Accelerating Energy Transition Series

ENGINEERS AUSTRALIA

Exploring the Water–Energy Nexus through Hydrogen: An Early Careers Perspective

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As two engineers in the early years of our careers, we are encountering a water industry that is different from what has existed historically. It seems that the water and energy sectors are converging, as both industries strive to deliver the elusive goals of instantaneous, affordable, and reliable supplies for all customers.

'Nexus' often refers to a connection between two or more elements, illustrating how they interact and influence each other. Traditionally, the water–energy nexus has looked at how the water industry can support energy production, such as by using water to generate hydropower, managing groundwater in the mining industry, and supplying cooling water for energy processes.

Recently, we've seen the same pattern emerge within the green hydrogen market, as it demands substantial amounts of water for feedstock and cooling purposes. We see this as an opportunity to shake up the traditional

approach to the water–energy nexus. With a truly symbiotic relationship between the two industries, both will be better equipped to handle the shared challenges ahead relating to climate change, ageing infrastructure, reliability, and increasing demand.

Millie: I've always been drawn to the water industry because it plays a crucial role in our daily lives. Because of this, I'm eager to contribute to the delivery of reliable, high-quality water supplies for urban and regional populations and industrial sectors, while supporting crucial environmental flows. This balancing act involves managing conflicting demands for a finite resource. As a chemical engineer, the opportunity to engage with this conundrum and collaborate with a variety of stakeholders is an exciting career path that promises diverse experiences around the world.

Simone: My choice to pursue engineering was deeply influenced by my education on the threats of climate change and the urgent need for action from our generation. With a strong interest in maths and science, as well as a passion for earth science and the environment, I found the water industry to be a perfect crossover of these fields. As new challenges emerge regarding water security and quality, the water industry is an exciting and important field. A lot of new water infrastructure is needed in the coming years to manage growing populations and mitigate climate change risks, so it's energising to be early in my career and have all these opportunities ahead.

Working in industry for almost 3 years, we've had growing exposure to green hydrogen, and the role water plays in our transition to net zero. Given the water demands required for hydrogen production, it's exciting that the water industry has such a critical role to play.

We've been fortunate to gain exposure to numerous hydrogen projects in our early careers. This includes work on large-scale strategies, such as the 2024 National Hydrogen Strategy refresh, state-level investigations, and more site-specific technical projects.

These large-scale strategy projects offer an opportunity to shape the future development of the sector in Australia and highlight the importance of sustainable water usage. The National Hydrogen Strategy refresh, completed earlier this year, provided an opportunity to reframe the hydrogen discussion around water. The original strategy failed to recognise the challenges surrounding water supply, given its critical nature. However, in the refresh, we advocated for greater inclusion of water source considerations. Through our technical analysis, we integrated water sources, water availability, transport and treatment requirements into scenario modelling to generate a levelised cost of water at various hydrogen production locations in 2050. This linear optimisation modelling considered renewable energy zones, hydrogen carriers and users, and water sources across Australia. Collaborating closely with our energy colleagues, we gained valuable insights into the hydrogen sector and brought a fresh perspective. Ultimately, our work helped to identify potential challenges in constructing and developing large-scale water infrastructure for hydrogen.

Another interesting piece of strategy work was completed at state level, where we examined potential hydrogen demands and the associated water and treatment requirements. A particularly fascinating aspect of this project was interviewing water authorities, especially those in the wastewater sector, to gain insight into their understanding and perception towards hydrogen. These interviews revealed a strong interest in beneficial water reuse opportunities, with many authorities expressing readiness to upgrade current assets to meet the growing demands of hydrogen production.

This willingness underscores the importance of a collaborative approach between the energy and water sectors. By working together, we can gain a clearer understanding of the water available to support hydrogen production and opportunities for mutual benefits, such as co-location with wastewater treatment plants for oxygen reuse.

Alongside this broader strategy work, we've also been involved in site-specific projects across Australia. Our projects have ranged from coordinating with water utilities on available resources and infrastructure for specific hydrogen projects, to investigating the potential for recycled water use, and weighing up the cost implications of alternative water sources. In these projects, we're observing a growing focus on how clients can manage waste responsibly, optimise their water usage, and handle variable flows.

We're often asked whether the hydrogen hype is all it's cracked up to be. As with any emerging industry, sometimes it can feel like there are more questions than answers. From our experience so far, there are some key issues we keep revisiting when thinking about the role of water in the future hydrogen sector.

I didn't realise water was such a big part of the green hydrogen picture. Why?

From a water perspective, achieving Australia's ambitious hydrogen targets to create a green energy future presents significant challenges. One key issue is the conflicting water demands that will inevitably arise with the large scale of hydrogen ambition in Australia. For example, the National Hydrogen Infrastructure Assessment (2023) notes that the sector's water demand could be of a similar order of magnitude in 2050 to current water use by the mining sector.

Planning for future water use is complex, given the uncertainties surrounding how to best manage the impacts of climate change on water supplies, population changes, environmental needs, cultural water flows, and social attitudes towards water usage. Other major competing demands could include coal mine rehabilitation, data centre developments, and various industrial, agricultural, and mining activities. This underscores the importance of planning hydrogen infrastructure with careful consideration of water supply and demand in the context of current and future needs, so as to ensure appropriate water distribution among all these beneficial uses.

But water is cheap, so why does it matter?

Despite how critical it is for hydrogen production, we've observed limited attention given to water, largely due to its lower cost compared to renewable energy generation. The belief that water will always be affordable and readily available is a misconception that often misguides feasibility assessments for these projects. While this assumption may initially help get hydrogen initiatives off the ground, the reality of water supply challenges frequently reveals that the costs associated with securing water are significantly higher than anticipated. A crucial lesson here is the importance of involving the water industry early in the planning process and remaining open to exploring alternative water sources and supplies.

While the cost of water is relatively small compared to other project costs, promoting hydrogen as an ethical water user is essential. To be truly green and for this sustainable energy source to contribute to achieving Australia's net zero target, we must consider all resources involved in its production. Sustainable and responsible water use is a crucial part of this discussion.

Aren't we just splitting water into hydrogen and oxygen? Where is this waste coming from?

Another challenge we've encountered on our hydrogen journey is the management and disposal of concentrated brine streams, particularly in remote areas. Water sources such as seawater or surface water need to undergo significant treatment to be usable in the hydrogen production process, which produces a concentrated waste stream that must be managed. This is in addition to the waste generated from the cooling processes, called 'blowdown'.

Flagged green hydrogen production regions often have ample land for renewable electricity generation, but the issue of waste management remains significant. Brine reduction can be achieved through the recycling and treatment of cooling water waste; however, the effective management of this waste is largely constrained by factors such as land availability, potential for sewer connection, environmental and waste regulations, and potential alternative uses for the brine.

Can the hydrogen sector provide benefits to the water industry?

Considering the challenges arising in hydrogen development projects, much of the discussion has focused on what water can do for the energy sector. However, we need to reframe this discussion to promote collaboration and encourage mutual benefits for both the water and energy sectors. For example, we can discuss using new desalination water sources to supply industry, cities, or remote communities. There are other co-benefits to the water side of the equation, such as using stormwater to meet hydrogen's water demand to remove runoff and pollutants from entering our waterways. We need to look at how leveraging the needs of the energy sector can contribute to positive water outcomes.

From our perspective, we are at the beginning of an exciting time where exploring co-benefits, particularly in waste management, appears to be an emerging market. This area offers possibilities for achieving a genuine circular economy where green hydrogen production creates more than just an energy source.

Looking to the horizon

Starting our careers in a developing landscape is exciting. Each project presents an opportunity to think creatively and differently about the water and energy challenges. Our exposure began through high-level research pieces to understand the role of water in the hydrogen production process. As the industry has developed, we've progressed into site-specific water treatment and waste management design. Where we go next on this journey is ultimately unknown, but we will continue to advocate for the inclusion of sustainable water use in hydrogen development projects.

As junior engineers, we feel fortunate to be part of such transformative projects. While we may enter the workforce with enthusiasm but limited experience, we see this as an advantage that allows us to think outside the box and propose unconventional solutions to complex challenges. We are given the freedom to challenge established norms and explore innovative problem-solving approaches. In a market that increasingly values creative thinkers, we hope this presents a unique opportunity for us to make a significant impact early in our careers.

About the authors

Simone Costello *is an engineer in Arup's Victorian Water Team, where she contributes to both water and wastewater projects. Recently, she has been a key process engineer for several hydrogen production projects, focusing on the impact of large industrial users, such as hydrogen plants, on water availability. Simone was a keynote panellist at EA's CSE23 conference in Melbourne and has authored papers on the water–energy nexus for Singapore International Water Week and Ozwater in 2024. She holds a Bachelor of Science in Chemical Systems and a Master of Chemical Engineering from the University of Melbourne.*

Millie Simpson *holds bachelor's degrees in both chemical engineering (honours) and commerce (economics) from Monash University and is now a water process engineer in the Victorian Water Team at Arup. She specialises in projects focused on water reliability for regional and rural areas. Her work encompasses water treatment, solutions for alternative industries such as green hydrogen and agriculture, and resilience assessments. Millie has become a key process engineer on a number of hydrogen production projects, with a specific focus on the availability of water supplies to meet the extensive demands of the green hydrogen industry. She authored papers on the water–energy nexus as part of the Singapore International Water Week and OzWater in 2024. Her recent work to develop a resilience assessment framework for wineries and vineyards across Australia (WineRES) was presented at conferences in the Barossa Valley and at OzWater 24.*