

Targeted use of hydrogen Unite!Energy provides impetus for energy policy

Geopolitical conflicts continue to expose vulnerabilities in global energy supply. To secure energy supplies and reduce dependence on price fluctuations, greater use of renewable energy sources is needed.

Renewable energy does not always provide electricity when it is needed. This is why large-scale energy storage is essential. Hydrogen can fulfil this role, but its use has so far been expensive. In particular, the electrolysis plants used for its production are cost-intensive.

This is where the Unite!Energy project comes in. It follows a Power-to-Power approach: surplus electricity is converted into hydrogen, stored and converted back into electricity when needed. The aim is to reduce costs and improve efficiency. Unite!Energy is an international network of PhD students investigating the use of hydrogen for chemical energy storage. The EU is funding the network for four years as a Marie Skłodowska-Curie Action (MSCA).



Research progress to date

In the first project phase, the network made progress in the production and use of hydrogen. It also laid important foundations for storage. The focus is on new materials and technical solutions designed to reduce costs and maintain performance.

For hydrogen production, the project developed catalysts that require significantly fewer precious metals, such as iridium. These materials are scarce and currently drive up costs. Initial results show that their use can be reduced without compromising performance. At the same time, the team established standardised procedures to reliably test and compare new materials under realistic conditions. Progress has also been made with systems that use solar energy directly for hydrogen production.

In the reconversion of hydrogen to electricity, bio-based fuel-cell materials have been successfully tested. At the same time, it remains necessary to further improve stability and reproducibility.

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In addition, the project is investigating the interaction between the conversion, storage and use of hydrogen. The models demonstrate how electrolyzers and fuel cells can be adapted to a fluctuating electricity supply and what role storage plays in this. This lays the foundation for more efficient and reliable systems.

Results to date show that key technological approaches are working. However, many of the targets can only be achieved if the individual technologies – from hydrogen production to reconversion into electricity – work more closely together and operate in tandem.

At the same time, the project aims to train the next generation of researchers in the fields of renewable energy and green hydrogen.

The scientific results provide the basis for the following policy recommendations:

The Unite!Energy project has generated evidence that hydrogen-based Power-to-Power systems can be designed to achieve higher system efficiency and operational safety, while enabling significant reductions in the use of critical raw materials through optimised materials selection, catalyst design and system integration strategies.

The project also shows that many of the materials, component design approaches, modelling tools and safety methodologies developed for integrated energy systems are applicable beyond stationary energy storage and can support innovation in sectors including transport, industrial processes and integrated energy systems. However, moving from laboratory-scale innovation to large-scale deployment requires a coordinated policy framework that addresses regulatory, economic, sustainability and safety challenges.

Based on the project findings to date, the current EU policy framework provides a strong foundation but contains important gaps that should be addressed to accelerate hydrogen as an energy storage solution while also supporting broader hydrogen applications.

1. Our research demonstrates that hydrogen production, storage, and electricity generation should be treated as interconnected elements of a single energy system. Project results also confirm that hydrogen embrittlement, component degradation, and high-pressure operation should be considered from the earliest design stages. A harmonised regulatory approach would facilitate deployment while improving safety and enabling knowledge transfer across multiple hydrogen applications.
2. Investment barriers remain significant, with revenue uncertainty limiting commercial deployment. Our analysis indicates that double charging and taxation of electricity used in Power-to-Power cycles, together with the absence of long-term market signals, continue to undermine

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project viability despite technical feasibility. Targeted market mechanisms and greater regulatory certainty are needed to unlock investment in large-scale hydrogen-based energy storage.

3. The assessment framework developed within Unite!Energy combines life cycle assessment, techno-economic analysis and multi-criteria decision analysis to evaluate hydrogen technologies more comprehensively. While existing legislation focuses primarily on emissions, our initial results indicate that critical raw material dependency, material circularity and supply chain resilience should complement greenhouse gas emissions in sustainability assessment. Harmonised assessment methodologies incorporating these criteria would support more informed funding and investment decisions and strengthen the resilience of Europe's hydrogen value chains.

We invite you to visit us on our website: <https://www.unite-energy-msca.eu/>
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Unite!Energy Doctoral Network in Energy Storage is coordinated by Universitat Politècnica de Catalunya.

About us

Unite! is a network of nine European universities that combine science and technology to jointly address the major challenges facing society. As part of the “Unite!Energy” project, eleven PhD students from the Unite! universities will be conducting research into hydrogen as a sustainable energy storage solution in collaboration with industry partners.

The project, funded as a Marie Skłodowska-Curie Action (MSCA), brings together ten leading European universities: the Unite! universities Aalto University, KTH Royal Institute of Technology, Wrocław University of Science and Technology, Technical University of Darmstadt, Graz University of Technology, Grenoble INP-UGA, Politecnico di Torino and Universitat Politècnica de Catalunya, as well as Friedrich-Alexander-Universität Erlangen-Nuremberg and the University of Lisbon, which is involved in this project as a Unite! university and as an associated partner. Eight companies (EOS Finland, ABB, Powercell Sweden, KIC InnoEnergy, Heraeus, Solaronix, Snam and eRoots Analytics) and two R&I organisations (CEA Grenoble and Barcelona Supercomputing Center) are also associated partners in Unite!Energy.

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