Australia's critical hydrogen research questions

Derived from the 2023 Australian Hydrogen Research Conference

ANU, Canberra

8-10 February 2023

Preamble

On 8-10 February, 326 delegates met in Canberra for the inaugural *Australian Hydrogen Research Conference* – the first comprehensive gathering of Australia's hydrogen research community. This mainly comprised Australian researchers working across the entire hydrogen supply chain – production, storage, distribution, utilisation, and cross-cutting areas (the enabling areas in which the industry will develop within responsible and timely societal and environmental constraints). Other attendees included policy makers, industry representatives, and 47 international visitors.

The conference program heard presentations across the hydrogen supply chain and held three expert discussion panels on Industry and on Policy, leading into a final Key Research Questions panel discussion on the last day chaired by Australia's Chief Scientist, Dr Cathy Foley. The research panel was asked to discuss Australia's top hydrogen research questions.

A survey of the plenary session was also held that asked delegates the question, '*What are Australia's primary competitive advantages in hydrogen energy that are being held back by uncertainties requiring research'*? (The results are posted below with a postscript note that the research community has strong interest to conduct further, more refined prioritisation and coordination of efforts towards common research objectives).

Panel Discussion Insights

Key insights from all three panel discussions and follow-up activities organised by the AHRN committee members, include:

- There is an enormous challenge ahead to roadmap Australia's energy transition and the role for hydrogen
- A large and diverse body of research is underway in Australia and internationally. While there is consensus that some R&D areas are priorities for Australia there is a difference in views on the prioritisation of other R&D areas. For example, there is consensus that Australia has a tremendous opportunity to export hydrogen and its derivatives, and to export green steel/iron and associated technologies; but it is debatable, for example, whether we should undertake more research on developing electrolysers here, or instead take advantage of the advanced electrolysis field developing overseas.
- A lot of change and progress has occurred since the 2019 *Hydrogen Research, Development and Demonstration (RD&D): Priorities and Opportunities for Australia* report, and to now apply a greater prioritisation and coordination of research efforts would help focus limited resources and accelerate the industry.
- In particular, hydrogen storage, distribution, and end-use applications – including new unanticipated possibilities for hydrogen use – need more research. More techno-economic and technology acceptance research is needed to discover the optimal prospects for hydrogen use in Australia, versus transporting hydrogen over long distances to end-users overseas. One example is the use of hydrogen in the production of direct reduced iron (DRI) which could be exported as a 'clean energy embodied' product; another is combining renewable hydrogen with Direct Air Carbon Capture (DACC) to created synthetic fuels, plastics and other chemical products.

- Establishing demand for hydrogen is crucial to building viable business cases for hydrogen projects – whether for export or domestic applications. Mobility was identified as a local demand source with near-term potential. Heavy industry and export markets were identified as important medium-to-long term opportunities.
- Australia is facing a shortage of workers with the skills required for developing its hydrogen industry. It is important that Australia develops a 'hydrogen-ready' workforce to realise its ambition of being a world-leading hydrogen and hydrogen derivatives producer.
- Several critical minerals, e.g. platinum and iridium, are used in hydrogen technologies. There is growing concern for the risk of critical mineral supply issues emerging as global demand for hydrogen technologies increases. Given Australia's rich minerals endowment, there is an opportunity for Australia to play a role in mitigating critical mineral supply risks.
- There was consensus that one of Australia's main competitive advantages is its abundance of cheap renewable energy resources. Due to this advantage and its potential as a trusted supplier, Australia has been considered a preferred location for hydrogen production. However, it was highlighted that there is a risk that major policy movements in other countries, e.g. the *Inflation Reduction Act* in the USA that incentivises domestic renewable hydrogen production, could undermine Australia's competitive advantage.
- Improved coordination between researchers, industry, and policy makers is urgently needed. This requires investment in and improved processes/policies for knowledge sharing. Improved sharing of lessons learned from both failed and successful projects is critical for preventing repetition of past mistakes
- Gatherings such as the 2023 AHRC with its many multidisciplinary stakeholders provide the opportunity for expert discussion of Australia's hydrogen industry challenges and add significantly to the dialogue needed to create clear ways forward.

Within this mix of priority settings and challenges that exist alongside significant opportunities, the three panels and the conference overall highlighted important research underway and identified many key questions that need to be addressed to advance Australia's hydrogen industry.

Key specific research questions identified throughout the conference included:

Technical topics

a. What critical materials are required for the hydrogen economy and can they be sourced locally, reliably, cheaply and quickly?
b. What alternative materials – materials that are easily recoverable – can we identify and use to ensure these hydrogen technologies/systems are economically viable?
c. How can renewable hydrogen systems best be integrated into current energy systems during the energy transition?
d. What applications can use hydrogen close to production points? For other applications, can research and innovation reduce costs and enable new storage and transport options along the supply chain?
e. What are the potential new applications and industrial niches for hydrogen?

f. What are the system-level integrative opportunities (energy co-location including excess heat, chemical by-product streams etc.) for new industrial applications of hydrogen?

Enabling topics

g. What mechanisms can be devised (economic, policy, financial, regulatory) to build demand and encourage supply in the hydrogen economy?

h. What safety considerations do we need to tackle, particularly regarding new applications?

i. What retraining/reskilling will be needed to work in hydrogen?

j. What monitoring and evaluation strategies will help us to ensure we follow-through in the communities that are engaged and involved in hydrogen consultation during development of the strategy?

k. What are the most feasible ways to produce, store and utilise hydrogen so that it is attractive for investment?

l. To what extent can low-carbon hydrogen be developed alongside renewable hydrogen in Australia without impacting the development of renewable hydrogen?

m. What are the potential co-benefits to society and how can they be obtained?

n. What are the barriers to accelerating industrial transformation under realistic conditions?

o. What are the triple-bottom-line effects of using methane to transition to a renewable hydrogen economy and under what timeframes?

p. What are the techno-economic conditions needed to create a market structure that would support the manufacture/import of fuel cells and the manufacture/import of electrolysers?

q. What are the likely supply chain structures in Australia over the next 10-40 years, while understanding the whole supply chain from upstream to downstream including waste? What are the significant tipping points? What changes need to occur in cost along the supply chain compared to what is happening today to fully transition?

Non-research questions

- What opportunities can we find for synergies and cooperation when implementing a national hydrogen strategy?
- How do we coordinate the multiple players that will be involved with implementing these technologies?
- What is Australia's competitive advantage in the global hydrogen economy? In what areas specifically can Australia contribute to this industry compared to other countries?
- What are the necessary, optimal and possible causal pathways in a hydrogen economy?
- How can we incentivise this industry (consider especially attracting finance to where it's needed)? What are the most effective and efficient policy instruments to support and steer the hydrogen transition?

Concluding remarks

At this early stage of the hydrogen industry, Australia needs to clarify the prospects for the industry and commit to our emerging competitive advantages. Research needs to focus on accelerating Australia's strengths and address supply chain gaps to determine what technologies we should develop here in Australia, what technologies we should adopt from overseas, and what our investment framework overall should be. RD&D will play an important part in defining the role that Australia will play in the global hydrogen economy, and a nationally coordinated effort between the research sector, industry and government is required.

This document and the following recommendations were finalised in consultation with the Office of the Chief Scientist, Dr Cathy Foley, and with the Conference Organising Committee comprised of Dr Andrew Dicks (AHRN), Prof Ken Baldwin (ANU), Dan O'Sullivan (CSIRO), Dr Siva Karuturi (ANU), Dr Andrew Feitz (Geoscience Australia), Dr Mahshid Firouzi (University of Newcastle), Dr Emanuelle Frery (CSIRO),Dr Aleks Kalinowski (Geoscience Australia), Prof Paul Medwell (the University of Adelaide), and Prof Bahman Shabani (RMIT).

It's also worth highlighting that recommendations 1, 4 and 5 were also similarly referred to in the 2019 Hydrogen RD&D report: Srinivasan, V., Temminghoff, M., Charnock, S., Hartley, P. (2019). *Hydrogen Research, Development and Demonstration: Priorities and Opportunities for Australia*, CSIRO and that this occasion now serves as a timely cue to consider forward hydrogen R&D pathways for Australia.

Recommendations

1. **Develop and implement a mechanism to help identify, monitor, and refine Australia's hydrogen R&D priorities. Monitoring should be linked to other monitoring of hydrogen industry development.**
2. **Consider leading this mechanism from the Office of the Chief Scientist.**
3. **Report the identified R&D priorities in the next version of Australia's Hydrogen Strategy.**
4. **Build collaborative hydrogen industry-research sector interactions through engagement programs and activities which unite industry and R&D communities in identifying and addressing key industry challenges.**
5. **Continue to grow a comprehensive stakeholder network by supporting future hydrogen-specific conferences and events.**

ATTACHMENT – PLENARY SURVEY

Conference participants were asked in a plenary session the question: "what are Australia's primary competitive advantages being held back by uncertainties requiring research?". They then were asked to select 10 research priority areas out of a list of 33. Research priority areas were then ranked based on the number of times that they were selected by the 120 survey participants. The top ten research areas were as follows:

1. Energy systems integration (grids and renewables)
2. Electrolysis
3. Advanced manufacturing
4. Water use
5. Safety
6. Hydrogen certification schemes
7. Ammonia
8. Policy and regulations
9. Export infrastructure
10. Skills and labour market

Postscript note: The research community has strong interest to conduct further, more refined prioritisation and coordination of efforts towards common research objectives.

The full list of 33 hydrogen technologies and research themes provided were:

Advanced manufacturing
Ammonia
Biomass and waste conversion
Compressed hydrogen
Electrolysis
Emissions and atmospheric impacts
Energy systems integration (grids and renewables)
Export infrastructure
Fossil fuel conversion
Natural gas networks and appliances (distribution)
Hydrides
Hydrogen certification schemes
Hydrogen embrittlement
Industrial feedstock processes (synthetic fuels and methanol production)
Industrial heat processes (cement, metals refining, etc.)
Land use and ecological impacts
Liquid hydrogen
Liquid organic carriers
Mobility (fuel cells and refuelling stations for land, sea, air)
Photochemical and photocatalytic processes
Pipeline materials
Policy and regulations
Recycling and waste management
Safety
Sector coupling
Skills and labour market
Social licence
Supply chain integration
Synthetic fuels and chemicals
Techno-economic assessments
Thermal water splitting
Underground storage
Water use