



TETRA TECH

Quenching the **T H I R S T**

**Strategic Water Management
for Sustainable Hydrogen Production**

HYDROGEN H₂

H₂

H₂



Quenching the Thirst: Strategic Water Management for Sustainable Hydrogen Production



Imagine powering major industries and large-scale transportation without emissions, or storing renewable energy for extended periods, eliminating the need for fossil fuels. This is the promise of hydrogen, an alternative fuel and industrial commodity that produces no harmful carbon emissions when consumed.

Achieving net zero emissions by 2050 will require significant changes across several sectors. Among these, global demand for hydrogen will need to increase by over 350 percent, [rising from today's 95 million metric tons \(Mt\) to 430 Mt](#). Much of this growth will need to come from clean hydrogen production methods.

However, the water requirements for hydrogen production, particularly clean hydrogen, raise important questions. Water is a crucial input across all hydrogen production methods, but the sustainability of water use in this context requires closer scrutiny. **Is the need for water so significant that it becomes a dealbreaker?**

This paper explores the question, details the drop-by-drop requirements of today's hydrogen production technologies, and examines innovative solutions for sustainable water management, particularly in water-scarce regions where potential hydrogen development is most promising.

Tetra Tech understands hydrogen's role in the future of energy decarbonization and has extensive experience helping our clients select technologies and processes most suitable for their project-specific and overall energy transition needs.

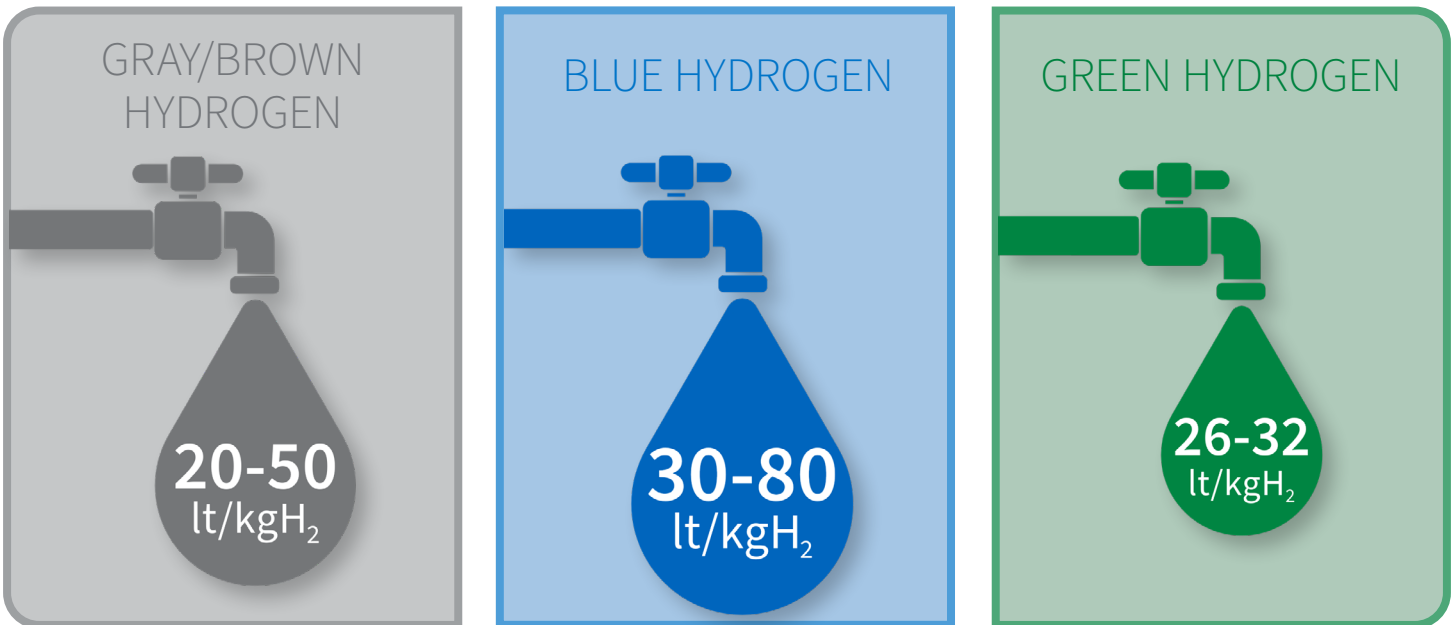
Is Clean Hydrogen Production Too Thirsty to Thrive?

Although energy is the key input for generating hydrogen—and the most controversial—water is also stirring debate. Hydrogen production methods vary widely in their water usage. According to the [International Renewable Energy Agency \(IRENA\) and Bluerisk](#), the most common method for producing hydrogen via steam methane reforming (SMR), requires approximately 20 liters of water per kilogram of hydrogen (lt/kgH₂).¹ Coal gasification, another widely used process, demands about 49.8 lt/kgH₂. Both of these fossil-based hydrogen production methods, often referred to as "gray" and "brown" hydrogen respectively, contribute substantially to carbon emissions due to the release of CO₂ during the process.

When carbon capture technologies (CCUS) are added to this process, creating "blue hydrogen," the water requirements increase to 36.7 lt/kgH₂ for SMR and 80.2 lt/kgH₂ for coal gasification.

Water electrolysis, which splits water (H₂O) into hydrogen (H₂) and oxygen (O₂) using an electrical current, is considered a clean hydrogen production method. Water electrolysis powered by renewable energy like wind, solar, or hydropower produces "green hydrogen." This method consumes about 32.2 lt/kgH₂ using alkaline electrolyzers, the most mature and commonly used technology.² While this process is often lauded for being "clean" in terms of carbon emissions, its water intensity remains a critical factor.

Water Requirements for Hydrogen Production Methods



¹ This and all values account for withdrawn water, meaning they include not only consumed water for hydrogen production, but also water used for cooling purposes.

² For proton exchange membrane (PEM) electrolysis, the requirements are 25.7 lt/kgH₂.

Hydrogen’s Global Water Footprint

Hydrogen production is currently estimated to account for around 2,200 million cubic meters (MCM) of freshwater withdrawals annually. As clean hydrogen—whether blue or green—takes a more prominent role in decarbonizing global energy systems and chasing global climate goals, these figures are expected to rise significantly.

To achieve net zero emissions by 2050, the International Energy Agency (IEA) forecasts that [water demand for hydrogen production](#) will need to approach 18,000 MCM annually by 2050 (Figure 1).

Does this mean that increased hydrogen production will have long-term detrimental environmental and socioeconomic effects?

Perhaps not. The increase in hydrogen-related water usage must be seen against a backdrop of declining water demand for fossil fuel extraction and refining, also required for us to reach net zero emissions by 2050. Only for extraction, the global water footprint of fossil fuels, which stands at around 45,000 MCM, would shrink to 10,000 MCM by mid-century as part of the broader energy transition (see Figure 2). This backdrop will increase further if water consumed from refining is taken into account.³ In addition, factoring in water use for refining and downstream processes, the reduction in water demand from fossil fuels is likely to be even greater.

On a global scale, the shift to hydrogen could result in a net reduction in water usage.

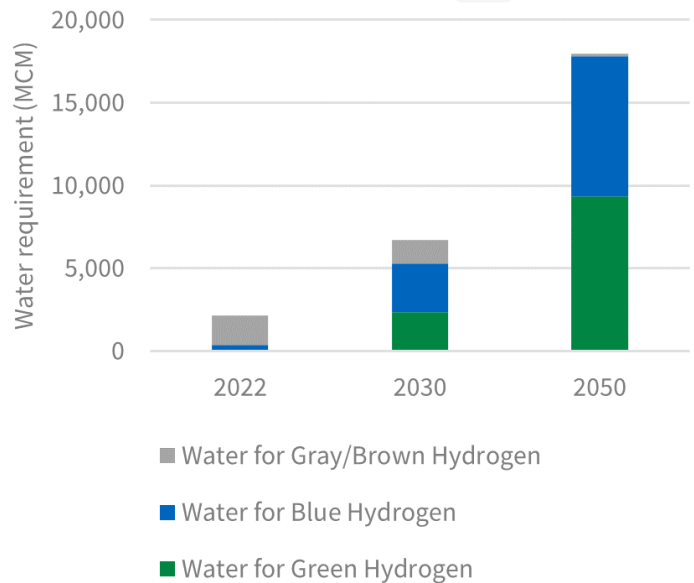


Figure 1: The IEA’s forecasted water requirements for hydrogen production to achieve net zero emissions by 2050 (Tetra Tech analysis using IEA data)

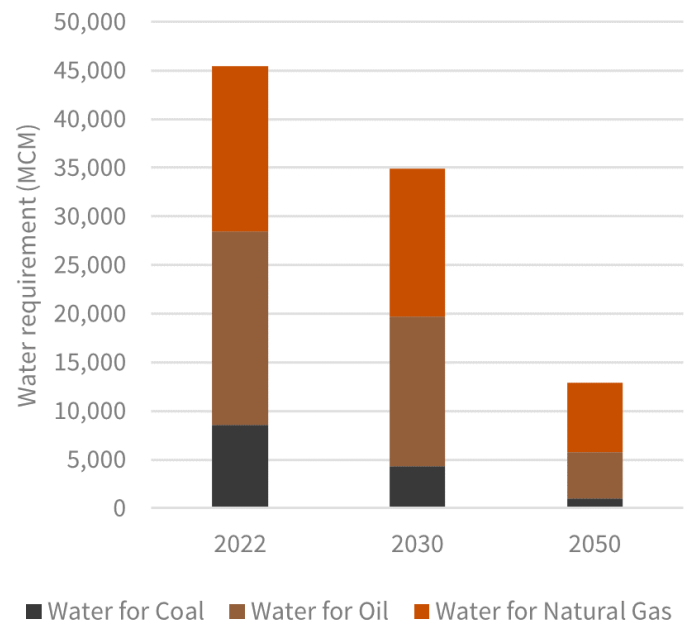


Figure 2: Forecasted water requirements, only for extraction by conventional fuel type, required to achieve IEA’s net zero emissions by 2050 (Tetra Tech analysis using World Bank data)

³ Considering the oil, gas, and coal demand from the same forecast and the water requirements to produce each type of fuel.



Regional Impacts

Despite the potential for a net decrease in global water consumption, hydrogen development may still pose challenges in water-scarce regions. Chile, Australia, and parts of the Middle East and North Africa are emerging as key players in the green hydrogen market due to their abundant renewable energy resources. Yet, many of these regions face significant water stress, raising concerns about localized environmental and socioeconomic impacts.

For these areas, water management will be a critical factor in the feasibility of hydrogen production. This underscores the importance of integrating advanced water recycling and reuse technologies into hydrogen projects. Additionally, coastal hydrogen production sites may turn to desalination for sustainability. The cost of desalination, although significant, is just a drop in the bucket of an overall project budget for large-scale hydrogen facilities. Plus, the desalination process can create opportunities to develop shared water infrastructure that benefits both hydrogen production and local communities.⁴

⁴ Only a minor impact on the total cost of a green hydrogen project, increasing costs by \$0.01–\$0.02/kgH₂, according to the International Energy Agency.

Innovative Water Solutions for Hydrogen Projects

To promote alignment with water sustainability goals, strategic water management practices in hydrogen production are essential.

1. Advanced Water Recycling and Air Cooling

Technologies that allow for the reuse and reduction of water within hydrogen production processes can significantly reduce overall consumption. This is particularly valuable in water-scarce regions.

2. Desalination Integration

Coastal green hydrogen projects can leverage desalination for sustainability, with potential co-benefits for local populations through shared infrastructure.

3. Resource Mapping

Site selection should incorporate detailed resource mapping that considers both water availability and renewable energy potential. This will help optimize the location of hydrogen production facilities, reducing the environmental impact while maximizing operational efficiency.

Tetra Tech's Role in Water and Hydrogen Innovation

At Tetra Tech, we combine our industry-leading expertise in [water](#) and [energy](#) to help clients navigate the complex challenges of [hydrogen](#) production in a water-constrained world. Our custom-built resource mapping processes assess both renewable energy availability and water resources, enabling our clients to make informed decisions about where and how to develop their hydrogen projects.

As Engineering News-Record's #1 ranked firm in Water Treatment and Desalination since 2014, Tetra Tech brings innovative solutions to overcome water scarcity and desalination challenges for green hydrogen projects.

We specialize in designing advanced water treatment systems—including reverse osmosis and nanofiltration—that meet the stringent purity standards required for hydrogen production.

Conclusion: A Sustainable Path Forward

The global transition to clean hydrogen offers immense promise for decarbonizing the energy sector, but its success depends on careful management of water resources.



By employing advanced water reuse technologies and strategically locating hydrogen production facilities in regions with access to renewable energy and sustainable water supplies, the hydrogen industry can mitigate the environmental risks associated with its water footprint.

Tetra Tech is at the forefront of this evolution, providing the technical expertise and innovative solutions that can drive sustainable hydrogen production in the decades to come. As hydrogen emerges as a cornerstone of the global energy transition, our commitment to Leading with Science® guarantees that water, one of our most precious resources, is managed responsibly for future generations.

Learn more from our hydrogen team on the role H₂ plays in the clean energy transition.

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