Hydrogen Research & Innovation Days

24-25 November 2025

Clean Hydrogen Partnership

Co-funded by the European Union

SUSTAINABLE USE OF WATER IN THE HYDROGEN VALUE CHAIN

Alessio Tarantini, RINA

Sustainable use of water is a critical factor for the hydrogen value chain; this project has been launched to assess this challenge

Water is a fundamental resource for hydrogen production; both in conventional processes (e.g., steam methane reforming) and in low-emission green processes (e.g., electrolysis)

Water sustainability and carbon footprint must progress together, ensuring that environmental stewardship addresses both resource conservation and climate impact for truly sustainable development.

The goal of the project is to assess how expanding renewable hydrogen production will impact freshwater availability, now and through 2050, by analysing water needs, alternative sources, regional vulnerabilities, and sustainability constraints, and by providing strategies to ensure hydrogen development remains compatible with long-term water resilience.

Project activities

The project is structure in four subsequent tasks.

1 **State-of-the-art** 100%

- **Investigate** the relationship between renewable hydrogen production steps and related water consumptions.
- **Analysis** of cost and feasibility for hydrogen production via various water sources.
- **Definition** of the study's methodology.

2 **Impact assessment** 25%

- **Map** current and future renewable hydrogen production against available water resources.
- **Analyse** hydrogen’s impact on water availability across key economic sectors.
- **Create** clear GIS maps showing water conditions alongside hydrogen projections.

3 **Case studies** 0%

- **Evaluate** water system resilience under current and future seasonal conditions.
- **Refine** Task 1 models to accurately represent regional water realities.
- Draft actionable **recommendations** to strengthen long-term water system resilience.

4 **Conclusion and recommendations** 0%

- Provision of a **conclusive summary** presenting the insights of the study.

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Direct water consumption for hydrogen production is only one side of the coin

Both for renewable and conventional production technologies, once both process and CCS-related cooling requirements are considered, total water use increases by a factor of three to five compared to the pure process demand, underlining a clear trade-off between decarbonisation and water efficiency.

25-50%

Direct water consumption

for H2 production

50-75%

Indirect water consumption

for process and CCS-related cooling

Renewable production technologies

1% of the current global hydrogen production

AEL and PEM technologies use ~9.2÷12.8 litres of water per kg of H2 produced; however, process water represents only 25-50% of the total water consumption for renewable.

Conventional production technologies

99% of the current global hydrogen production

Although the direct process water demand of reforming technologies such as SMR and ATR may appear (~6÷2.6 l/kg H_2, respectively) significantly lower than renewable technologies, the overall process for blue hydrogen consumes much more water, reaching 20–32 l/kg H_2 for SMR + CCS and 24–33 l/kg H_2 for ATR + CCS.

Improving efficiency is a key lever for water sustainability in low-carbon hydrogen

Investing in more efficient electrolysers and carbon capture technologies may bring significant benefits by reducing both direct process water consumption and indirect water use for cooling.

Direct process water consumption is proportional to the amount of hydrogen produced and the efficiency of the electrolyzer or reformer.

Cooling water withdrawal may be reduced as well; indeed, higher efficiency means less energy lost as heat and, in turn, less cooling water required for thermal management.

Improving electrolyzer efficiency from 70% to 80% can reduce both process and cooling water needs by up to 20–30%

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The choice of water source is a strategic lever for hydrogen project sustainability

The choice of water source directly impacts costs, sustainability, and feasibility of hydrogen projects. Diversifying and optimizing water sourcing is essential to reduce water footprint and ensure project resilience.

Each source presents specific trade-offs in terms of availability, treatment needs, costs, and project risks

1 Freshwater (surface or groundwater)

Preferred for ease of treatment and lower costs.

Limitations: increasing scarcity, competition with civil and agricultural uses.

2 Treated wastewater

Enables circular economy and reduces freshwater withdrawal.

Requires advanced treatment to achieve necessary purity.

3 Seawater

Abundant, especially in coastal or arid regions.

Requires desalination with energy costs and brine management.

4 Brackish water

Compromise between freshwater and seawater: lower treatment costs than seawater.

Risk of overexploitation and aquifer salinization.

5 Rainwater harvesting

Supplementary source, useful for local applications or areas with abundant rainfall.

Volumes often limited and variable.

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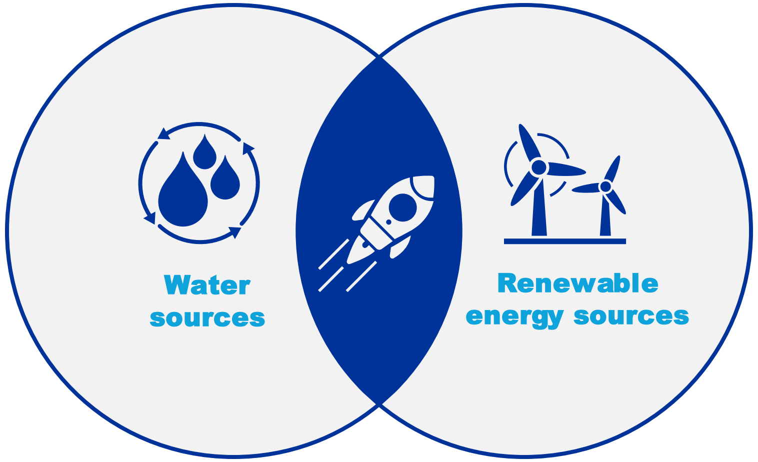
Renewable energy sources and water availability are uneven distributed

There is not a single common solution applicable everywhere; each area has its own strengths and challenges. Selecting the priorities combining the needs of the whole address area is not an easy choice.



Water availability varies significantly across Europe and North Africa. As part of this project, we already conducted an initial clustering of those countries in homogeneous areas; in the second task, currently underway, we will delve into a mapping exercise to assess water sources available vs presence of renewable energy sources.

This exercise is crucial since **the best option depends on the combination of those two resources (water and renewable energy)**:

- In regions where freshwater is abundant, seawater treatment is unnecessary.
- In water-scarce areas, seawater could be the best option, but brine management strategies are to be put in place.

Brine management is a challenge

Brine generated during water treatment for electrolysis is often treated as waste, creating disposal issues and environmental impact.

Optimize treatment processes

See brine as a resource to be reused

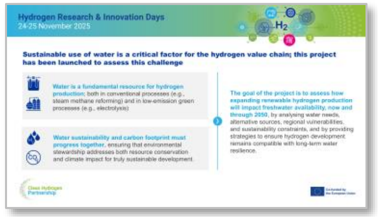
Direct seawater electrolysis

Optimize conventional treatment processes and reframe brine as a resource, recovering valuable minerals or enabling reuse, rather than discarding it.

Just as water sustainability and carbon footprint must progress together, there is a clear analogy with CCUS and brine management: both require turning a liability into an asset through innovation and circular approaches.

Direct seawater electrolysis could also a valid option but requires further development.

Key takeaways



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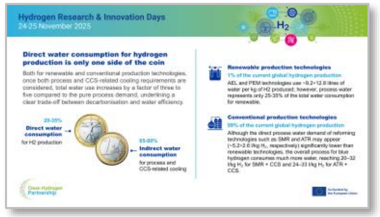

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Both for renewable and conventional production technologies, once both process and CCS-related cooling requirements are considered, total water use increases by a factor of three to five compared to the pure process demand, underlining a clear trade-off between decarbonisation and water efficiency.

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Direct water consumption
for H2 production

65-80%
Indirect water consumption
for process and CCS-related cooling

Renewable production technologies
1% of the current global hydrogen production
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99% of the current global hydrogen production
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1 Sustainable use of water is a priority in the hydrogen value chain

- Water is a fundamental resource for hydrogen production.
- Water sustainability and carbon footprint must progress together.

2 Improving technology and process efficiency is the key to reduce water footprint of green and blue hydrogen

- Direct water consumption for hydrogen production is only one side of the coin; cooling is the real elephant in the room.
- Improving electrolyzer efficiency could be beneficial for both direct and indirect water consumption.
- Improving efficiency is a priority also for carbon capture technologies, since 99% of the current global hydrogen production is fossil fuel based
- Optimization of closed cooling loops could be a valid option as well.

3 Improving brine management will allow to exploit RES in regions with water scarcity

- Each water source presents specific trade-offs in terms of availability, treatment needs, costs, and project risks. The choice of water source is a strategic lever for hydrogen project sustainability
- The best option depends on the combination of water and renewable energy sources locally available
- Optimization of treatment processes for brine management should be combined with a reframed approach to see brine as a resource to be used rather than disposed.
- Direct sea water electrolysis could also be a valid option but requires further development.

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Back-up slides

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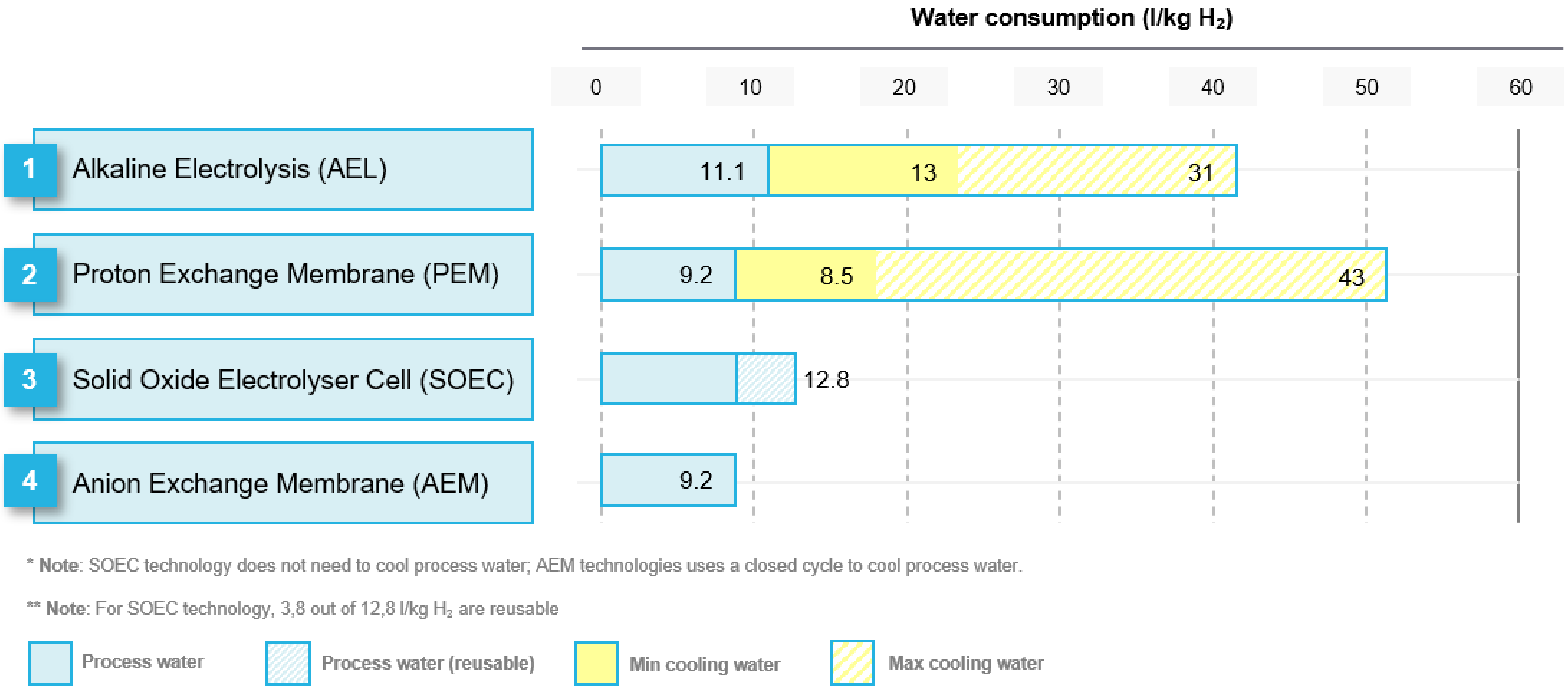

* **Note**: SOEC technology does not need to cool process water; AEM technologies uses a closed cycle to cool process water.

** **Note**: For SOEC technology, 3,8 out of 12,8 l/kg H_2 are reusable