

**Submission
No 41**

INQUIRY INTO DEVELOPMENT OF A HYDROGEN INDUSTRY IN NEW SOUTH WALES

Organisation: UNSW Sydney

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Submission to the Inquiry into the development of the NSW hydrogen industry

1. Overview

UNSW Sydney welcomes this inquiry into the development of the NSW hydrogen industry. We are pleased that this inquiry recognises the increasing importance of hydrogen, given it is gaining international momentum as a clean energy solution with the potential to lead to significant new market opportunities.

The government notes that by 2030, the hydrogen market could be worth up to \$1 billion, increasing fuel and electricity system security while attracting green investment.¹ We agree that NSW is well-placed to take advantage of the opportunity that hydrogen presents to transform large sectors of the economy, such as transport and manufacturing as articulated in the NSW Net Zero Plan 2020-2030.²

To achieve this vision for NSW, we encourage the government to draw on the expertise of universities such as UNSW which is well-positioned to help the NSW Government achieve its priority to 'accelerate the research, development and demonstration of low emissions technologies that show potential for becoming scalable, replicable and cost-effective.'³

UNSW is in the unique position of not only having multiple world-class experts in the broad area of hydrogen, but is also experienced in the leadership role it played in the development of a low-emission technology industry through pioneering work in the area of silicon solar photovoltaic (PV) cells. Technology developed at UNSW is now used in more than 85 percent of all solar panels being manufactured worldwide. At UNSW we are applying the lessons learned from the development of the solar PV industry to hydrogen. We stand ready to assist the government in the development and implementation of NSW's Hydrogen Program.

Key recommendations:

1. That the government needs the right programs, policies and incentives in place to ensure that there is a sufficient pipeline of students in areas which will support the establishment and growth of the hydrogen industry. There also needs to be programs to upskill technicians and engineers so they are ready to contribute to the development of the hydrogen industry – people with the requisite skills are currently hard to find.

¹ Department of Planning, Industry and Environment (2020), Net Zero Plan Stage 1: 2020-2030 available at: <https://www.environment.nsw.gov.au/-/media/OEH/Corporate-Site/Documents/Climate-change/net-zero-plan-2020-2030-200057.pdf?la=en&hash=D65AA226F83B8113382956470EF649A31C74AAA7>

² Department of Planning, Industry and Environment (2020)

³ Department of Planning, Industry and Environment (2020)

2. That the government has the right programs, policies and incentives in place so that on graduation there are jobs for these students in the sector.
3. That targeted long-term investment that covers the full R&D spectrum from innovation through to commercialisation is available and dedicated to the hydrogen sector. Given the pace of the market, funding needs to be flexible, responsive and available quickly as ideas emerge, so that applicants don't have to wait for established research funding rounds with fixed parameters and timeframes to enable Australia to keep pace with international competitors.
4. Cooperation between government, industry and universities will be crucial to the establishment, and critical to the success, of a domestic hydrogen industry in NSW.
5. Investment in industrial-scale facilities that can bridge the gap between research in the laboratory and its successful commercialisation is encouraged.
6. Support for research commercialisation is critical to the establishment of a domestic hydrogen industry. We recommend that the NSW government supports initiatives, such as a technology translation impact fund, which would enable the translation of research to products and industries.

Our central message is that **timing is critical**: significant funding targeted at the hydrogen sector is required as soon as possible to ensure that Australia, and specifically NSW, seizes the opportunity that currently exists to lead the world in hydrogen.

2. The importance of developing a domestic hydrogen industry

Globally, the race to commercialise hydrogen technologies at cost is highly competitive, with early risk takers and players, including Germany, France, Japan and Korea, predicted to take a major share of future market opportunities.

With the rise of the global hydrogen industry, hydrogen research is advancing rapidly, and thus the race to commercialise proven and reliable hydrogen technologies is critical. Australian industry can play a leading role in creating a major hydrogen export market with associated benefits to the domestic economy, while supporting the transition to low emissions energy across electricity, heating, transport and industry, improving the resilience of energy systems and providing consumers with cost-competitive energy options.

If the appropriate strategy and activities can be put in place, Australia should be well-placed to establish itself at the forefront of this market and create opportunities beyond the export of hydrogen. Australia's National Hydrogen Strategy aims to establish Australia's hydrogen industry as a major global player by 2030. Australia is extremely well positioned to take a major share of the predicted \$2.5 trillion hydrogen market, given our natural advantages and proximity to markets, by enabling our unique capacity to produce hydrogen at scale. Australia's National Hydrogen Strategy estimates that

the Australian hydrogen industry could generate around 7,600 jobs and add about \$11 billion a year in additional GDP by 2050.⁴

The hydrogen opportunity will only become a reality if it can be produced, stored and transported safely, at scale and at lower cost. Australia needs to support the transition of hydrogen research and technology into an affordable and accessible domestic energy source and build a lucrative export industry which creates jobs and contributes to the Australian economy. For this to happen, Australia needs to create an ecosystem in which the use of hydrogen can be de-risked and the early adoption of hydrogen technologies across various industry sectors incentivised.

3. UNSW has world-class expertise translating research into industry

UNSW is ready to assist the NSW Government to realise its strategy to develop a hydrogen industry in NSW by drawing on our experience translating university-led research into a thriving industry and applying it to the hydrogen sector.

UNSW has a formidable reputation as one of the world's leading research and technology hubs for energy innovation. Already, more than \$100 billion worth of economic activity around the world is underpinned by renewable energy technology developed at UNSW.

UNSW's research in silicon solar photovoltaic (PV) technology has created and transformed the global solar industry. Solar PV electricity is now a worldwide economic and clean alternative to conventional energy sources. Today, more than 85% of solar panels manufactured across the globe use technology developed at UNSW. Vulnerable households and communities that might otherwise be without power now benefit from low-cost solar PV. The Australian Centre for Advanced Photovoltaics (ACAP) at UNSW has created billions of dollars of economic benefit to Australia including: direct wealth in Australia of around \$1.4 billion; Australian tax revenues of \$1.5 billion; reduced system costs due to higher cell efficiencies of \$0.75 billion; and net societal benefits of between \$5.5-11 billion.⁵

It is very difficult for energy technologies to progress from the lab into industry and society. UNSW is able to help the NSW Government and other stakeholders learn from the lessons gleaned from the development of the solar PV industry and apply them to development of the hydrogen industry in NSW.

UNSW has reviewed the history of this success for solar PV and has identified **essential ingredients that were instrumental in achieving this global impact:**

- Research vision and tenacity, and ability to attract and retain high calibre and highly motivated researchers;
- Training and education creating a pipeline of new researchers and industry leaders;
- Quantifiable research outcomes;

⁴ COAG Energy Council Hydrogen Working Group 2019 quoted in the Technology Investment Roadmap Discussion Paper, Australian Government Department of Industry, Science Energy and Resources available at https://consult.industry.gov.au/climate-change/technology-investment-roadmap/supporting_documents/technologyinvestmentroadmapdiscussionpaper.pdf

⁵ Australian Centre for Advanced Photovoltaics and UNSW Energy Institute

- World-class fundamental research labs;
- Technology translation in industry-facing, pilot manufacturing facilities;
- Trusted strategic partnerships with industry;
- Pipeline of intellectual property leading to spinout companies; and
- Continuity and diversity of funding: co-investment by universities, industry, philanthropists and government.

The solar PV “innovation ecosystem” at UNSW has created social, environmental, commercial and economic impact, both in Australia and across the globe.

We understand what worked for solar PV, and are excited about applying that knowledge and experience to hydrogen. Yet, knowing what we now know, and knowing how competitive the international space is already for hydrogen, **what should be done differently for hydrogen?**

4. Applying our translation expertise to develop the NSW hydrogen industry

Given the enormous potential for commercial and economic impact, there is already **a highly competitive space for hydrogen** research, development, demonstration and deployment internationally that wasn't obvious for solar PV in its infancy. INSW must therefore:

- **Act early** to recreate these essential ingredients for success outlined above;
- Be highly strategic about **identifying and filling gaps**;
- Involve **government in activities that include both research and the active translation of research**;
- Encourage **early commercial partnerships with industry and researchers**;
- Spin out **new hydrogen companies, and consumer and industrial hydrogen products with local partners and/or local manufacturing**; and
- **Offer and enable more local training.**

To leverage our learning from solar PV, and the urgency of replicating that for hydrogen, we have been rapidly building an “innovation ecosystem” at UNSW to **translate our hydrogen research outputs to impact**. The pillars of this ecosystem are:

- Education;
- Research;
- Industry skills, services and partnerships;
- Commercialisation of hydrogen technology.

Below we consider each of the pillars of this ecosystem in turn, articulating UNSW's expertise and activities to date, and highlighting gaps that could be filled by partnerships between UNSW, industry, government and other research partners.

5. Education to support the establishment of the hydrogen industry in NSW

Education is an essential ingredient for the development of a domestic hydrogen industry. To build and sustain an emerging hydrogen industry requires job-ready graduates with adequate skills not only to support and implement existing technologies but also to innovate and develop the next phase of technology.

For Australia to become and remain competitive as the hydrogen economy grows, a pipeline of talent that industry can access quickly is required to build the hydrogen industry. Australia needs to educate and retain the most skilled graduates and encourage them to study engineering, in particular chemical engineering, with a focus on hydrogen. We also need to ensure that there are jobs available for these students upon graduation. Governments will need to ensure that there is support for new start-ups and the transformation of existing industries to ensure that they are ready to take-on graduates emerging in this field.

In terms of education, we encourage the NSW government to consider the following:

- The engineering sector already lacks graduates, and establishing a new domestic hydrogen industry will require a critical mass of skilled workers. What policies and programs does the government have in place to encourage talented high school students to study engineering and so grow the cohort of graduates required to develop a domestic hydrogen industry?
- It takes time to train students (4-5 years for undergraduates, longer for higher degree candidates). What policies, programs or incentives does the government have in place? What will it need to do to ensure that industry will be ready, and jobs will be available for these graduates?

UNSW recommends that the NSW Government (and Commonwealth Government) develop policies, programs and incentives to attract students to study engineering and incentives for industry to employ engineering graduates to ensure that there is a pipeline of graduates with the requisite skills to contribute to and grow the proposed domestic hydrogen industry.

6. Research for the hydrogen industry in NSW

Our experience in establishing a global solar industry clearly demonstrates that research, both fundamental and applied, is an essential ingredient for creating a hydrogen industry in NSW.

UNSW has world-class hydrogen experts across several schools and faculties leading research into hydrogen. A full outline of UNSW's hydrogen expertise is at Annex 1.

We also have world-class laboratories such as **The PARTCAT research lab**⁶, one of the best catalyst/photocatalyst fabrication and characterisation facilities available in Australia, and the **Materials Energy Research Laboratory in Nanoscale (MERLin)**⁷, an energy research laboratory used to research use of hydrogen as a clean energy vector, and fully equipped for the development, characterisation and translation of hydrogen storage materials and fuel cells.

Our experts are also collaborating to convert heavy **reciprocating engines** to use hydrogen.

In addition to our own expertise in hydrogen, UNSW is formally connected with the universities of Newcastle, Wollongong and Western Sydney, in a partnership called **NUW Energy, under the NUW Alliance**. Minister Matt Kean launched NUW Energy in 2020 and the universities are already collaborating with each other; we are keen to ensure our active and ongoing collaboration with the NSW Government and commercial partners furthers NSW's leadership of the hydrogen industry.

Given our world-leading researchers and our extensive expertise in hydrogen, UNSW has been successful at attracting funding through the existing government funding schemes which support research and development. However, competitive schemes such as the Australian Research Council (ARC) scheme for fundamental research (both Discovery and Linkage schemes) and the Cooperative Research Centre (CRC) program for applied research support relatively short-term initiatives. In contrast, enabling an internationally competitive Australian hydrogen ecosystem will require sustained investment across the whole R&D spectrum, from innovation through to commercialisation.

The international and domestic hydrogen sector is moving too fast to wait for existing, competitive research and innovation funding cycles. It is only by providing significant, sustained and flexible support directly to the sector that the hydrogen industry can be built and de-risked.

UNSW recommends that government commit targeted long-term funding specifically dedicated to the hydrogen sector that covers the full R&D spectrum from innovation through to commercialisation. Given the pace of the market, funding needs to be flexible, responsive and available quickly as ideas emerge, so applicants don't have to wait for established research funding rounds with fixed timeframes and strict parameters. This is necessary for Australia to keep pace with international competitors.

7. Industry skills, services and partnerships for a hydrogen economy in NSW

NSW's Accelerating R&D Advisory Council notes that 'NSW has a high performing research sector, but performs relatively poorly in industry collaboration, research translation and commercialisation'.⁸

UNSW has been successful in partnering with industry to bring about significant and timely research in the hydrogen sector. Examples of our successful collaborations with industry and governments include:

- The NSW Power-to-X Industry Feasibility Study (announced 2021)
- The Australian-German hydrogen supply chain study (announced 2020)

⁶ <https://www.pcrq.unsw.edu.au>

⁷ <http://www.merlin.unsw.edu.au>

⁸ Accelerating R&D in NSW Advisory Council, 2021, Turning ideas into jobs: Accelerating research and development in NSW available at: <https://www.dpc.nsw.gov.au/assets/dpc-nsw-gov-au/publications/Accelerating-research-and-development-in-NSW-listing-1690/Accelerating-RD-in-NSW-Turning-ideas-into-jobs-web.pdf>

- The Hydrogen Energy Research Centre (announced 2020)⁹
- The Australian Research Council Training Centre for the Global Hydrogen Economy (GlobH2E) (announced 2020). See full details of these initiatives in Annex 1.

However, we agree with the assessment of the NSW Accelerating R&D Advisory Council that more needs to be done in this area.

For companies and communities that want to establish a sustainable leadership position in a new industry, we cannot overstate the importance of partnering with universities that have demonstrated expertise. Communities in NSW will need trained industry experts to build the hydrogen industry here, and ensure NSW is part of a global supply chain with potential trading partners, such as Germany.

In addition to funding for the whole R&D spectrum, UNSW recommends that governments develop opportunities and mechanisms for public and private co-investment in innovation and development.

Cooperation between government, industry and universities will be crucial to the establishment, and critical to the success, of a domestic hydrogen industry in NSW.

NSW's Accelerating R&D Advisory Council's Action Plan recommends priority actions such as: targeted strategic support for universities; launching a Small Business Innovation Research program; and establishing an R&D platform. The Committee should consider how these actions could contribute to the development of the hydrogen industry in NSW, and whether any government funding committed to implement the R&D Action Plan should include funds ear-marked for the hydrogen sector.

8. Gaps in translating research to industry

The NSW government includes among its priorities in this area to 'accelerate the research, development and demonstration of low emissions technologies that show potential for becoming scalable, replicable and cost-effective.'¹⁰

We know from our solar PV experience that establishing a successful commercial energy technology industry requires funding for demonstration and deployment, so research can be translated to industry and commercial applications. Indeed, UNSW's Solar Industrial Research Facility has been a key enabler of solar PV research translation.

Australia does not yet have the depth or scale of research and industrial expertise let alone industrial scale supporting facilities to establish and sustain a successful hydrogen economy.

We have identified an **opportunity to establish an industrial-scale facility in NSW that can bridge the gap between research in the laboratory and the successful commercialisation and potential export of the technology**. This will ensure that funding for the hydrogen sector can be directed towards creating and developing hydrogen as a viable and successful domestic industry in Australia and will reduce our reliance on purchasing hydrogen related technologies from overseas.

⁹ <https://www.herc.unsw.edu.au>

¹⁰ Department of Planning, Industry and Environment (2020)

Hydrogen Industrial Research Facility, an opportunity for collaboration, involving NSW Government, industry and UNSW

UNSW plans to establish a Hydrogen Industrial Research Facility, a facility where researchers and industry partners can collaborate to securely deliver hydrogen projects that are de-risked from a technical and financial perspective.

The Facility will have equipment and expertise to assess, validate and certify all industry relevant technologies over the entire hydrogen value chain, including large electrolysers, storage technologies, fuel cells and power management and conversion systems.

The Facility would allow startups, SMEs, and other stakeholders to access on-site expertise to enable collaboration and testing of hydrogen technologies and projects and develop full-scale feasibility studies.

It will contribute to the development of a sophisticated hydrogen energy ecosystem by delivering:

- Hydrogen feasibility studies and consultation work, including systems integration, evaluation and design studies
- Hydrogen systems and manufacturing prototyping
- Hydrogen economic value and de-risking technology to enable industry transition
- Setting new global standards in hydrogen technologies
- Testing and certification of hydrogen equipment to various local and international standards
- Performance and benchmarking validation of technologies
- Training of the future hydrogen workforce
- Collaborating with industry partners to execute commercial projects
- Certification, as Australia needs a place to certify technology and possibly establish the world best practices for this.

Creating a facility that brings together R&D and industry would be the first of its kind in NSW; there are only a few laboratories in the world with real expertise in hydrogen technologies and often this expertise is not well integrated (i.e., all the capability cannot be found in a single location and, more importantly, is not connected to industry).

There is also an opportunity to set global industry standards for a range of hydrogen technologies including hydrogen to be produced and used in Australia. Setting the baseline for these international standards will cement Australia's position in the global hydrogen market. For example, there are currently no standards for metal-hydride storage technology in key markets.

UNSW would welcome NSW Government support to bring this vision to fruition.

9. Commercialisation of hydrogen technology in NSW

Many solar PV companies were spun out of UNSW by staff and student alumni, but as the Australian Government notes, one of the key lessons learned from the development of solar PV is that Australia has not reaped the full rewards that might have come from being more strategic in translating early-stage research into commercial opportunities within Australia.¹¹

UNSW's hydrogen technology has already helped to establish two new hydrogen companies, *LAVO*, **the world's first** integrated **hydrogen hybrid battery** and *H2Store*, a revolutionary, safe, **dense bulk storage solution** fully funded by Providence Asset Group which means hydrogen can be safely and cost-effectively transported in shipping containers on trucks or on regular cargo ships, without the need for complicated compression or liquefaction processes. These are great examples of industry led problem solving, which accelerate the commercialisation of university R&D into real commercial outcomes in the development of the new hydrogen economy.

Despite these examples, commercialising new energy technology is notoriously difficult: Australia favours "founder-centric" commercialisation models, yet many academic inventors would prefer to solve new challenges and create new IP than create new companies; high potential inventions without founder teams cannot access support systems; Australia lacks "technology-centric" and "market centric" commercialisation models; universities lack funding and deep domain expertise for early-stage commercialisation activities such as business case and business model development. Furthermore, hardware requires more investment than software; business models are changing; new markets are evolving; and new market participants are emerging.

As a result, many potentially high-impact inventions sit undiscovered or rather undeveloped in Australian universities. This creates a major hurdle in achieving the Government's vision for low-emissions growth, new jobs, exports, new industries (such as hydrogen), and advanced manufacturing opportunities.

In the current ecosystem, we note that transforming the industry sector can be challenging. Current start-ups struggle to find investment and often have had to go overseas to develop their innovative technologies. On the one hand large Australian companies recognising the hydrogen opportunity are reluctant to take early commercialisation risk and invest in innovation; their preference is to remain end-users. Other businesses on the other hand, have difficulty in understanding how they can adapt to the coming hydrogen opportunity.

UNSW and several other NSW universities have been exploring **establishing a technology translation impact fund** to overcome such systemic challenges and we have interest from influential cornerstone investors. We encourage the NSW Government to partner and invest in this opportunity and so create a new model for translating innovation into local markets and jobs.

10. Conclusion

For further information, please contact Justine Jarvinen, CEO of the UNSW Energy Institute, at
or Professor Kondo-Francois Aguey-Zinsou at

¹¹ Technology Investment Roadmap: First Low Emissions Technology Statement, Australian Government Department of Industry, Science, Energy and Resources, September 2020 available at <https://www.industry.gov.au/sites/default/files/September%202020/document/first-low-emissions-technology-statement-2020.pdf>