

HYDROGEN AS A LONG TERM AND LARGE SCALE ENERGY STORAGE SOLUTION

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About PGNiG Group

- PGNiG is the **leader of the natural gas** market in Poland and one of the largest companies listed on the WSE.
- PGNiG's business comprises **exploration for and production of natural gas and crude oil**.
- Through the Group's key companies, PGNiG is also **active in the area of import, storage, sale and distribution of gas and liquid fuels**, as well as heat and electricity generation and distribution.
- The contribution of PGNiG Capital Group to the development of zero and low emission technologies can be seen in the area of **Renewables Energy Sources, Biomethane and Hydrogen**.

LEADER
**OF HYDROCARBON
PRODUCTION IN
POLAND**

90%
MARKET

3. **POLAND'S THIRD LARGEST COMPANY LISTED
ON THE WSE**

201 **DISTRIBUTION
NETWORK LENGHT
INCLUDING SERVICE LINES**
thousand km

**IN 2021
THE GROUP
SPENT A TOTAL OF**

74 M
EURO

**ON R&D&I AND
HYDROCARBON
EXPLORATION
PROJECTS**

A key element of energy transformation ...

A key element of energy transformation **is sector coupling** which will be possible only with the use of zero-emission and preferably renewable, energy sources. Developing the technologies for production and **use of hydrogen in the economy will be one of the crucial factors.**

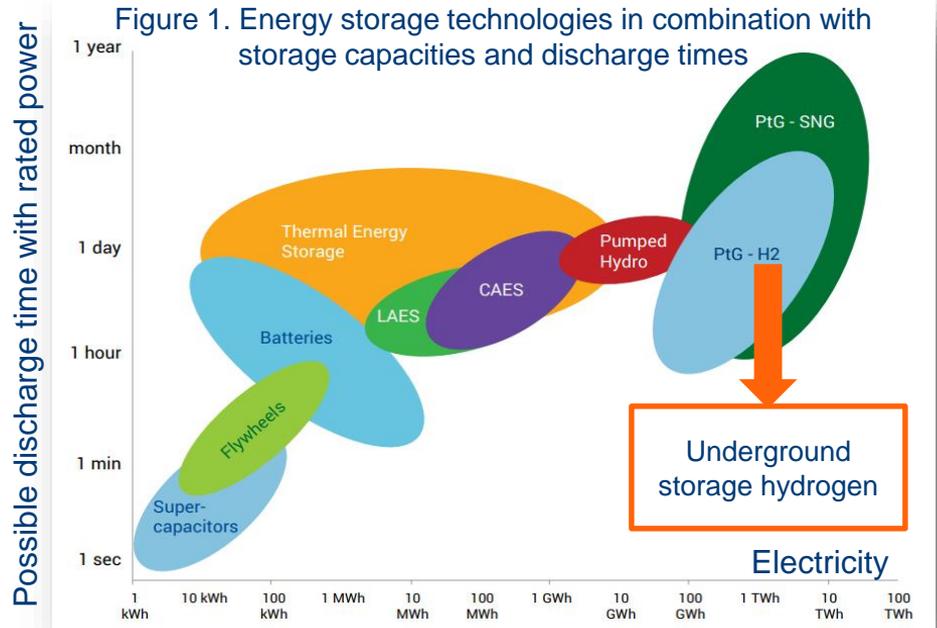
The EU energy policy provides for a significant increase in **Renewable Energy Sources (RES)**.

Hydrogen is supposed to be a medium enabling storage of electricity. This will solve the greatest weakness of RES, that is seasonal fluctuations and unstable production in relations to the demand.

As the RES share in the energy mix increase, the development of technologies for **large-scale storage of energy becomes more and more important in order to enable efficient balancing of the power system.**

Energy storage - a prerequisite for electricity security in systems based on renewable sources

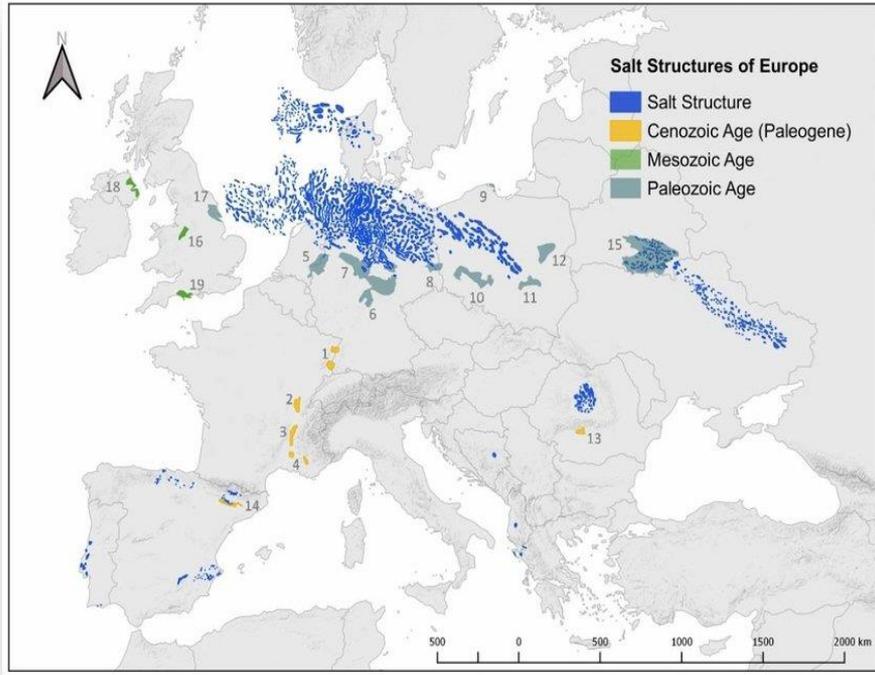
- Along with **the increase** in the share of **RES in the power system**, the essence of **energy storage** is significantly increasing, allowing for **effective system balancing**.
- With the growing demand for energy and the developing RES market, it is necessary to **increase the storage capacity as quickly and continuously as possible**.
- When considering the necessity of using surplus RES generation on the scale of the national power system, one has to consider energy storage capacities on **the level of terawatt-hours (TWh)** - as can be seen in Fig.1, this only involves gas-based solutions: **hydrogen or SNG**.



Source: own study based on J. Paska, Electric energy storage in the power system

European Salt Structure for Underground Hydrogen Storage

Map of European salt deposits and salt structures as a result of suitability assessment for underground hydrogen storage



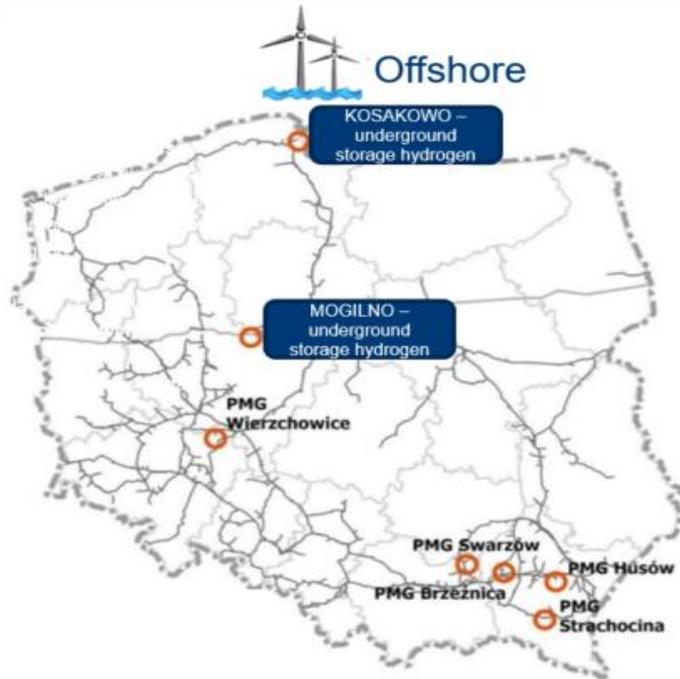
Source: M. H. Albadí and E. F. El-Sadany, "Overview of wind power intermittency impacts on power systems."

- Poland has very favorable geological, mining and technical conditions for the construction of cavern storage facilities in salt domes. According to data from the Gas Infrastructure Europe [GIE] report **Poland ranks high among European countries with respect to the possibility of storing hydrogen in salt caverns.**
- Salt caverns have been gaining importance in recent years due to the **possibility of large-scale storage** of all types of gaseous and liquid hydrocarbons, hydrogen and compressed air as well as excellent technical and operational parameters.
- Among all types of storage facilities in geological structures, **only salt caverns are characterized by very high flexibility of operation**, i.e. the possibility to switch from injection to withdrawal and vice versa within several hours.

Potential capacity of hydrogen storage: salt caverns

Poland 2.2 TWh

As part of the Hydrogen Program, we have launched a H2020 project – large scale underground hydrogen storage in salt caverns

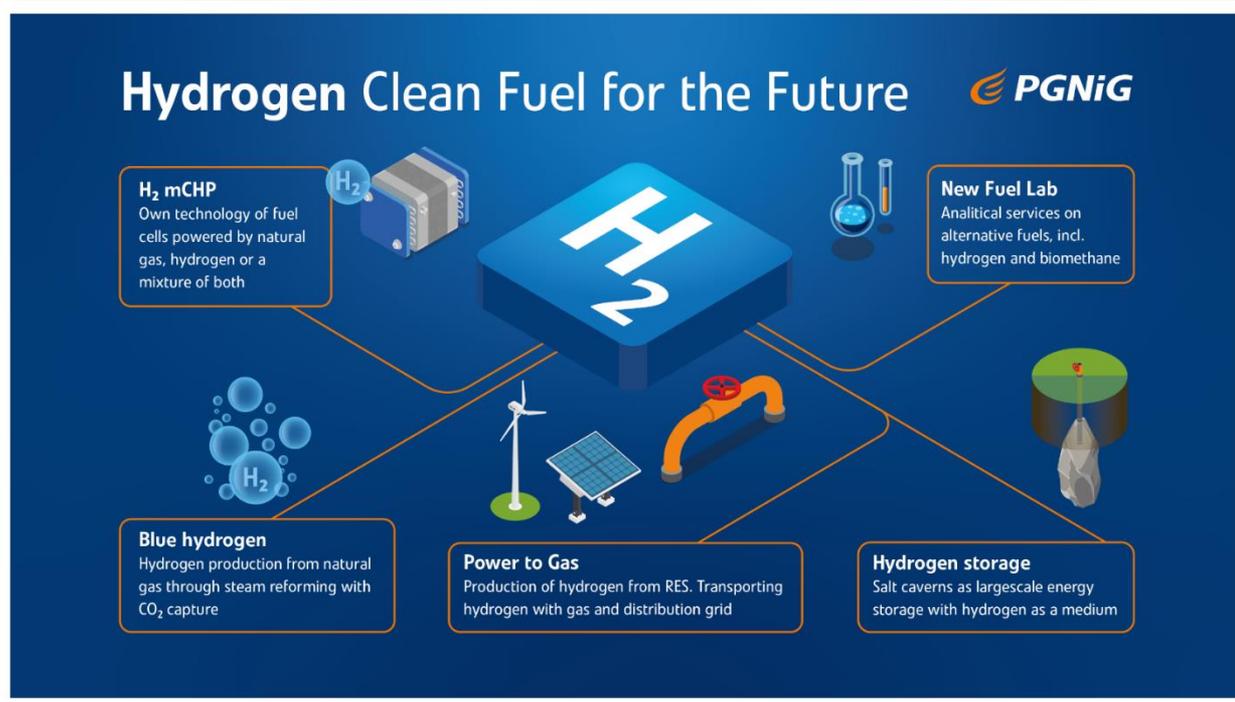


- As part of a research project carried out in Mogilno, we are investigating the possibility of storing hydrogen in Cavern Underground Gas Storage Facilities (CUGSF). **It is an important project, because only large-scale energy storage will facilitate increasing the share of RES in the energy mix, and storing energy in the form of hydrogen creates a genuine opportunity to achieve the scale required for economy.**
- PGNiG have submitted an application with the **IPCEI mechanism** in the area of commercial caverns development and once procedures and regulations for hydrogen storage at CUGSF are developed, we plan to make caverns available in the Baltic coast area to, among other, offshore wind farm operators.

Construction of a large-scale underground storage for Green Hydrogen:

- UGS Mogilno – demonstration installation:
 - ✓ Electrolyser 4,6MW, Fuel cell 1 MW,
 - ✓ 1 salt cavern capacity - ca 4 000 MWh,
- Commercial caverns/UGS Kosakowo/UGS Mogilno (2 salt caverns for each location):
 - ✓ Electrolyser 100 MW for each location,
 - ✓ Storable H2 capacity – min. 80 000 – 160 000 MWh for each caverns,
 - ✓ Fuel cell / H2 Turbine min 50 MW

PGNiG Group invests in energy storage as a part of Hydrogen Programme



- **Hydrogen** is a natural direction for PGNiG. It can be an essential piece of in the **energy transformation** process.
- **The InGrid - Power to Gas** project, an installation will be built in one of the company's current locations, with the production of "green hydrogen" slated to begin in 2023. For this purpose, we plans to use electricity generated by solar panels. This installation will allow us to test the impact of various mixtures of natural gas and hydrogen on gas system infrastructures.
- **Hydrogen storage**— consists of a group of individual projects from a demonstration project with an R&D scope to large-scale commercial projects sharing the same objective and based on a coherent systemic approach to the storage of hydrogen in salt caverns to ensure the security of the supply of a zero-emission energy carrier.

Time frame for PGNiG's projects to meet the challenges of energy transformation

❖ **New Fuel Lab** - the laboratory in Poland to study hydrogen and its mixtures as fuel

❖ **Mogilno I Cavern** for hydrogen storage with geometric volume of ca. 20,000 m³, located within a rock salt dome deposit, along with underground and surface installations for hydrogen production, treatment, injection and disposal.

❖ **Commercial Kosakowo Caverns** for hydrogen – 2 caverns, ca. 200,000 m³ of designed geometric volume each, located within the Mechelinki rock salt bed deposit, completed with underground and surface installations for green hydrogen production and disposal. Start of operation for 1st caverns (12.2027)

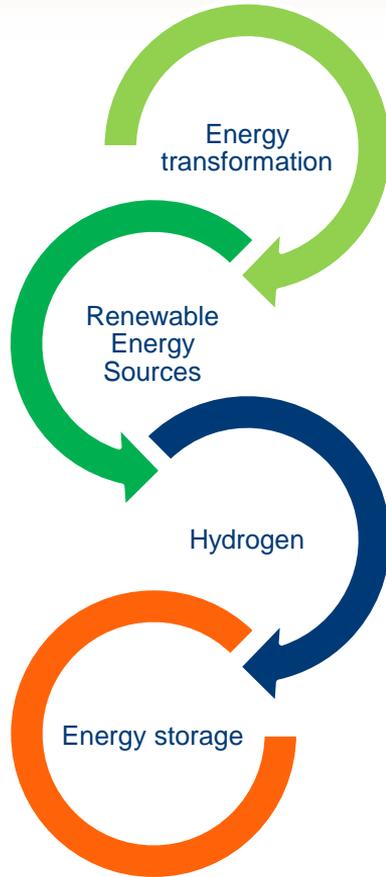


❖ **Blue H₂** - the production of hydrogen from natural gas with carbon capture and utilization (CCU)

❖ **Power to Gas** - an installation which will allow us to test the impact of various mixtures of natural gas and hydrogen on gas system infrastructures (pipelines, gas receivers, gas meters and other)

❖ **Commercial Mogilno II Caverns** for hydrogen – 2 caverns, ca. 300,000 m³ of designed geometric volume each, located within the western part of the Mogilno II rock salt dome deposit, together with underground and surface installation for green hydrogen production and disposal.

Summary - Where is this all leading?



- **RES and hydrogen technologies will become a pillar for the energy transformation** and increase safety.
- **Hydrogen** is a key enabler for the energy transformation.
- **The use of salt caverns – as hydrogen storage** facilities supporting the development of a low-emission economy, is an optimal solution for national system-scale energy storage.
- **PGNiG Capital Group already have extensive and unique experience in operating underground gas storage facilities.**

Thank you for your attention

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