the landscape of sustainable energy. By providing specialized education and training, ORLEN's H2 Academy not only equips individuals with the skills needed for the evolving hydrogen sector but also fosters a community of experts poised to drive innovation and propel the industry forward. Each year, 30 graduates are selected for the academy program and the top 5 recieve the opportunity to complete an internship at the ORLEN company.









The aim of the project is to exchange knowledge between experts and practitioners with many years of experience in the field, and people interested in the indicated topics who are starting out in the industry.

The goal of the H2 Academy is to create and continuously develop an innovative educational program, combining substantive content with the practical aspect of the application of hydrogen in business.

Each edition of the Academy is organized by ORLEN Group in cooperation with technical universities in Poland. Companies that are part of building the hydrogen market in Poland (PESA, Solaris, Toyota) also participate in the organization of the Academy.

We currently have 8 employees at ORLEN on full-time positions. The third edition is underway.

For more information visit: **akademiah2.pl**

Main features:

- Connecting experts and practitioners with students interested in hydrogen;
- A combination of practical and theoretical classes;
- Extensive cooperation with universities and business representatives.



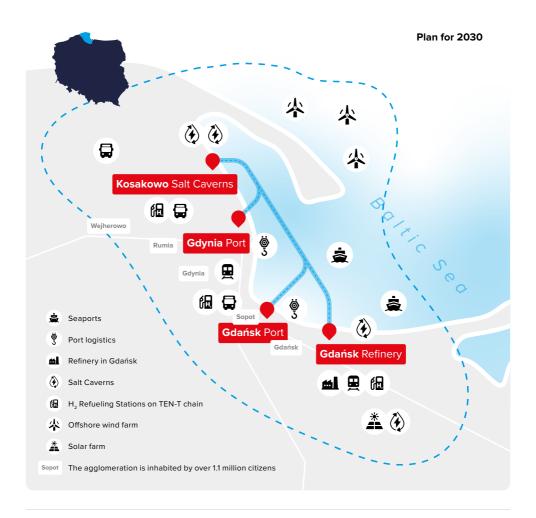
Hydrogen Valleys

Hydrogen valleys like Mazovian and Amber highlight the value of collaboration in advancing hydrogen technology. These initiatives foster cooperation among industry, research, and policymakers. ORLEN Group active role in both valleys showcases its commitment to driving innovation and more sustainable solutions, contributing significantly to the development of hydrogen-based economies in Central Europe.





Amber Hydrogen Valley



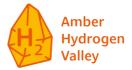
ORLEN is the coordinator of the Amber Hydrogen Valley covering the Pomeranian Voivodeship, which was created in 2023.

The plans for the Amber Hydrogen Valley include:

- the launch of several sources of renewable hydrogen production;
- the supply and refueling H₂ in few locations at the Port of Gdynia;
- the deployment of publicly accessible stations in key cities across Pomerania.

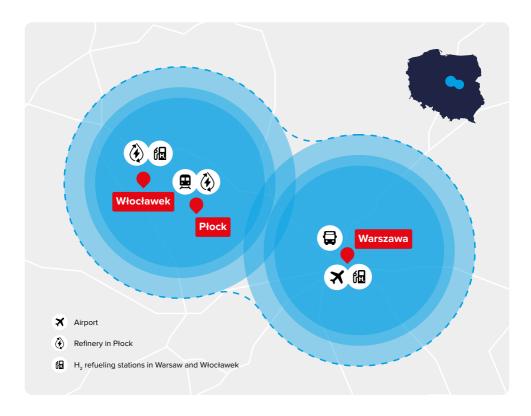
The project also includes the creation of the Poland's first fleet of hydrogen-powered port vehicles to support operations at the port of Gdynia and Gdańsk.

In addition, investments will be made in dozens of hydrogen-powered vehicles, including passenger cars and light commercial vehicles, for use by courier and grid maintenance companies.





HySPARK – project of Mazovian Hydrogen Valley











The aim of the project is to create a regional hydrogen ecosystem in Mazovia, which will connect hydrogen producers with technology providers and end-users in various sectors, including transportation (use of hydrogen as fuel in vehicles) and industry (for example in the production of fertilizers) in 2025-2029.

The HySPARK (Hydrogen Solutions for euroPean Airports & Regional Kinetics) project, which includes a consortium of 15 partners from 4 countries, is the first Mazovian Hydrogen Valley project to receive a positive decision from the European Commission for funding. The project was awarded nearly EUR 9 million under Horizon Europe (lunched by Clean Hydrogen Partnership).

You can find details on CORDIS EU platform: https://cordis.europa.eu/project/id/101192536



The key elements of the project are:

- · Hydrogen-ready airport;
- · Production of low-emission hydrogen;
- Logistics and transport based on hydrogenpowered heavy-duty transport;
- Hydrogen-powered public transportation in the capital of Poland;
- · Modeling and optimization of the valley;
- Production of green ammonia, which will be used for the production of fertilizers.

2 hydrogen powered buses will be supplied by ARTHUR BUS, 4 hydrogen semi-trucks by ENNOVATION Technology and 6-8 ground service equipment (GSE) for the Warsaw Chopin Airport by the ATENA. The users of the vehicles will be Miejskie Zakłady Autobusowe in Warsaw, ORLEN and LS Airport Services.

Research and development activities for the project will be provided by IEN-PIB, Warsaw University of Technology, RINA, and Bureau Veritas Poland. Project dissemination activities will be the responsibility of the City of Warsaw, the Foundation in Climate, and the two international airports SEA Milan Airports and Aer Arann Islands, among others.

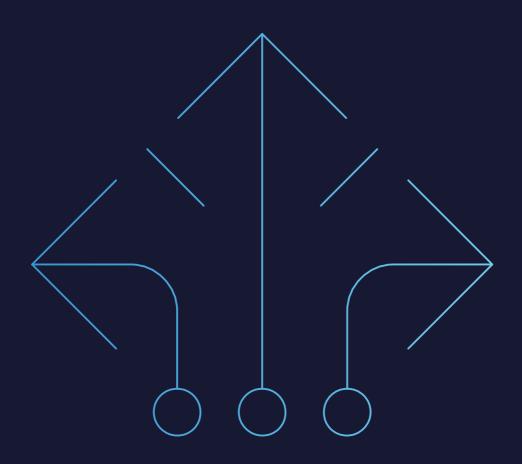
The small-scale hydrogen valley will be fundamental in understanding how a global hydrogen market should function as a complete open system.

05

Research & Development

Collaboration in research and development is paramount for advancing hydrogen technology. ORLEN Group acknowledging the transformative potential of collective expertise, actively engages in collaborative initiatives. By fostering partnerships in research, particularly in the realm of hydrogen, ORLEN Group contributes to the development of innovative solutions, underlining the crucial role of cooperation in shaping the future of sustainable energy.









The Green H2 project, has been started and will be completed in 2027 and plans to produce green hydrogen using a 1 MW electrolyser system, strategically located next to the refinery in Gdańsk, Poland.

The project's objective is to build a modular and scalable hydrogen production system, that includes and electrolyser powered by solar panels anlong with energy management and residual heat recovery systems. The green hydrogen produced will be used by the refinery. The system will also include a storage facility for compressed hydrogen, so that the hydrogen produced can also be used for other sectors.

The Green H2 project plans to modernise and decarbonise the current method of industrial hydrogen production. The innovation in the project is that it involves not only the integration of the electrolyser, but also an energy management system, heat recovery and a dedicated renewable energy source.

Implementation of the project will lead to the partial reduction of ${\rm CO_2}$ emissions from refinery processes.

- Funding from ETS Innovation Fund CAPEX: EUR 7,490,000.00;
- Grant amount: EUR 4.490.000.00







The aim of the project was to develop and construct a power-to-gas (P2G) system based on a stack of solid oxide electrochemical cells (SOC) operating in the electrolyzer (SOE) mode, also intended for reversible operation (rSOC) in the fuel cell mode (SOFC).

As part of the project, R&D work was carried out focused on developing the concept and building a prototype installation with a power of 10 kW with an rSOC stack.

The rSOC stack is a repeatable element that can be combined into larger modules to build high-power systems. During the project, a series of SOE/SOFC installations were developed allowing the system power to be scaled: 10 kW, 50 kW, 100 kW, 250 kW, 1 MW.

Financing: The project is co-financed by the European Union from the European Regional Development Fund, through the National Center for Research and Development.

- Planned total cost of the Project: PLN 7.398.754.09:
- Maximum funding amount: PLN 5,687,621.77

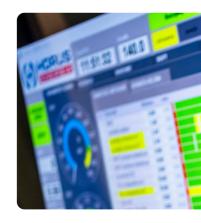
Main features:

- · Technology: solid oxide electrolyzer;
- Installation class: 10 kW (SOE) 5 kW (SOFC);
- · Round-trip efficiency: 42.3 %;
- Energy input: 40.3 kWh/kg H₂;
- H₂ magazine: cylinder bundles with a pressure of 200 bar;
- Status: Put into operation (2023).



The Multifuel, as method of supplying an internal combustion piston engine with gaseous fuel containing hydrogen and hydrocarbons invention was submitted for both national and international patent protection:

- Patent Office of the Republic of Poland (UPRP): #P.443048;
- European Patent Office (EPO): #EP23214234.9;
- United States Patent and Trademark Office (USPTO): #18/529,863.



The Multifuel was technically developed, implemented and subsequently tested on a real scale 1 MW_{el}CHP unit as a part of an R&D Project called HyCogen After successful testing campaign the Multifuel technology is being currently commercialized.

The Multifuel is the first of its kind in the world integrated fuel system enabling supply of piston gas engines with hydrogen, natural gas and other gaseous hydrocarbons, simultaneously or interchangeably.

Given functional integration of the gas mixing system and the gas injection system in an engine intake system the Multifuel allows for a smooth change in the proportions of hydrocarbon mixtures and automatic self regulation depending on the availability of these fuels, optimization of their use or the need to reduce CO₂ emissions.





Key functionalities of the Multi-fuel:

- Ability to operate on various gaseous hydrocarbons, including hydrogen each alternatively or simultaneously;
- Designed to enable continuous control of gas air mixture composition;
- Automatic adjustment of the gas fuel dose at any range of engine operation with no need to reduce the power;
- Higher effectiveness and easy optimisation practically for any fuel;
- Enabling for 100 x faster change in the gas mixture composition;
- Integrated control system continuously monitoring combustion process and able to apply changes from cycle to cycle;
- Universal design, simple configuration, reliability and operational safety;
- Adaptable and scalable for various engine selection with an ability to implement as a retrofit for the existing units.





Research on the production of hydrogen from seawater on the ORLEN Group platform in the electrolysis process and on the use of hydrogen for decarbonization of assets.

Project stages:

The implementation is scheduled for the period 2023 - 2025:

- Phase I: laboratory tests regarding the selection of a desalination system for further tests in real conditions; conducting technical and economic analyzes regarding the possibility of upscaling the tested H₂ production systems from seawater;
- Phase II: design of the research installation, including the design of the desalination module, was completed in Q3 2023 a milestone was achieved. Key equipment: H₂ compressor, electrolyzers, gas turbine;
- Phase III: onshore prefabrication and construction of a research installation on an oil platform;
- Phase IV: research work on a real installation on an oil platform, data analysis, development of conclusions.







In the ORLEN Group in Odolanów, as part of the InGrid Power to Gas research program, an installation for processing electricity produced from renewable sources into gaseous fuels such as hydrogen has been launched. Now, the possibilities of supplying hydrogen via natural gas distribution networks and using a mixture of these fuels in end devices will be tested.

As part of the program, test production of green hydrogen has already been launched using electricity from a photovoltaic farm with a capacity of almost 0.5 MW, operating on the premises of the ORLEN Group in Odolanów.

The capacity of the installation, using the electrolysis process, is 20 tons of hydrogen per year. The fuel produced will be combined with natural gas and then injected into the research distribution network to check how hydrogen and natural gas mixtures affect individual elements of the infrastructure and on receiving devices.

The research installation in Odolanów also includes two energy storage facilities. One is an electrical energy storage facility with a capacity of 0.4 MWh, which can power an electrolyzer, the other is a hydrogen storage facility, which consists of two chambers - each with a capacity of 10 cubic meters, which can store over 50 kg of this fuel at one time. The electrolyzer used in the installation is one of the first and largest devices launched in Poland. Its power is 0.4 MW.





Vetni objective was to develop and construct a pilot unit for high-purity hydrogen production in solid oxide electrolysers (SOE) (with efficiency higher than the currently available technologies), powered with renewable energy. The project includes R&D work focused on the development, construction and testing under real operating conditions of a system with electrolysers integrated into the refinery process, which would supply process steam for hydrogen production.

Vetni and ORLEN Group is a globally unique project due to the deep integration of electrolysers with an existing industrial process. The highly innovative project relies on Polish solutions in the technology and materials. Partly funded by the European

Union, it is conducted in partnership with the Institute of Power Engineering and the AGH University of Science and Technology of Kraków. The project is co-financed by the National Centre for Research and Development under the Smart Growth Operational Programme 2014-2020.

The electrolyzer developed as part of the project, powered by electricity from renewable energy sources, creates a complete system for producing and compressing hydrogen with a capacity of approx. 18 kg $\rm H_2$ /day. The installation is the largest of its kind in Poland.

Main abbreviations and terms:

AEL - Alkaline Electrolyser

Automotive - quality hydrogen – hydrogen that is in accordance with ISO14687 grade D

Bio - CO₂ - biogenic CO₂ is a carbon source originating from biomass

Blue ammonia – is produced from hydrocarbons where the CO₂ emitted during production is sequestrated via carbon capture utilization & storage (CCUS) technology.

CCS - Carbon Capture and Storage

CCUS - Carbon Capture, Utilisation and Storage

CEF AFIF – Connecting Europe Facility Alternative Fuel Infrastructure Facility, EU funding program for alternative fuels

CEF Transport Blending Facility – EU funding program CHP – Clean Hydrogen Partnership, public-private partnership available for research and innovation (R&I) in

- hydrogen technologies in Europe e - crude — a synthetic raw hydrocarbon produced through Power-to-X (PtX) processes, which combine renewable electricity, water and CO_2
- ${\bf e}$ ${\bf Jet}$ ${\bf SAF}$ sustainable aviation fuel made from ${\rm CO}_2$ and renewable energy with up to 90 % lower emissions compared to traditional jet fuel
- e LPG synthetic liquefied petroleum gas, produced from renewable energy sources
- **e Naphtha** a synthetic alternative to conventional naphtha, produced using renewable Energy sources

EPO – European Patent Office, is the authority that grants European patents

Green ammonia / zero - carbon ammonia – ammonia produced using green hydrogen, which is obtained via water electrolysis

Green hydrogen / Zero - carbon hydrogen / Renewable hydrogen – produced through the process of electrolysis, using renewable electricity to split water into hydrogen and oxygen and is therefore a 'renewable fuel of non-biological origin' (RFNBO)

HRS - hydrogen refueling station

HUB – infrastructure for hydrogen production and distribution

HVCh - High Value Chemicals

Low-carbon hydrogen / low-emission hydrogen – The Hydrogen and Gas Market Directive (EU) 2024/1788 defines low-carbon hydrogen as hydrogen derived from nonrenewable sources that meets a GHG threshold of 70 % compared to the fossil fuel comparator

P2G - Power-to-gas

PEM – Proton Exchange Membrane

PVPP - photovoltaic power plant

R&D - Research and Development

RED II - Renewable Energy Directive

RED III - Renewable Energy Directive (2023/2413/UE)

RES – Renewable Energy Sources, energy that comes from a source like solar, wind

RFNBO – Renewable Fuels of non-biological origin, enewable liquid and gaseous fuels of non-biological origin. It is a product group of renewable fuels defined in the Renewable Energy Directive (Art. 2.36)

RWGS - Reverse Water Gas Shift

SAF - Sustainable Aviation Fuel

SOE - Solid Oxide Electrolyser

SOFC – Solid Oxide Fuel Cell, is an electrochemical conversion device that produces electricity directly from oxidizing a fuel

TEN - T – Trans-European Transport Network - EU programme for creating road, rail, water and air networks

UPRP - Patent Office of the Republic of Poland

USPTO – United States Patent and Trademark Office, is the federal agency for granting U.S. patents and registering trademarks











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