X-SEED, a new European project to boost the production of renewable hydrogen

Illustration 1 Full view of the X-SEED consortium

Terrassa, February 20, 2024 – Leitat, a national and European reference technology center accredited by ACCIÓ and recognized by the Ministry of Economy and Competitiveness, has begun coordinating a **new European project called X-SEED.** The goal of X-SEED is to develop an electrolyzer that has the potential to **generate renewable hydrogen more efficiently and at a lower production cost** than the electrolyzers currently used industrially.

"*Renewable hydrogen is one of the key technologies for decarbonizing the economy*" says Pau Bosch, scientific coordinator of the project and principal investigator of the BioElectrochemical Systems group at Leitat. "The X-SEED project, with a consortium formed by different European companies, Snam S.p.A., Particular Materials, Industrie De Nora and the Technical University of Denmark, and co-financed by the European Union and supported by the Clean Hydrogen Partnership, **aims to develop a new technology that will make the production of renewable hydrogen economically competitive."**

The new technology could be used to produce renewable hydrogen for a wide variety of applications, such as: vehicles, electricity generation, industrial processes (steel, cement and fertilizers) among many others, helping to decarbonize our economy.

An electrolyzer is an advanced device that utilizes electricity to obtain hydrogen and oxygen from water, serving as a key component in the diverse range of hydrogen generation systems available in the market. The electrolyzer that will be developed in

Project X-SEED with Grant Agreement number 101137701
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the X-SEED project is based on an innovative **technology that uses supercritical water conditions** (high pressure and temperature). These conditions are very different from the usual operating conditions of currently commercialized electrolyzers, allowing to reduce the energy needed to produce hydrogen, and to reduce the need for scarce and expensive raw materials such as catalysts and membranes. In addition, the new electrolyzer has a **membrane-free system**, which simplifies its design and manufacturing. This also contributes to reducing the hydrogen production cost, as well as extending the equipment's lifetime.

"We believe that the X-SEED project has the potential to boost the production of renewable hydrogen," says Bosch. "This technology ***could have a significant impact on the decarbonization of the European economy,*** *especially in those industries that have high-temperature processes, which are difficult to electrify. In these industries and by means of the electrolyzer developed in the project, their waste heat* ***could be used to generate hydrogen in a very efficient way****, which could replace fossil fuels burned in these industrial processes or be used for other purposes."*

Illustration 2 Project Coordinator, Pau Bosh starting the project Kick Off Meeting in Terrassa, Barcelona

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SUPPLEMENTARY INFORMATION (EXTRA WITH MORE DETAILS):

How does the new hydrogen generator work?

The electrolyzer that will be developed in the X-SEED project works similarly to commercial electrolyzers. An electric current is applied and the water is dissociated, producing hydrogen and oxygen, which is why it is so interesting environmentally. **The difference with the X-SEED project electrolyzer with other electrolyzers is that it will work with water in a supercritical state (high pressure and temperature).** This allows for two major advantages: on the one hand, working at a high temperature requires less electrical energy to carry out the process, therefore increasing the energy efficiency of hydrogen production. On the other hand, working at a high pressure eliminates or significantly reduces the energy required to compress the hydrogen in the electrolyzers currently on the market, thus making the entire process of obtaining hydrogen for different applications more efficient.

In addition, the electrolyzers that are currently being implemented industrially contain a membrane necessary to separate the hydrogen and oxygen production reactions and thus obtain a pure stream of hydrogen gas. **This membrane is one of the main sources of problems, as it reduces the lifespan of the equipment** and decreases the energy efficiency of the process. The **X-SEED electrolyzer does not have a membrane, thus avoiding this expensive and limiting component of the hydrogen generator**. Thanks to the physicochemical properties of water in a supercritical state and to a design of the electrolyzer created and optimized through simulations and multiphysics models, the oxygen and hydrogen are separated inside the electrolyzer, obtaining a pure stream of hydrogen without the use of membranes. **This novel technique simplifies the design and manufacture of the electrolyzer, which also contributes to reducing its cost.**

What benefits does the new electrolyzer offer?

The new hydrogen generator based on an electrolyzer, developed in the X-SEED project, offers a number of potential benefits over current electrolyzers, including:

- **Higher efficiency**, allowing more hydrogen to be generated per unit of electricity consumed.
- **Lower production cost**, making renewable hydrogen more affordable and economically competitive with hydrogen compared to fossil fuels.
- **Lower environmental impact**, as it requires fewer critical materials (critical materials are those that are essential to a country's economy and security, but which are scarce and vulnerable to supply disruptions), and also generates less waste.
- **Longer life** than currently commercially available electrolysers.

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Illustration 3 X-SEED Consortium

How will the project be developed?

The X-SEED project will be developed over the next three and a half years, until 2026. In the final stage of the project, a prototype of the new electrolyzer will be built and tested in a pilot plant. The first **part of the project** will **focus on the design of the reactor** and the research and development of the catalysts and electrodes necessary to build an electrolyzer. The **second part of the project will design, build, and test the operation and evaluation of the X-SEED** electrolyzer operating it with water in supercritical conditions.

A project kick-off meeting was held at the Leitat Technology Center headquarters in Terrassa (Barcelona) from January 25 to 26, where the first lines of action for the project were defined, which will outline the next steps and progress of the project.

The project is funded by the European Union's Horizon Europe program, with a budget of 3.5 million euros. In addition to Leitat, it is also participated by 3 other leading European companies in the hydrogen and renewable energy sector and a renowned university: Sban S.p.A., Particular Materials, Industrie De Nora and the Technical University of Denmark.

Leitat has extensive experience in the financial and administrative management of EU projects, having coordinated 44 projects since 2010.Leitat has significant experience in communication and dissemination management activities, having acted as the activity leader in numerous EU projects. At a technical level, Leitat has electrospinning, material characterization and electrochemical equipment, which allow the production and advanced characterization of catalysts for electrochemical reactions for the production of oxygen and hydrogen. In addition, Leitat's sustainability team will ensure the integral viability of the X-SEED project technology, carrying out an exhaustive evaluation from three perspectives: environmental, social and economic. Guided by a life cycle

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approach, they will select materials and processes that minimize environmental impact and maximize circularity. In turn, the social aspects of the technology will be analyzed to ensure its acceptance by all stakeholders.

Snam S.p.A.'s fundamental contribution to the project lies in sharing its knowledge on hydrogen gas handling (being one of the largest gas transmission companies in Europe). In addition, as a historic Italian company, it has a solid network of industrial partners that could provide useful contributions for the integration of the technology with existing processes and serve as the main end users.

IDN has four R&D centers worldwide with full capacity for the synthesis, development, optimization, characterization and performance/lifetime testing of electroactive materials, catalysts, active coatings, electrodes from laboratory scale to equipment for industrial electrochemical applications.

Particular Materials (PMat) has unique capabilities in supercritical water processes. Leveraging these capabilities, PMat will produce a wide range of non-precious metal catalysts from supercritical water metal precipitation processes. In addition, PMat's engineering expertise and infrastructure concerning supercritical water processes will be instrumental in the development of the electrolyzer capable of operating under these extreme conditions.

DTU has extensive experience in 2D and 3D multiphysics modeling, allowing for the optimized design of electrolysis cells and their stacking to form the stack. This modeling expertise will be crucial to achieving the optimum performance of the supercritical water electrolyzer.

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Key concepts:

• **Hydrogen Generator (Electrolyzer):** A device that uses electricity to obtain hydrogen and oxygen from water.

• **Renewable Hydrogen**: Renewable hydrogen is a type of hydrogen that is produced from renewable sources, such as solar or wind electricity. This type of hydrogen does not produce greenhouse gas emissions, so it is considered a clean and sustainable energy source or carrier.

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• **Catalyst:** A substance that accelerates chemical reactions. In the case of commercial electrolyzers, materials such as platinum, ruthenium, etc., are used, which are scarce and have a very high price.

• **Membrane-free Electrolyzer:** A membrane-free electrolyzer is a device that produces hydrogen and oxygen from water without using a membrane for the anodic and cathodic reactions. The membrane in a conventional electrolyzer separates the hydrogen from the oxygen to prevent them from mixing.

• **Supercritical Water Conditions:** Water at a temperature and pressure above its critical point. Specifically, supercritical water conditions occur at a temperature above 374 °C and a pressure above 221 bar. Under these conditions, water loses its typical liquid and gas properties and behaves like a supercritical fluid. Supercritical fluids have a number of properties that make them attractive for a wide range of applications.

Additional Information:

What are the applications of hydrogen?

Currently, more than 100 million tons of hydrogen are used in different industrial processes. The most relevant industries that use hydrogen are the petrochemical and fertilizer production industries. The hydrogen currently used in these processes comes from fossil-based natural gas, and is what we call gray hydrogen, which is associated with a large amount of CO2 emissions, specifically 10 tons of CO2 for each ton of hydrogen generated. Therefore, there is already a great demand for hydrogen and it is necessary to replace gray hydrogen with renewable hydrogen.

Renewable hydrogen has great potential to be used in a wide range of real-world applications. Among the main ones are:

- **Mobility:** Renewable hydrogen can be used as a fuel for fuel cell vehicles, which offer a range similar to gasoline or diesel vehicles, but with zero CO2 emissions.
- **Electricity generation:** Renewable hydrogen can be used to generate electricity through fuel cells or gas turbines. This application is especially interesting in remote areas or with limited access to the electricity grid.
- Industry: Hydrogen can be used in the industry to produce steel, cement, fertilizers, among other products. In these processes, renewable hydrogen replaces the combustion of fossil fuels, required in the production process of these products, which reduces CO2 emissions.
- **Energy storage:** Renewable hydrogen can be stored and transported, making it an ideal option for storing renewable electricity, such as solar or wind energy. This application is especially important to ensure electricity supply during times of low renewable energy production and to avoid curtailment.

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In addition to these applications, renewable hydrogen also has the potential to be used in other areas in the future, such as heating homes and buildings, or food production.

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