NERA NATIONAL ENERGY RESOURCES AUSTRALIA

Creating connections for growth

Maximising the benefits of Ammonia Energy Exports through the development of Regional Technology Clusters

The 2nd Ammonia = Hydrogen 2.0 Conference

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NERA's Vision

Australia as a global energy powerhouse:
a sought-after destination for investment and the leading source of knowledge and solutions.

NERA's Focus: **Australia's Energy Resources Future is Smart Technology Led**: High Productivity, Globally Competitive & Low Carbon

OPTIMISE TODAY

- Asset performance: ops & maintenance
- Data-driven opportunities
- Industry-led R&D
- Innovation with supply chains
- Tech Clusters
- Emerging cross industry sector partnerships

- AI health check
- Organisational culture supports experimentation, adaptation and change
- Pilots and scale
- Remote operations opportunity
- Growing data insights

ADAPT FOR TOMORROW

- Low carbon
- Interoperability
- Agile and adaptive skills strategies
- Focus on leading data scientists in multi functional teams
- Cross industry supply chains in global markets

TRANSFORM THE FUTURE

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Growing Australia's Energy Sector

Australia has strategic advantages in:

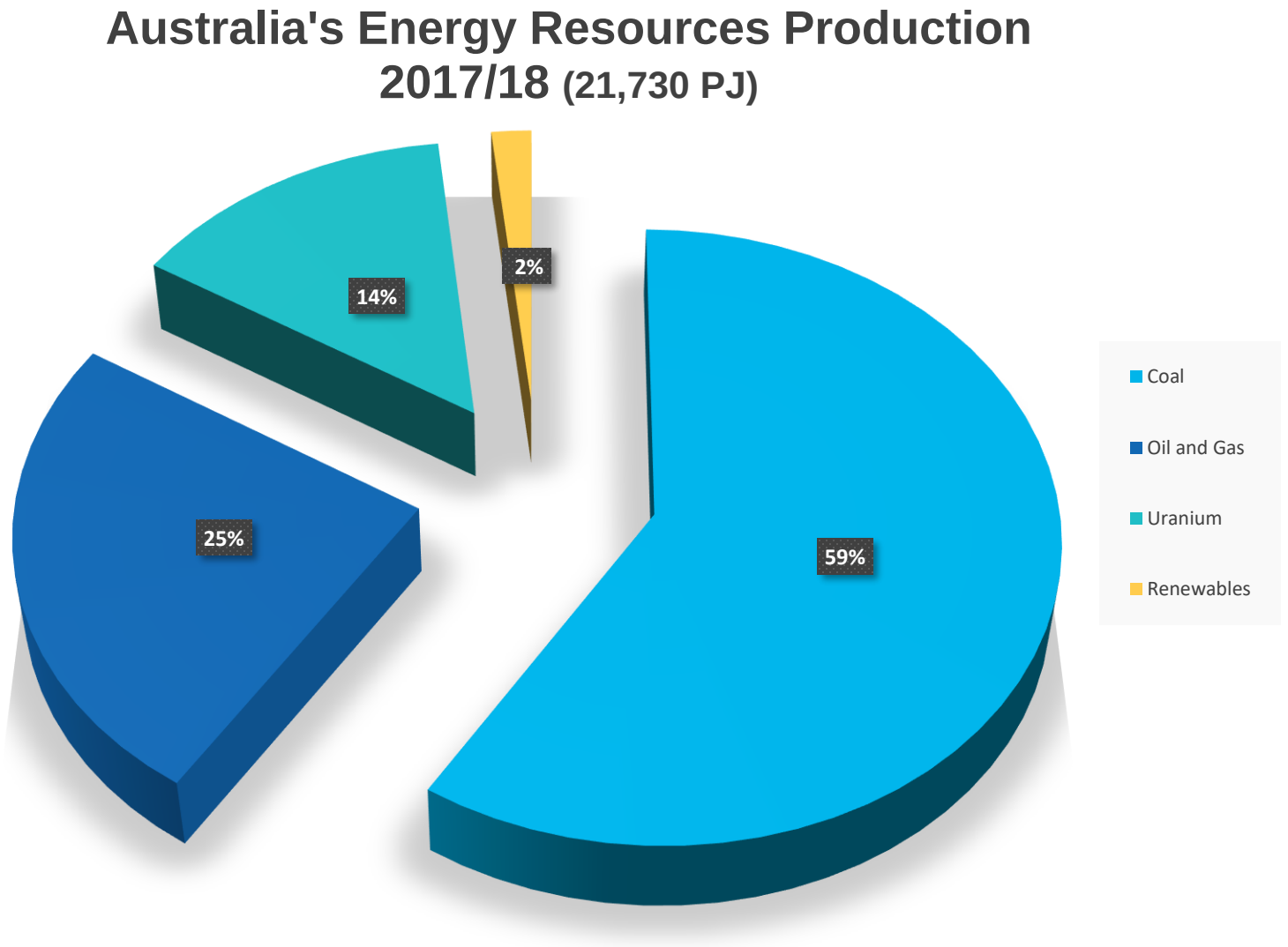
- Coal, natural gas, uranium, CCS
- Renewables (biofuels, waste to energy, wind, solar, wave, tidal)
- Ammonia and Hydrogen
- Battery minerals
- Generation, storage, transmission and distribution
- Energy technologies and services

Global primary energy demand to increase by 25% between 2017 and 2040 (International Energy Agency)

Australia's Energy Resources Production

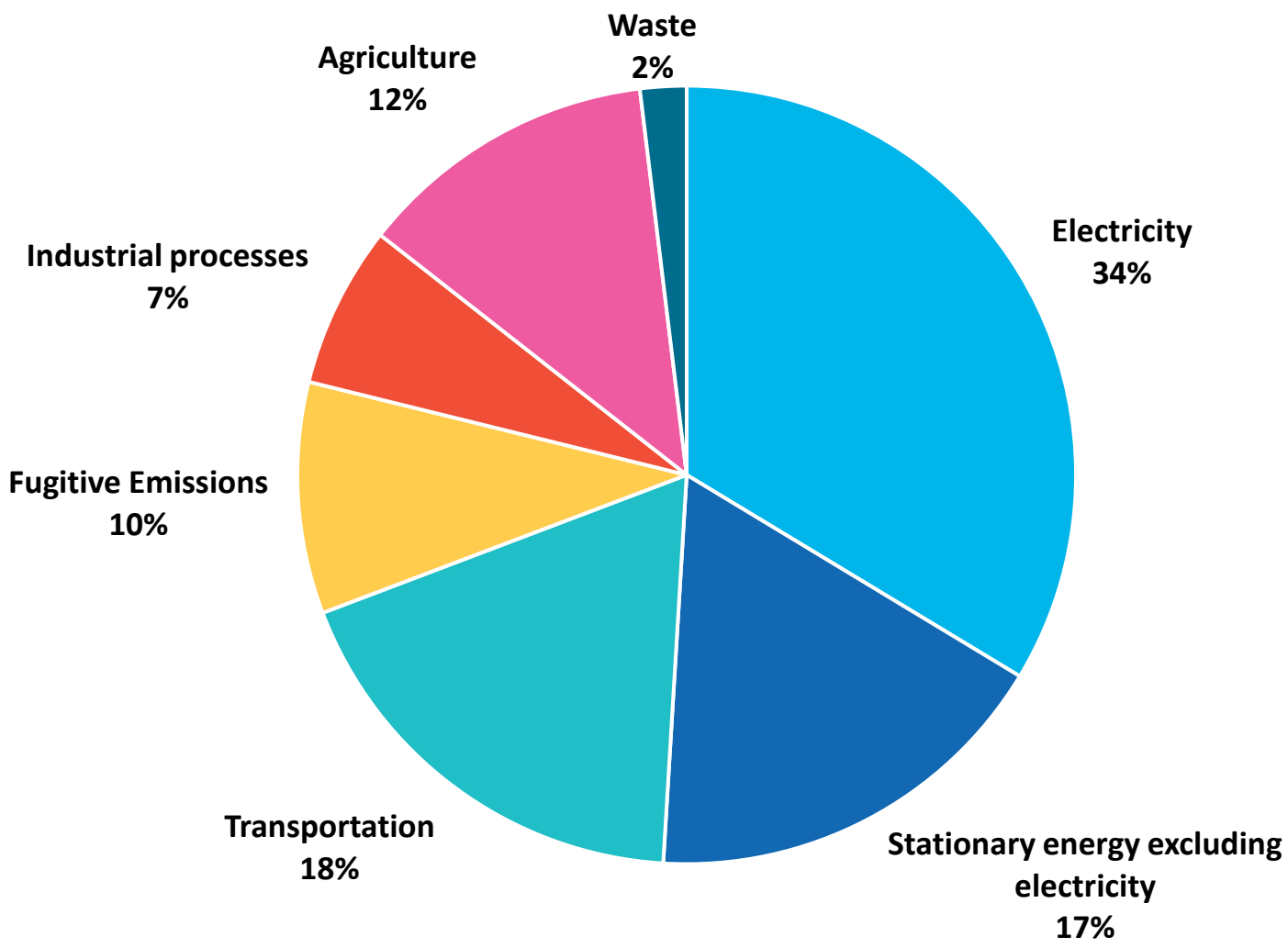
Australia is a global energy economy, exporting more than two-thirds of annual production:

- largest exporter of LNG
- 2nd largest exporter of coal
- largest known uranium deposits
- renewables, virtually untapped



https://www.energy.gov.au/sites/default/files/australian_energy_statistics_2019_energy_update_report_september.pdf

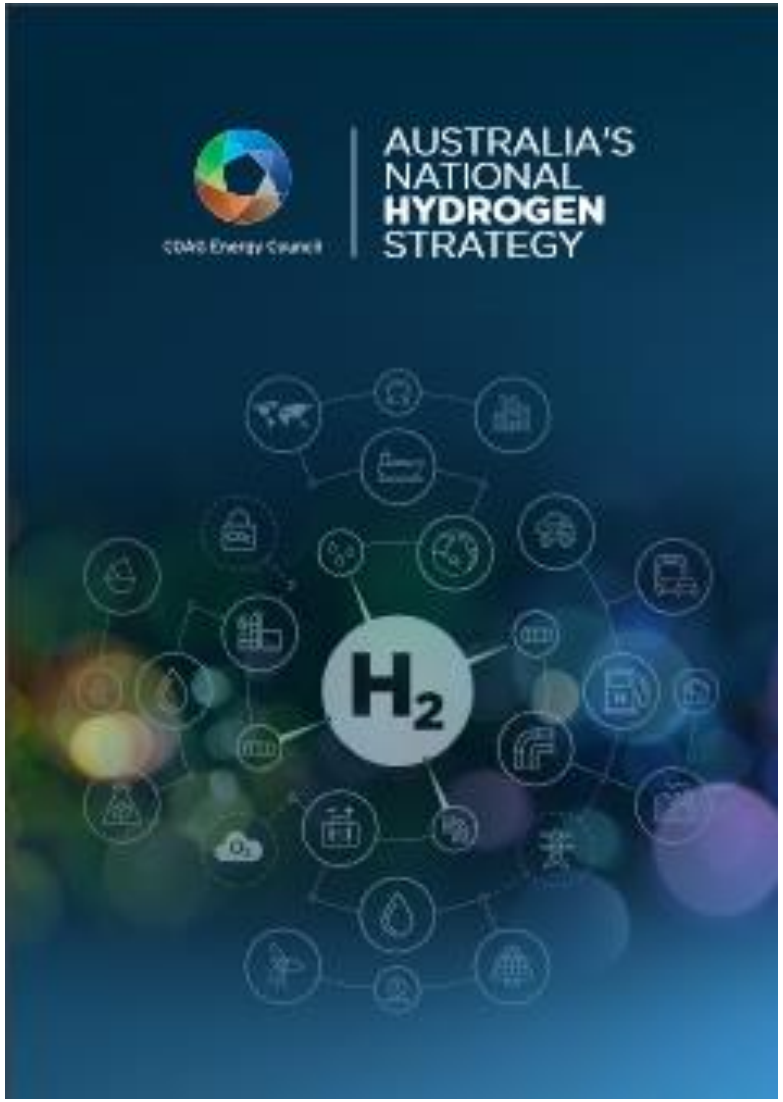
Australian Greenhouse Gas Emissions by Source



Note: Land use, land use change, and forestry (LULUCF) is -4% of annual GHG emissions (more emissions absorbed than generated)

https://www.climatecouncil.org.au/wp-content/uploads/2018/06/CC_MVSA0143-Briefing-Paper-Australias-Rising-Emissions_V8-FA_Low-Res_Single-Pages3.pdf

"The Ammonia Advantage"



The ammonia advantage

The single biggest current use for hydrogen globally and in Australia is for making the chemical ammonia. Ammonia production could be a key driver in creating a clean hydrogen industry.

Ammonia, comprised of hydrogen and nitrogen, has been used in industrial applications for more than a century. Its major uses are in fertiliser, explosives and production of plastics, textiles, pesticides, dyes and other chemicals. Although ammonia is toxic in its concentrated form, industry has a good safety record in handling, storing and transporting it.

Globally, more than half of hydrogen produced goes to making ammonia.[4] In Australia, it is almost three-quarters, amounting to more than 350,000 tonnes of hydrogen a year. As typically occurs elsewhere around the world, that hydrogen is currently made using natural gas without CCS.

Ammonia made from clean hydrogen provides an opportunity for Australia to jump-start large-scale production of clean hydrogen for other uses.

Not only is potential global demand for ammonia produced from clean hydrogen a future export market in itself, ammonia is also an immediately available carrier to export clean hydrogen. There are currently no commercially available ships to transport liquefied hydrogen, but ammonia is already commonly transported in tankers. It can be used as a carrier of hydrogen (just as hydrogen is a carrier of energy). It is easier to transport and store, can be used as a fuel and can be separated back to hydrogen and nitrogen when needed.

While it does take energy to turn hydrogen to ammonia and back again, CSIRO has developed a game changing technology that makes extracting hydrogen from ammonia much easier.

Given its potential as a cost-effective low carbon energy source, there is growing consideration of using ammonia (produced with clean hydrogen) directly as a fuel.

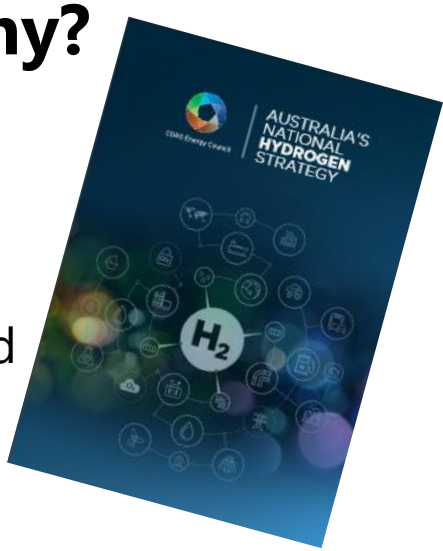
Because of its toxicity, it is likely using ammonia for fuel will be limited to large-scale industrial activities. Applications being explored include its direct use as fuel for ships, burning it alongside coal in existing coal-fired power stations and directly using it in fuel cells for electricity generation. These and other new uses for ammonia made from clean hydrogen could provide significant future growth for ammonia in an otherwise relatively mature industry.

https://www.industry.gov.au/data-and-publications/australias-national-hydrogen-strategy

National Energy Resources Australia is supporting the establishment of a National Hydrogen Industry Cluster that will drive economic opportunities for SMEs and build the capability needed to establish Australia as a world leader in the hydrogen value chain

National Hydrogen Industry Cluster – Why?

The National Hydrogen Strategy includes NERA leading the establishment of a National Hydrogen Industry Cluster to connect and align Australia's efforts and **support the preparedness of the supply chain** to unlock this broad-based economic value for Australia.



- **National network of regional technology clusters supporting regional hubs and supply chain/technology solution businesses**
- Innovation, collaboration and high impact R&D
- **More cost effective technology and infrastructure development**
- Accelerated supply chain and skills development
- **Efficiencies, economies of scale and remove duplication of effort**
- Sector coupling and circular economies

Clusters can help Australia get there

- Globally successful approach to scaling smart supply chains.
- Focus on innovation, value and productivity driving down costs rather than just a 'cheap' cost focus first.
- Formed by a group of firms that are operating in the same industry sectors and value/supply chains – this can include cross sector coupling such as the hydrogen opportunity.
- Market/demand driven and industry led (not research led).
- Technologies and solutions orientated.
- Encourage collaboration but also competition.
- Drive faster skills and knowledge transfer across firms and sectors – this is vital for success in the digital age.
- Encourage novel ways of combining innovation and technology solutions.
- Flexible and adaptive business model – again essential for a rapidly changing economic and technological environment.
- Ultimate goal is collective marketing to global markets (Norwegian experience).

Clusters Matter

Trends in European clusters: results from the 2019 European panorama, trends and priority sectors reports published – December 2019

13.5%
Higher average wage

+0.7%
Higher annual wage growth rate

+0.5%
Higher annual employment growth rate

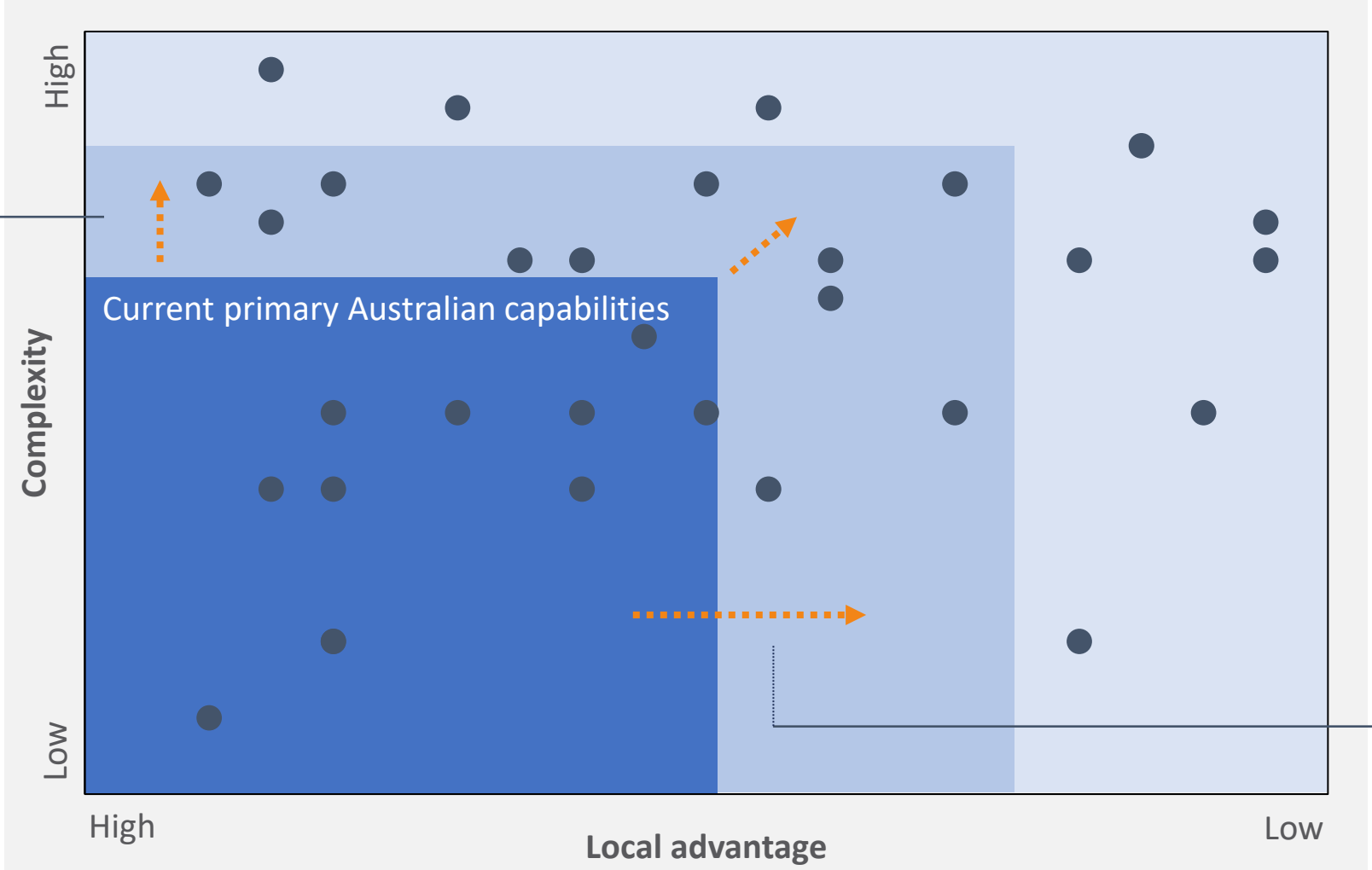
143%
More global frontier firms

77%
More high-growth firms

141%
More rapidly growing start-ups

A cluster can extend supply chain capabilities to those with higher value add and greater exportability

Extending capabilities up the complexity chain can enable Australian suppliers to capture higher value activities that match Australia's high cost profile.



Extending to areas of lower local advantage would enable Australian suppliers to develop capabilities that are exportable.

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Leading the formation of a National Hydrogen Industry Technology Cluster

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- **Process**: NERA held a series of workshops with more than 240 professionals across the Australian hydrogen industry value chain in Feb–Mar 2020.
- **Purpose**: To understand key barriers and enablers for the hydrogen industry, identify opportunities for industry collaboration and to define the scope of a national hydrogen cluster.
- **Findings**: Feedback highlighted a currently fragmented national hydrogen landscape and an overwhelming desire to connect, share information and collaborate to address major technology and market challenges.
- **Outcomes**: NERA has built momentum and interest in the formation of a national cluster and refined scope.
- **Next steps**: NERA is working on supporting regional technology clusters of H2 technology businesses (scale-ups and SMEs) to form part of a National Hydrogen Cluster Network.

11 workshops

11 cities

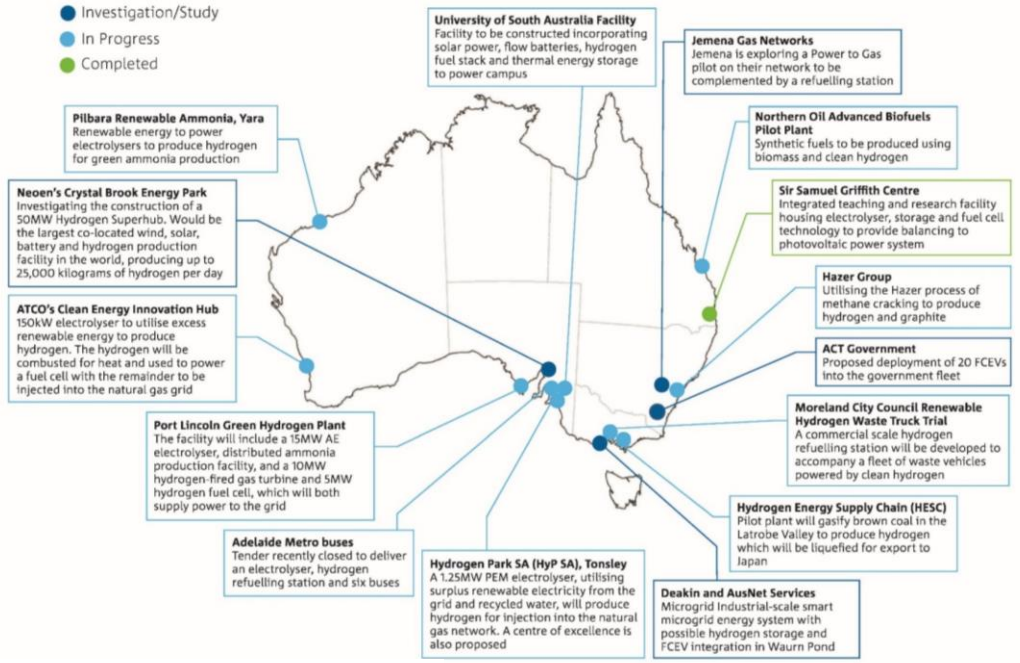
+240 stakeholders

Regionally Distributed Opportunities

Table 6. Potential Hydrogen Export Locations (Listed alphabetically)

STATE / TERRITORY	POTENTIAL SITE
New South Wales	Newcastle (Kooragang Island suggested), Port Botany / Kurnell, Port Kembla
Northern Territories	Darwin (Middle Arm suggested), Gove (near town of Nhulunbuy)
Queensland	Abbot Point, Brisbane (Bulwer, Gibson Island suggested), Bundaberg, Gladstone, Karumba, Port Alma, Townsville, Weipa
South Australia	Myponie Point, Port Adelaide, Port Augusta, Port Bonython, Port Giles, Port Lincoln / Cape Hardy, Port Pirie, Whyalla
Tasmania	Bell Bay, Hobart
Victoria	Altona, Port Anthony, Port of Hastings, Port of Melbourne, Port of Geelong, Portland
Western Australia	Ashburton / Onslow, Albany, Dampier, Geraldton, Oakajee, Port Hedland

Arup for COAG Energy Council Hydrogen Working Group, Issue 2, Australian Hydrogen Hubs Study, November 2019



* Bruce S, Temminghoff M, Hayward J, Schmidt E, Munnings C, Palfreyman D, Hartley P (2018) National Hydrogen Roadmap. CSIRO, Australia.

Ammonia Value Chain – Cross Sector Supply Chains

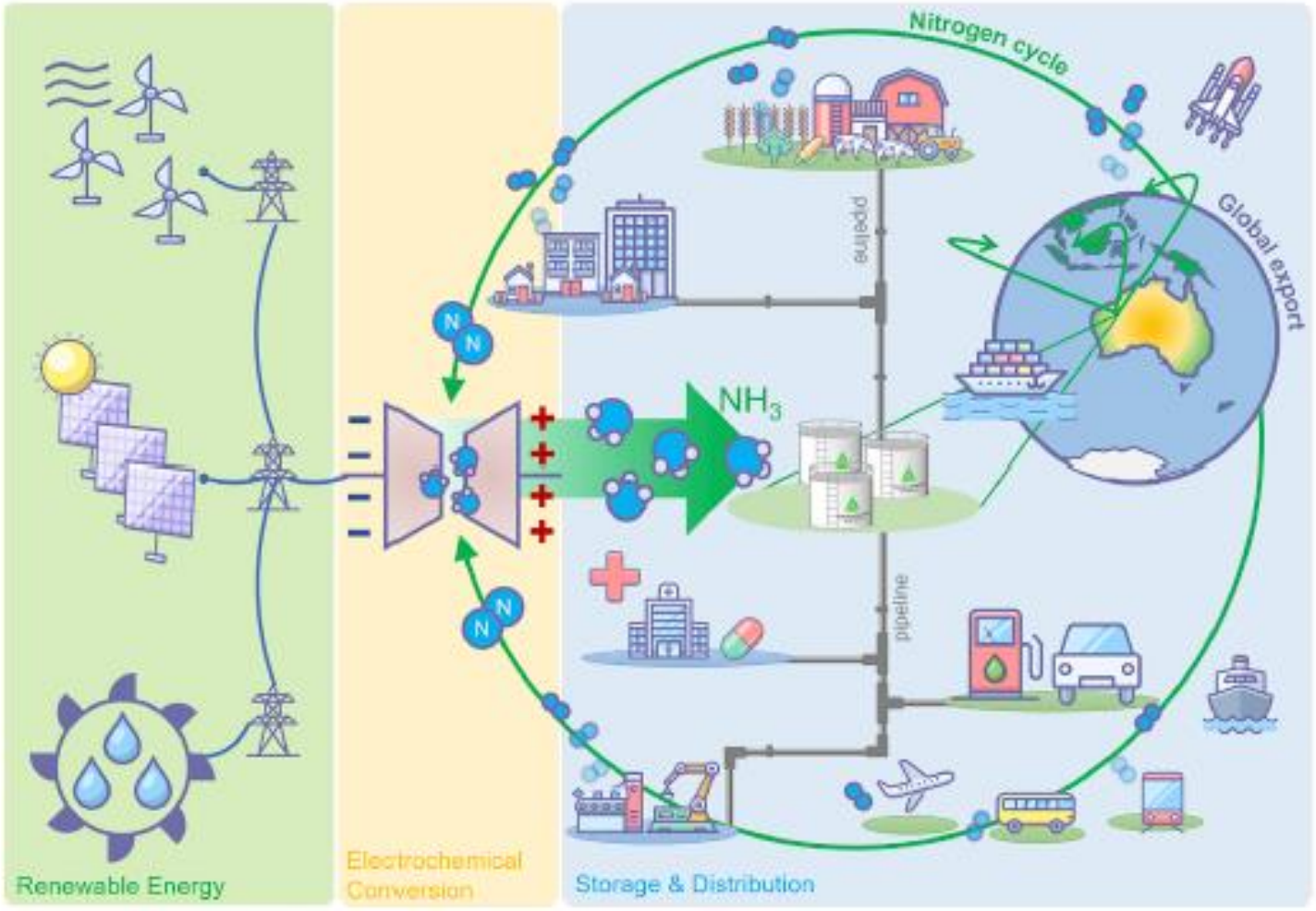


Figure 1. Vision of the "Ammonia Economy" in which the Energy Sources and Uses Are All Based on Ammonia

MacFarlane et al., A Roadmap to the Ammonia Economy, Joule (2020), https://doi.org/10.1016/j.joule.2020.04.004

Growing Australia's Oil & Gas Supply Chain Report

- Australia's domestic oil & gas supply chain **is not reaching its full potential** relative to the scale and value of the production industry.
- NERA's *Supply Chain* Report analyses the size and composition of the domestic supply chain, its challenges, its economic potential and its opportunities for growth.
- The Report shows that if growth challenges are addressed, **Australia's oil & gas suppliers could capture an additional $7 billion of value (GVA) by 2030, generating up to $49 billion to the economy.**

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Industry Growth Centres