

X-SeD

EXPERIMENTAL SUPERCRITICAL ELECTROLYZER
DEVELOPMENT FOR HYDROGEN PRODUCTION

LEITAT
managing technologies



About the project

X-SEED has the objective to do renewable hydrogen more affordable. The key innovation is to develop a membrane-less electrolyzer that operates under supercritical water conditions —above 374°C and 220 bar. This approach produces high-quality hydrogen, improving energy efficiency, sustainability, and system longevity.

Beyond technology, X-SEED drives the hydrogen ecosystem, to help Europe achieving climate goals and to sustain its leadership in the energy transition and technological innovation.

What is an electrolyzer?

An electrolyzer is a device that uses electricity to split water into hydrogen and oxygen through a process called electrolysis. When an electric current is applied to its electrodes, the anode produces oxygen, while the cathode generates hydrogen.

Main objectives

Efficient hydrogen production

Energy demand less than 42 kWh/kg H₂ and cost production lower than 3 €/kg H₂

Commitment to sustainability

Minimize the use of scarce materials and prioritize sustainability in development

Electrolysis at supercritical conditions

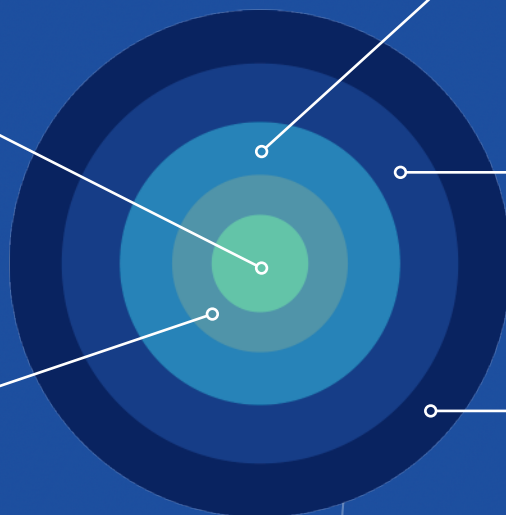
Develop and validate of electrolyzer operating at 374°C and 220 bar

Development of electrolyzer components

Advanced catalysts and electrodes to improve electrolysis efficiency

Membrane-less electrolyzer reactor

Design a membrane-less reactor for high-quality hydrogen and oxygen production



The X-SEED Electrolyzer Concept

X-SEED develops an innovative membrane-less alkaline electrolyzer that operates under supercritical water conditions (above 374°C and 220 bar) in a laminar flow regime.

The electrolyzer has an anode and a cathode placed in parallel without any membrane. High-quality oxygen (O_2) and hydrogen (H_2) streams are obtained as a result of an optimized reactor design by multiphysics modelling and laminar flow operation.

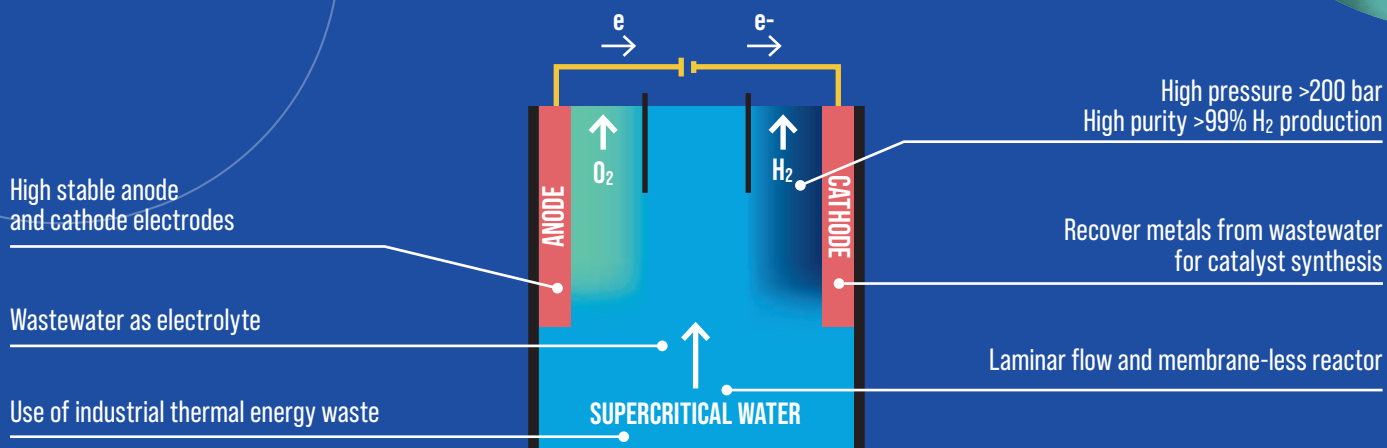
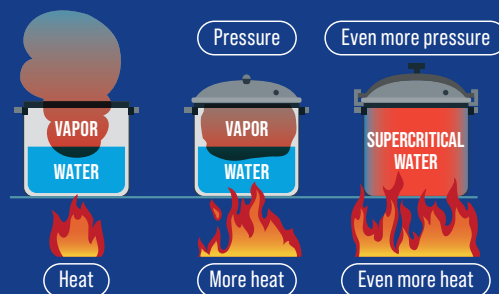
X-SEED electrolyzer plans to integrate circularity using wastewater and waste heat from industrial processes.

Electrolysis at supercritical water conditions (374°C and 220 bar)

Internal resistances are decreased and electrolysis efficiency is enhanced because of the following properties of supercritical water conditions:

- Absence of bubbles
- High conductivity
- High diffusion coefficients
- Modification of dissociation constant

Also, operating at high temperature provides both kinetic and thermodynamic benefits, which increase the voltage efficiency.



Renewable H₂ worldwide landscape

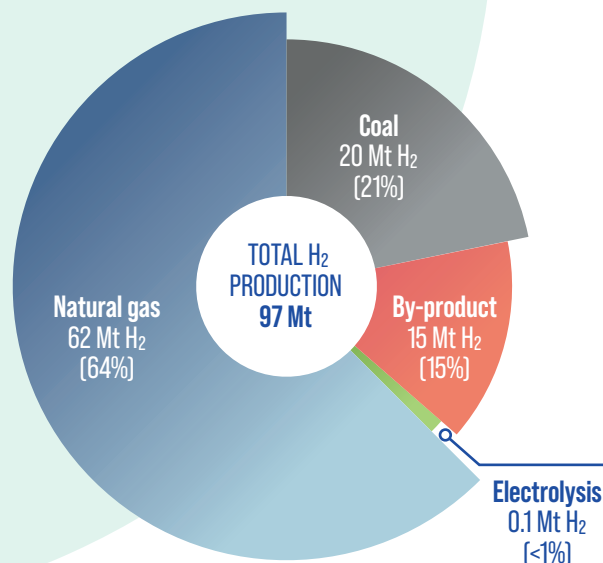
Renewable hydrogen is only 0.1% of the global hydrogen production. At the end of 2023, the global installed electrolyzer capacity was 1.4 GW, reflecting a notable increase from previous years. Electrolysis is ready to become a key player in the future of hydrogen production. There are several types of electrolyzers: alkaline (AWEL), proton exchange membrane (PEMEL), solid oxide (SOEL), and anion exchange membrane (AEMEL). The first two (AWEL and PEMEL) are already commercial but have three main bottlenecks:

- High production costs (4-12 €/kg H₂)
- Limited efficiencies (>50 kWh/kg H₂)
- Limited industrial manufacturing capacity

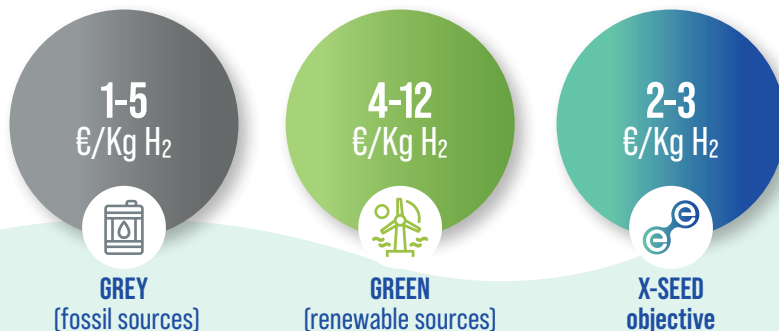
To meet climate goals for 2030 and 2050, electrolysis installed capacity should arise to 230 GW. For that reason, there is a pressing need to boost electrolyzer manufacturing capacity and to develop new electrolysis technologies with higher performances.

Hydrogen production by technology 2023

(in millions of tones, Mt)



Hydrogen cost by technology



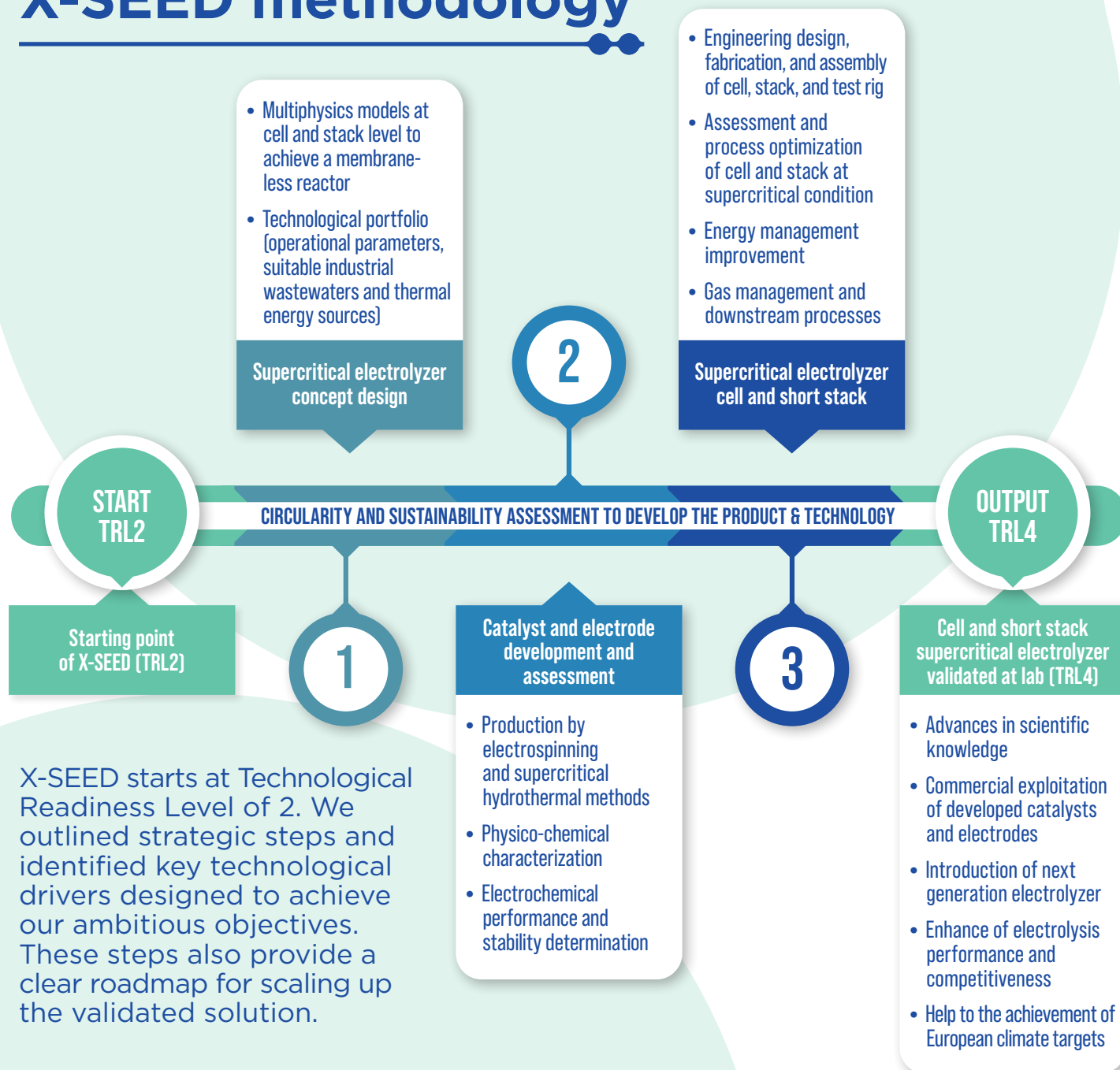
Challenges of X-SEED

To overcome the current challenges of renewable hydrogen, it is mandatory to diversify the technology portfolio. Additionally, investing in and developing technologies that are currently at low technology maturity is essential.

Project X-SEED is a fantastic example of that, and expects to:



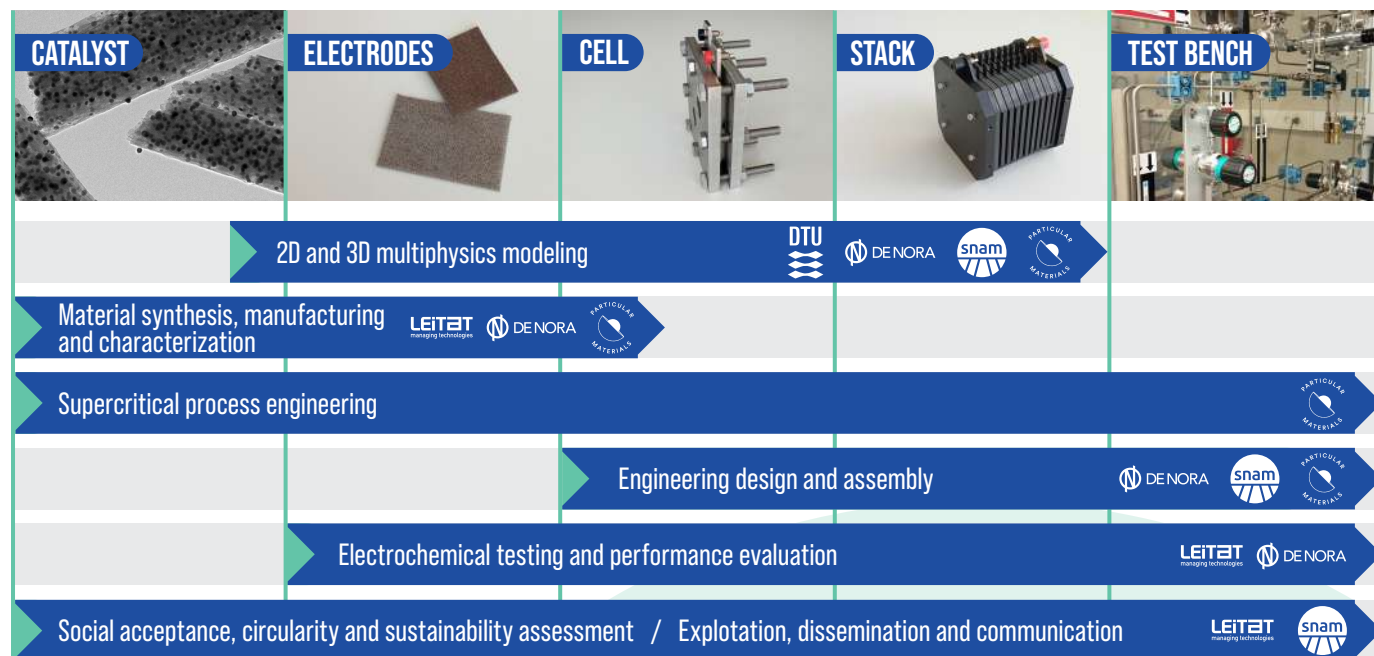
X-SEED methodology



Consortium capacities

The X-SEED consortium brings extensive technical expertise in enabling technologies, including simulation, material science, electrochemistry, engineering, and

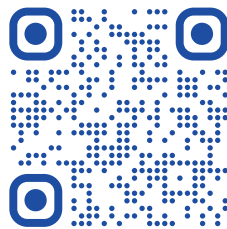
sustainability. These capabilities support various research activities, covering the entire project's value chain —from catalyst to test bench phases.



The project in numbers



**INNOVATIVE ELECTROLYZER
WORKING AT SUPERCRITICAL CONDITIONS FOR ENERGY-EFFICIENT
AND COST-COMPETITIVE RENEWABLE HYDROGEN PRODUCTION**



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