HySupply Progress to date - Australian Developments

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HySupply Partnership

Joint Feasibility Study of Renewable Hydrogen

German-Australian Hydrogen Supply Chain

Module 1: Production
Renewable energy \(\rightarrow\) Hydrogen \(\rightarrow\) \(\mathbf{H}_2\)

Module 4: End use
Steel industry, Refineries, Chemical industry

Module 2: Transport
Export \(\rightarrow\) \(\mathbf{H}_2\) Import

Module 3: Recovery
Hydrogen based energy carriers \(\rightarrow\) Recovery and distribution

Source: BDI/acatech

Key Partners
BDI
acatech
UNSW Sydney
Baringa

Lead and Administrating Organization
Note: We seek and welcome new consortium members across Australia’s emerging green hydrogen value chain. Please feel free to contact either Dr Rahman Dayan (r.dayan@unsw.edu.au) or Associate Professor Iain MacGill (i.macgill@unsw.edu.au) to explore this further.
Assessing the State-of-Play
Current global energy trade

Largely an outcome of the availability of easily extracted low-cost fossil fuels

Germany a world top 5 energy importer

Australia the world’s third largest energy exporter

Global energy imports by country (PWh/year)
A mostly renewable world more self reliant

... however, various countries still seem likely to require energy imports including Germany and some others in Europe, Japan, Korea

Potentially new renewables ‘electrostate’ exporters, likely some old ones

Global class 7 on-shore wind and tracking PV potential by country (TWh/year)
Trade relationships generally multi-faceted

Delivered price is key, but not the only consideration - existing trade relationships, stability, demonstrated capability, geopolitical considerations....

WEF Global Competitiveness Rankings

Germany – 7th

Australia – 16th
Significant government support – although competition is growing

Western Australia

- WA System Plan: Target established to convert WA’s energy supply capacity to 70% renewables by 2040.
- WA Renewable Hydrogen Strategy and Roadmap: The state has established long-term goals to develop a hydrogen industry. Key short-term goals (2022) include development of a renewable hydrogen export project and inject H₂ in gas grid.
- WA Renewable Hydrogen Fund: A$5 million was provided for hydrogen project feasibility studies. The state government also invested A$22 million in 2020 to develop a 1.5 GW renewable energy and hydrogen hub.

Northern Territory

- 2020 Renewable Energy Investment: A$100 million invested in 2020 to grow capacity by 64 MW.
- State Renewable Energy Funding: The state is financing development of large-scale activities for renewable energy storage, has made grants available for household solar systems and made “Sun Cable” project a key priority.
- Renewable Energy Target: NT has a target for 50% renewables supply in electricity grid by 2030 and to reach net zero by 2050.
- NT Renewable Hydrogen Strategy: The state has developed its hydrogen strategy to become a global hub for hydrogen research, production and technology manufacturing.
- Renewable Hydrogen Project: The state government is supporting the “Aqua Azero” demonstration project to generate hydrogen using water from an air and grid supplied

Queensland

- 2020 Renewable Energy Investment: A$41.4 billion invested in 2020 to grow capacity by 1.9 GW. (3rd highest amongst other states)
- Renewable Energy Corridors: A$145 million committed to develop renewable energy zones in the north, central and south-western part of the state.
- Renewable Energy Fund: A$500 million in additional funding committed as part of the Covid-19 Recovery Plan to support commercial energy projects and to develop infrastructure.
- Queensland Renewable Energy Target: The state has a target to become 50% renewable powered by 2030 and to attain net zero by 2050.
- Queensland Hydrogen Industry Strategy: The state government has committed A$19 million to support the emerging hydrogen economy.
- Queensland Hydrogen Hubs: QLD government has recently backed the development of a hydrogen hub in Townsville.

South Australia

- 2020 Renewable Energy Investment: A$2.4 billion invested last year to grow capacity by 1.4 GW.
- Renewable Energy Target: Target established to convert SA’s grid to 50% renewables to become net energy exporter to the Australia National Energy Market.
- SA’s Hydrogen Action Plan: Action plan developed to establish SA as a key renewable hydrogen strategy. State has provided A$17 million in grants and A$25 million in loans to hydrogen projects.
- South Australia Hydrogen Export Hub: The state has announced plans to develop 3 renewable hydrogen hubs with a combined capacity of 2.6 GW.
- Australia’s largest electrolyser: The state is home to Australia’s largest operational electrolyser of 1.25 MW capacity. The SA government provided A$4.9 Million in grant funding for the project.

NSW

- 2020 Renewable Energy Investment: A$5.6 billion invested last year to grow capacity by 3.6 GW. (Highest amongst other states)
- NSW Electricity Infrastructure Roadmap: The state expects investment of A$22 billion by 2030 to increase its renewable capacity by 12 GW. Hydrogen is expected to be a key growth driver.
- NSW Net Zero Plan Stage 1: Stage 1 of NSW Climate Change Policy: A$2 billion committed in partnership with the Commonwealth for low emission technology including H₂.
- NSW Climate Change Policy Framework: State target of achieving net zero by 2050.
- NSW Hydrogen Hubs: A$70 million committed to Hunter and Illawarra H₂ Hub as part of a greater A$750 million Net Zero Industry and Innovation Program.

Tasmania

- 2020 Renewable Energy Status: The state has the highest share of renewable electricity in power generation (~90%).
- Tasmanian Renewable Energy Target: Achieving 200% of current energy demand with renewable electricity supply by 2040 and become a net exporter.
- Tasmanian Renewable Hydrogen Action Plan: A$50 million package committed to develop a green hydrogen economy, start H₂ export by 2020 and become a global export hub by 2030.

Victoria

- 2020 Renewable Energy Investment: A$5.6 billion invested last year to grow capacity by 2.9 GW. (2nd highest amongst other states)
- Victorian 2020 Budget Commitments: A$1.6 billion committed for development of renewable energy hubs and auction 600 MWs of new solar and wind capacity.
- Victorian Emissions target: The state has a target to become net zero by 2020.
- Hydrogen Energy Supply Chain Project: The state is host to the world’s first H₂ supply pilot. The project was provided with A$50 million in funding by the state government.

Federal

- CEFC Advancing Hydrogen Fund: A$300 million.
- ARENA: A$103 million committed to develop electrolyser projects.
- National Energy Resource Australia: seed funding provided to develop 13 hydrogen clusters.
- Environment Budge: Reduce Australia’s emissions by 26% to 28% below 2005 level by 2036.
- Federal Funding for H₂ Hubs: A$314 million in funding for developing regional H₂ Hubs and carrying out 10 feasibility studies.
- German-Australia Hydrogen Innovation and Technology Incubator: A$50 million commitment.
- Hydrogen Ready Power Generators: A$24.9 million in funding to enable hydrogen capable gas power generators.
Australia well placed as an H2 energy exporter

### Study | Renewable Exporter | Renewable Importer
--- | --- | ---
Harvard Belfer Centre (2020) & Australia, Morocco, Western Sahara, Norway, United States, Canada, Mexico | North Western Europe, Korea, Japan, Southeast Asian Countries
Hydrogen Council (2021) & Australia, China, India, Saudi Arabia, South Africa, Iran, Turkey, Norway, Spain, Portugal, US, Chile | All Southeast Asian Countries, Russia, North-western and central European States.
Wood Mackenzie (2019) & Australia | Japan and Germany
ACIL Allen (2018) & Australia, Middle East, North African countries, and United States. | China, Japan, Korea, Singapore
ERIA (2018) & United States, North African Countries, Middle East | China, Singapore, Korea, and Japan
IEA (2018) & United States, Australia, Africa, Middle East, Chile | Japan, Europe
IRENA (2021) & Brazil, Norway, Australia, Chile, Sub Sahara, Middle East | Europe, China, Southeast Asia
Carbon Tracker (2021) & Namibia, Botswana, Ethiopia and most of South America, Northern Africa, Middle East, Australia | Singapore, Belgium, Germany, Netherlands, South Korea, Taiwan, Switzerland, Japan, Poland, Italy
HySupply analysis & Australia, Middle East, Northern Africa, Western South America, United States | Europe.

**ANU work reported in www.reneweconomy.com.au**
The backbone of this green hydrogen export value-chain is the sourcing of low-cost renewable energy. Preliminary modelling was completed to map out the capacity factor and average renewable energy generation potential for each state in Australia.

The preliminary electricity model was used to calculate an estimated levelised cost of hydrogen for each state. This modelling provides a high-level overview of how location and renewable generation source, underpins the economics of hydrogen production in Australia. Parameters affecting production costs were explored.

A preliminary investigation was performed to determine the most viable medium for hydrogen storage and transportation. The key hydrogen carriers that were investigated in this analysis include: ammonia, methanol, methane, liquified hydrogen and liquid organic hydrogen carriers (LOHCs). These carriers were selected as they provide varying degrees of benefit to store and transport hydrogen. A multi-criteria analysis (MCA) was used to compare the hydrogen carriers across broad range of socio-economic criteria, to provide a perspective to stakeholders on which options are the most viable.

Preliminary modelling based on literature was performed to provide an indicative guide for the shipping costs for each of implementation scenario. The foundational analysis from this chapter will form the basis for a more detailed value-chain model downstream.

The findings from the MCA were used to create three potential implementation scenarios for this export value chain. The scenarios expand on the key learnings and provide a current status of costs across the value chain, to present a few implementation scenarios considering Australia and Germany’s key technological, commercial and infrastructure capabilities and demands.
Becoming modesty required for all assessments

Hot commodities
Commodity prices, January 1st 2020=100

Getting to zero
The first big energy shock of the green era
There are grave problems with the transition to clean energy power

Making sense of the chaos in commodity markets
The 2000s were about the supercycle. The 2020s are about supermayhem
Breakdown of Cost Components in LCO2

Power Plant Operations

Electrolyzer Parameters

Operating Cost (OPEX)
- Electricity Costs
- Water Costs
- Maintenance
- Operational Costs

Available Power (MWh)
- Capacity Optimization
- Renewable Energy Supply

Levelized Cost Framework
- H2 Generated (kg)
- Cost of Power and Fuel
- Contingencies
- Engineering and services
- Site Preparation
- Capital Cost (CAPEX)
- Direct Costs
- Cost of Import and Shipping

Capital Cost Breakdown

Indirect Cost Breakdown

Total Indirect Cost: $-$
State of Play report findings, and associated open-source value-chain models

Hourly resolution renewables + electrolyser modelling required to properly assess processes, conversion systems, buffer storage needs and firmed energy requirements
Green H2 production costs

Location matters

Cost reductions needed
• Renewables costs down, CF up
• Electrolysers costs down, efficiency up
• Improved integration (CF optimisation) for both off-grid and NEM / SWIS / DKIS projects
• Low cost (de-risked) finance

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<th>Proponent</th>
<th>Target/projection /Scenario</th>
<th>Price range/kg&lt;sub&gt;out&lt;/sub&gt;</th>
<th>Adjusted to AS$/kg&lt;sub&gt;out&lt;/sub&gt;</th>
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<td>(US $1.40 in optimal locations)</td>
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<td>Hydrogen: A Renewable Energy Perspective, 2019&lt;sup&gt;16&lt;/sup&gt;</td>
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<td>Bloomberg</td>
<td>Projections</td>
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<td>BNEF: Hydrogen Economy Outlook, 2020&lt;sup&gt;20&lt;/sup&gt;</td>
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Consider multiple possible pathways.
Preliminary modelling: open-source models coming...
Shipping hydrogen

- Advantages for hydrogen production near point of use
- Pipelines the lowest cost, albeit less flexible, option for distances up to thousands of km, subject to route constraints
- However, shipping delivers 80% of global trade, flexible, low cost.... and needs clean fuels

Figure 23: LNG Shipping Density Map for 2019[376]

Figure 5: Shipped tonnage and average price ranges for some key traded commodities. Note that the price indications are spot price ranges over 2018-2020 and shipped tonnages from 2019. For hydrogen trade, prices of around US$1.50 – 2.50/kg would translate to ~US$1,500-2,500/ton, representing a relatively high value commodity while traded volumes in various 2050 scenarios would likely be well below the shipped tonnage of some existing commodities.
Preliminary findings (open-source tool coming)
HySupply Australia Preliminary Roadmapping Process

The roadmapping process will feature three key stages: planning, consultation and synthesis.

### Planning

**Knowledge Base Development**
Leverage the learnings from the COAG National Hydrogen Strategy (NHS), CSIRO National Hydrogen Roadmap (NHR) and HySupply State of Play (SoP)

**Stakeholder Identification**
The hydrogen/hydrogen-derivatives value-chain was mapped out, to identify the key stakeholders to draw insights from.

### Consultation

**Stakeholder Consultation**
Up to 50 stakeholders will be consulted for the Preliminary Unilateral Roadmapping phase. These stakeholders will be consulted to draw out the key implementation, technology, export, social license, policy, regulatory and workforce related barriers and opportunities for Australia.

**Consultation Findings**
The key insights from the consultations will be translated into a ‘stakeholder findings pack’.

### Synthesis

**Preliminary Unilateral Roadmapping Summary Paper**
- Builds on the actions from the NHS, NHR and SoP
- Highlights the key barriers and opportunities for Australia in developing a hydrogen/hydrogen-derivatives export value chain.
- Provides a framework for realising these export opportunities for Australia in the form of potential short-, medium- and long-term next steps.
Next steps for HySupply

Release of State of Play report for consultation

Rolling release of open source models

Preliminary roadmapping with Deloitte
Much to be optimistic about... but much more to be done

Questions, comments, suggestions all welcome
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