Accelerating Australia's Hydrogen Industry

Dr. Patrick Hartley
CSIRO Hydrogen Industry Mission
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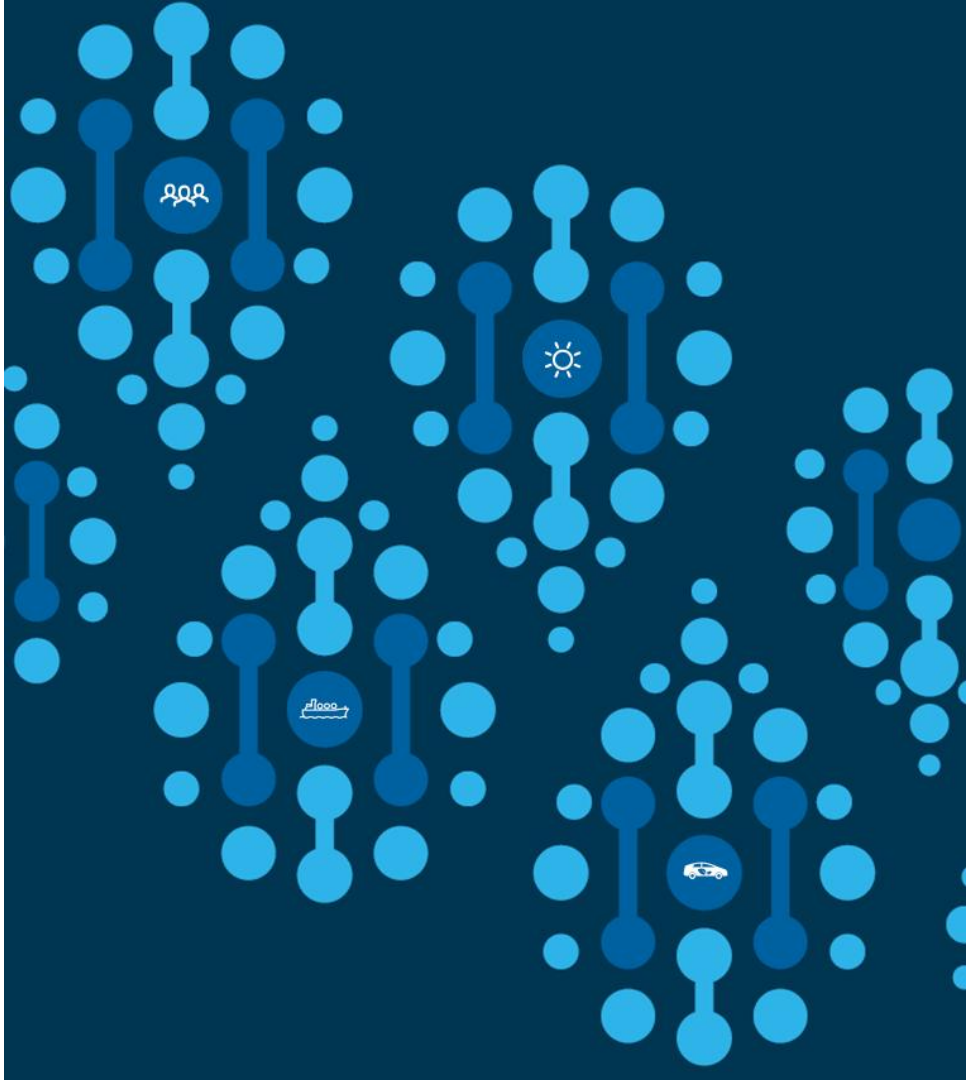


Who we are

Australia’s national science agency

One of the world’s largest multidisciplinary science and technology organisations

6,300+ dedicated people working across 51 sites in Australia and globally

State-of-the-art national research infrastructure

We delivered $10.2 billion of benefit to the nation in 2022

Challenge Driven Science at CSIRO

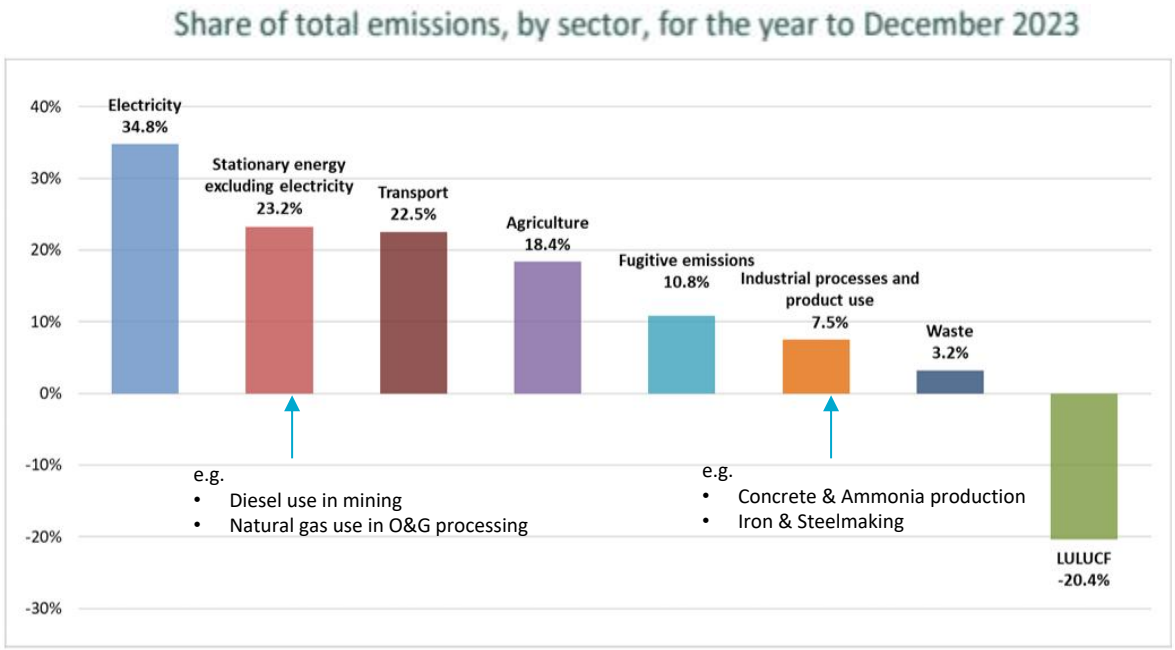
Health and wellbeing	Food security and quality	Secure Australia and region	Resilient and valuable environments	Sustainable energy and resources	Future industries
Enhance the health of Australians through preventative, personalised, biomedical, and digital health services.	Achieve sustainable security through new AgriFood products, technology and innovation for Australia.	Help safeguard Australia from threats (terrorism, regional instability, pandemics, biosecurity, disasters, and cyber-attacks).	Enhancing the resilience, sustainable use, and value of our natural and built environments, including by mitigating and adapting to the impacts of climate and global change.	Build competitiveness, sustainability and security, nationally and regionally, of our energy and minerals systems and resources while lowering emissions to Net Zero.	Help create Australia's future industries and jobs by collaborating to boost innovation performance and promote Science, Technology, Engineering and Math (STEM) skills.
• Supporting healthier lives • Preparing for, and prevention against, infectious diseases • Enabling transformation of the health care system • Advancing manufactured products and technologies to support health	• Agricultural productivity • High value foods • Trusted value chains • Sustainable farm systems	• Biosecurity • Defence and security • Sovereign resilience	• Climate resilience • Water security • Healthy ecosystems and biodiversity	• Electricity transition • Industry and transport decarbonisation • Unlock resources for a sustainable future	• Future manufacturing • Future digital industries • Circular economy • Innovation services

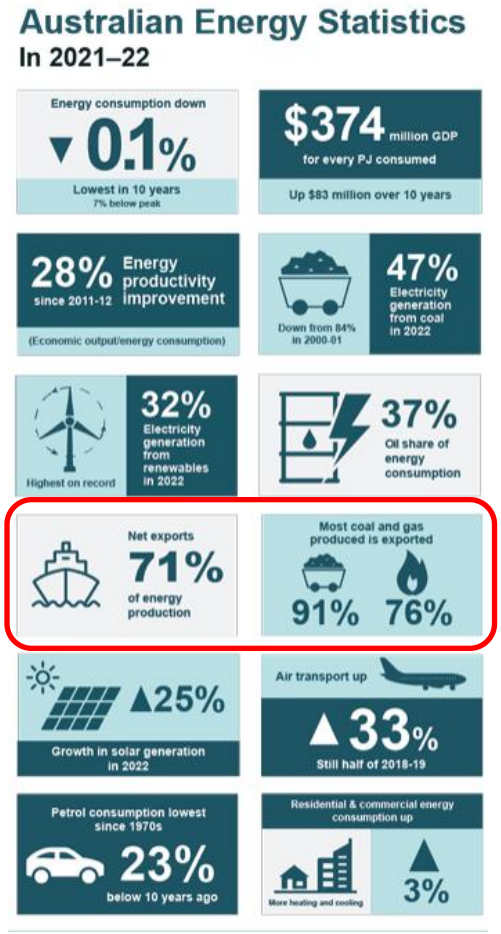
Missions Program

• Infectious Disease Resilience • Minimising Antimicrobial Resistence	• Trusted Agrifood Exports • Future Protein	• Catalysing Australia's Biosecurity • Critical Infrastructure Protection & Resilience	• Drought Resilience • Aquawatch Australia	• Hydrogen Industry • Towards Net Zero • Smart Energy	• Ending Plastic Waste

We are accelerating investment in future revolutionary science and technology including: Artificial Intelligence (AI) – Machine Learning (ML) | Space technologies | Understanding the universe | Quantum technologies | New materials

Australia's Greenhouse Gas Emissions

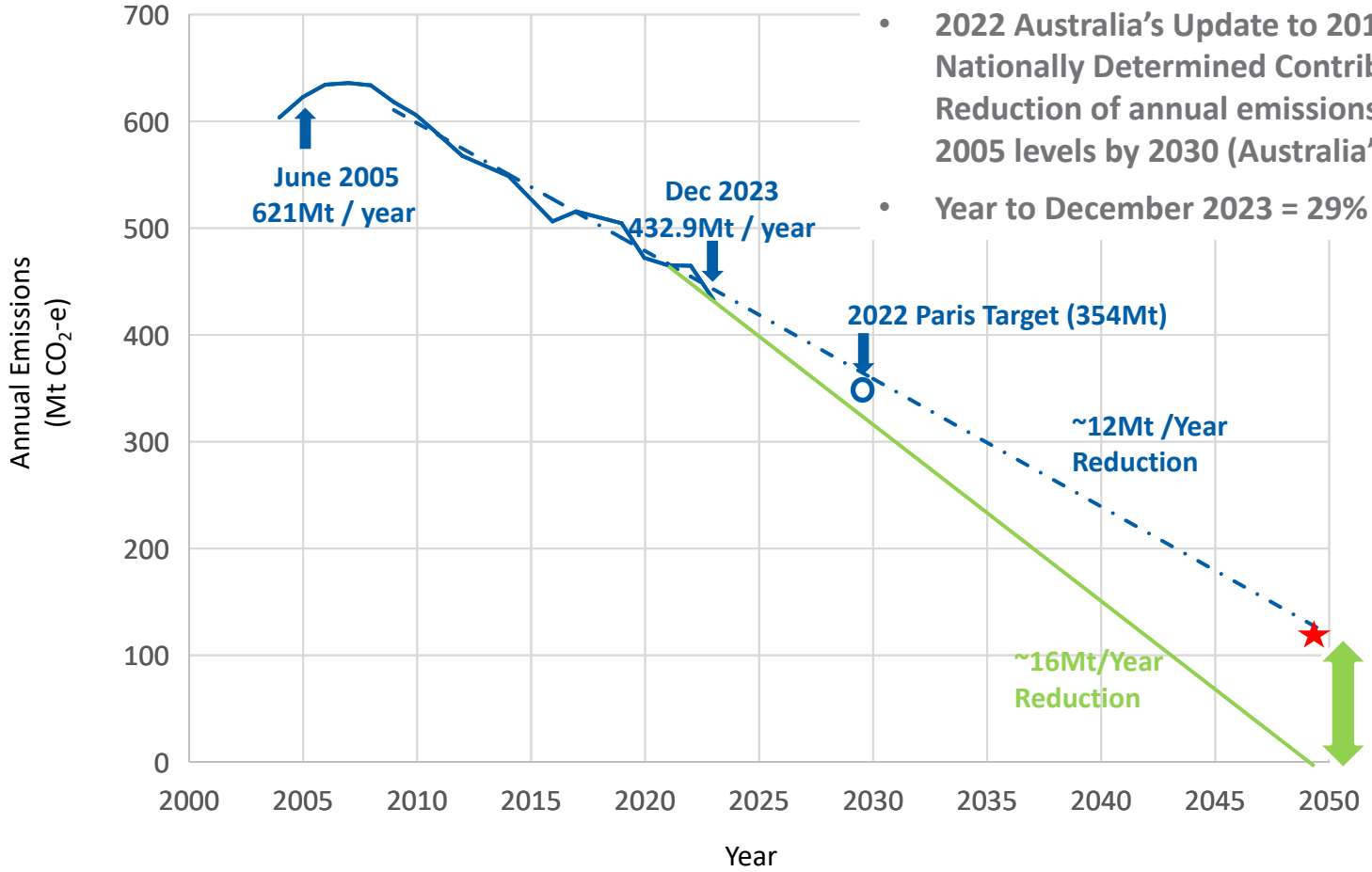




Key Message: There is more to emissions reduction than decarbonising our electricity and transport systems !

https://www.dcceew.gov.au/sites/default/files/documents/nggi-quarterly-update-dec-2023.pdf

Australia's Greenhouse Gas Emissions

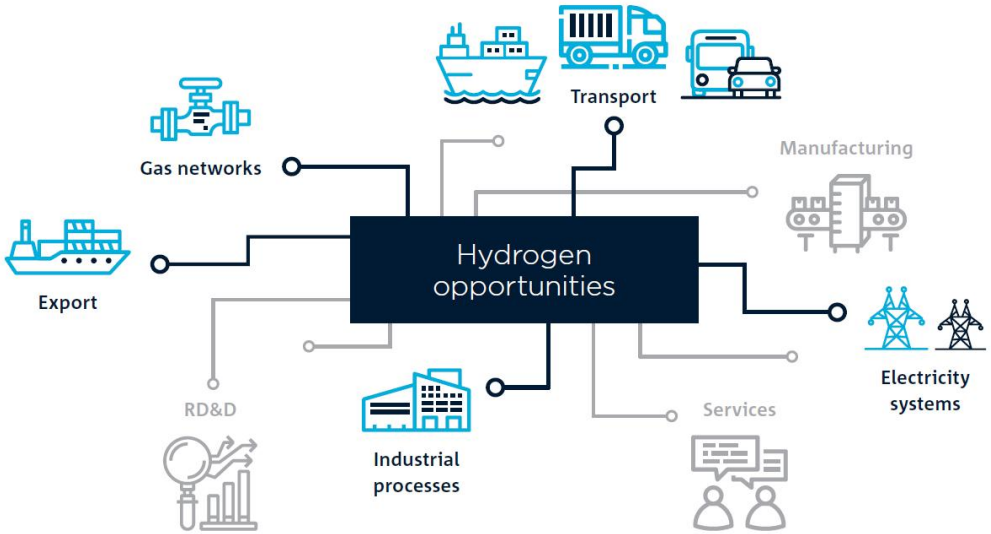


- 2022 Australia's Update to 2015 Paris Agreement Nationally Determined Contribution (NDC): Reduction of annual emissions to 43% below June 2005 levels by 2030 (Australia's original target 26%)
- Year to December 2023 = 29% below 2005

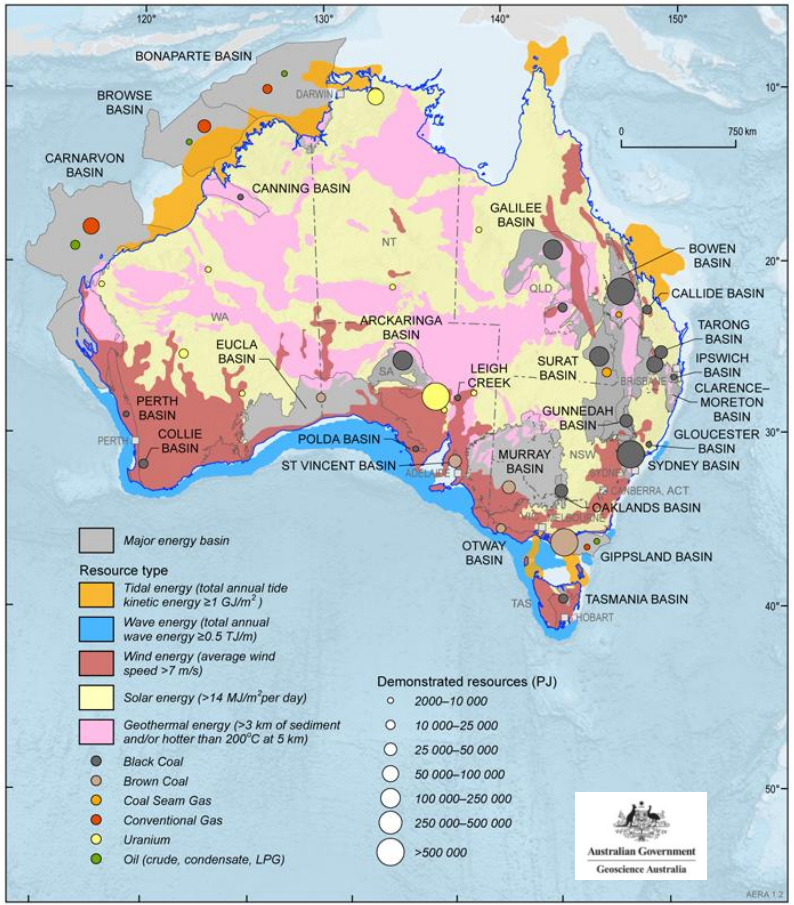
New science & technology (eg hydrogen) is needed to bridge this gap

https://www.dcceew.gov.au/sites/default/files/documents/nggi-quarterly-update-dec-2023.pdf

Why Hydrogen for Australia?



- **Hydrogen plays a key role in decarbonising and coupling diverse energy & feedstock value chains.**
- **Establishing an Australian hydrogen industry offers additional opportunities in associated sectors**



- **Australia has abundant resources for producing hydrogen**

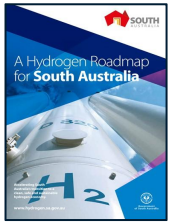
I: Australia’s Hydrogen Industry: Policy & Progress

Australia's National Hydrogen Strategy Development

Council of Australian Governments (COAG) Energy Council Joint Ministerial Statement (December 2018):

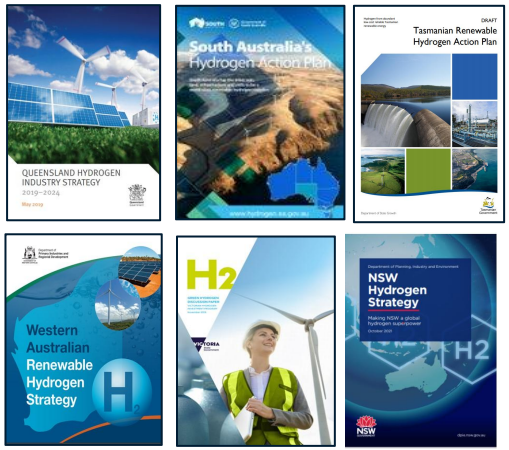
"We commit to working together to develop and implement a national strategy for hydrogen, in close consultation with industry and the community"

Alignment of State, Territory & Federal Government Strategies

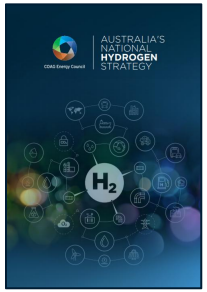


SA Hydrogen Roadmap (2017)

Scene Setting Reports (2018)



2019-2023 State & Territory Hydrogen Strategies



November 2019 National Hydrogen Strategy – **2024 Refresh Imminent**

Strategy Focus:

- Market barriers
- Build supply and demand
- Global cost-competitiveness
- Domestic and export value chains by 2030

Government Investments: Hydrogen Project Support

February 2018: South Australia Hydrogen Project Funding
- $17m grants & $25m loans program

April 2018: Victoria / Aust. Government / Japan Consortium
- $500m Hydrogen Energy Supply Chain Project

September 2018: Australian Renewable Energy Agency (ARENA)
- $22.1m funding for 16 hydrogen research projects

August 2019: Queensland Hydrogen Industry Development Fund
- $15m to support hydrogen industry projects

March 2020: Tasmania Renewable Hydrogen Action Plan
- $20m Renewable Hydrogen Fund

April 2020: ARENA Hydrogen Deployment Fund
- $70m towards large scale renewable hydrogen projects (electrolysis >10MW)

May 2020: Clean Energy Finance Corporation (CEFC)
- $300m debt & equity Advancing Hydrogen Fund

August 2020: Western Australia Renewable Hydrogen Fund
- $22m to fuel WA's renewable hydrogen industry

September 2020: Federal Govt Low Emissions Technology Statement

Commonwealth, State & Territory Government Hydrogen Investments

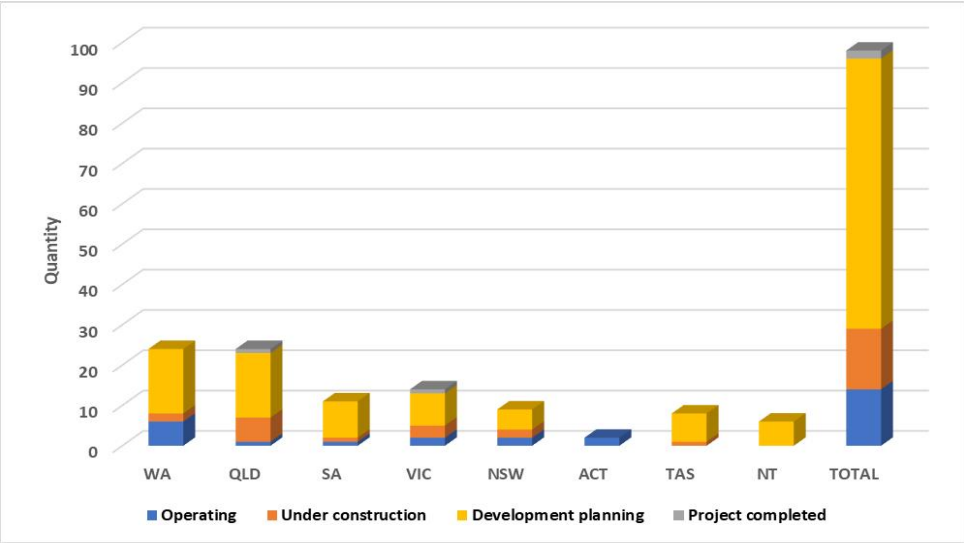
2023	Hydrogen specific support ($AUD)	Hydrogen eligible support ($AUD)
Commonwealth	$ 3.6 billion	$ 27.1 billion
States & Territories	$ 4.7 billion	$ 8.3 billion
Total	$ **$8.3 billion**	$ **$35.4 billion**

2024	Hydrogen specific support ($AUD)	Hydrogen eligible support ($AUD)
Commonwealth	$ 12.4 billion	$ 29.4 billion
States & Territories	$ 5.1 billion	$ 13.4 billion
Total	$ **$17.5 billion**	$ **$42.8 billion**

(AU $1 bn = US $670m = INR 5600 cr)

Australia's Hydrogen Industry Snapshot – September 2024

- Majority of the ~ 100 active industry projects are 'Under Development', with slow progress to 'Under Construction'. Most leading projects supported ~50% by government programs (e.g. Hubs, ARENA)
- Renewables-based projects dominate
- All major hydrogen end use opportunities represented.



https://research.csiro.au/hyresource/
https://www.csiro.au/hydrogen-map

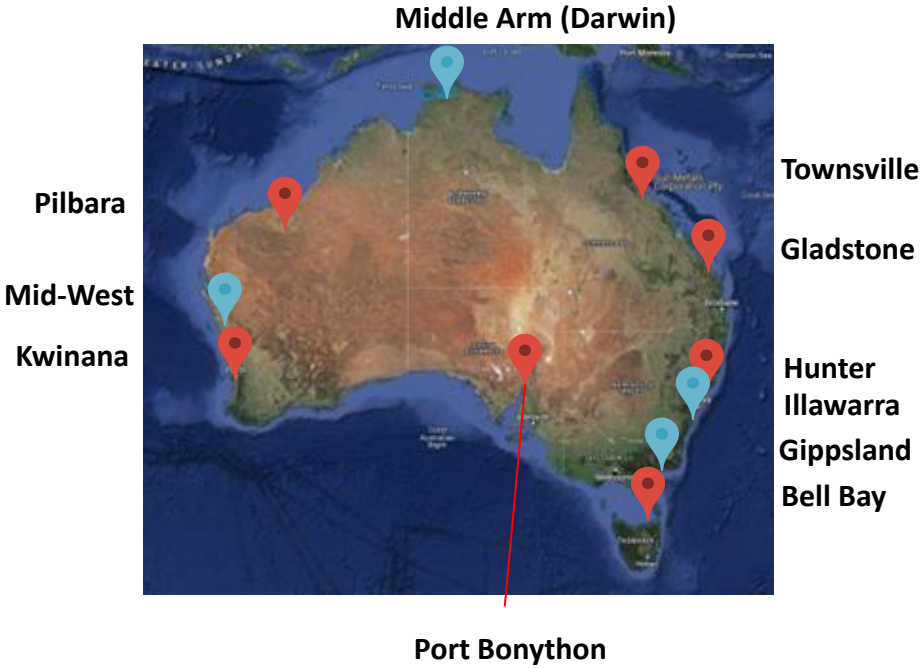
2023 State & Federal Government Policies: Hydrogen Hubs

Federal Government Regional Hydrogen Hubs Program

- $500m Federal Govt Investment via Australian Renewable Energy Agency (ARENA)
- Leverage existing capabilities, infrastructure and resources to aggregate supply and demand opportunities, share infrastructure, and realize economies of scale
- Most include hydrogen export opportunities (eg port) & domestic applications
- Approx $70m Funding x 7 Hubs Announced in Mid 2023

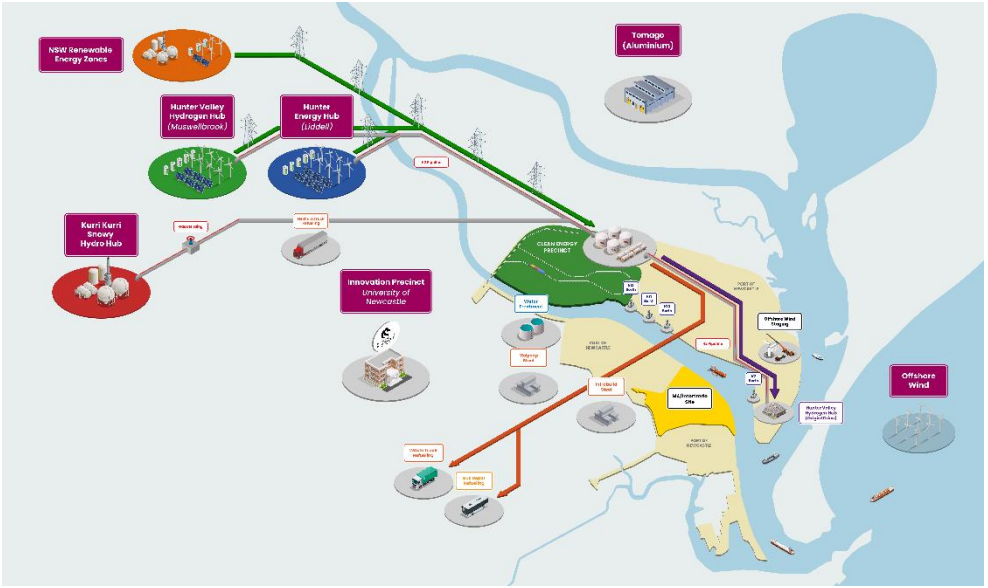
Additional Potential / State Government Supported Hubs

- Funded via other federal / state programs



Selecting Hydrogen Hubs: Key Considerations

Category	Considerations
General H_2 Production Considerations	Levelised cost of Hydrogen production
	Supportive State / Federal Government strategies
	Domestic H_2 offtake potential and large scale (eg industrial) use cases
	H_2 storage & distribution potential
	Planned / Existing H_2 projects and demonstrations
Green H_2 Specific Considerations	Availability of Grid infrastructure
	Renewable Energy inputs for green H_2 eg Large scale (GW+) renewable energy projects
	Water Resources
Supporting ecosystem	Port infrastructure for export projects
	Social and regulatory environment

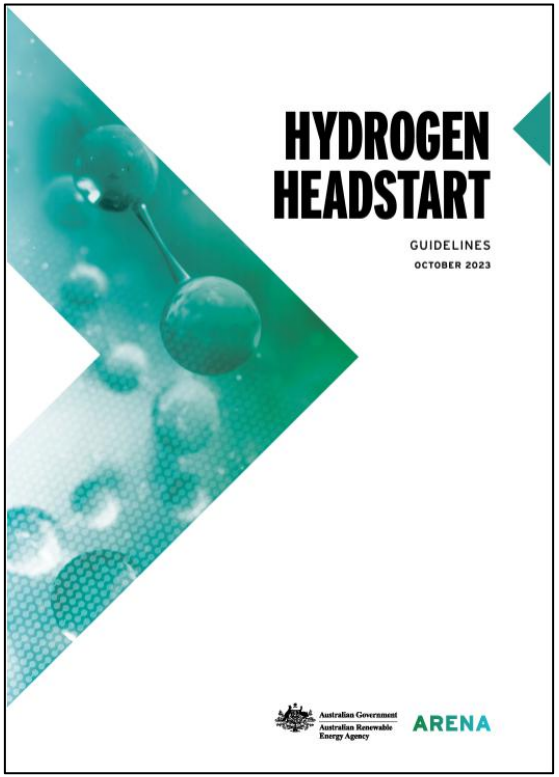


Port of Newcastle Hydrogen Hub

2023 Federal Government Hydrogen Headstart Program

Hydrogen Headstart Program

- $2bn Federal Govt Investment via Australian Renewable Energy Agency (ARENA) Competitive Program
- >50MW Electrolysis projects, 100% renewable electricity only
- Provides a Production Credit (in the form of a 10 year grant) aimed at bridging commercial gaps to encourage hydrogen use
- 6 shortlisted applicants, 4 associated with Hydrogen hubs



Hydrogen Headstart Program: Shortlisted Applicants (December 2023)

Applicant	Project	End Use	Electrolyser Size (MW)	State
Bp Low Carbon Australia	H2 Kwinana*	Ammonia, SAF, Minerals Processing	105	WA
HIF Asia Pacific Pty	HIF eFuel Facility	E-Fuels	144	TAS
KEPCO Australia	Port of Newcastle* Green Hydrogen	Ammonia	750	NSW
Origin Energy Future Fuels	Hunter Valley* Hydrogen Hub	Ammonia, Mobility	Up to 200	NSW
Stanwell Corp	CQ Hydrogen*	Ammonia	720	QLD
Murchison Hydrogen Renewables	Murchison Hydrogen Renewables Project	Ammonia	1625	WA

* = Associated with federal govt. regional hydrogen hub

2024 Policy: Future Made in Australia

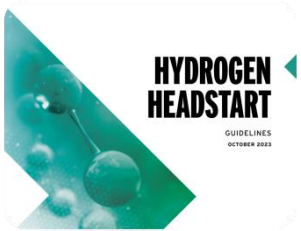
The Budget invests $22.7 billion over the next decade to build a Future Made in Australia. This plan is about maximising the economic and industrial benefits of the move to net zero and securing Australia's place in a changing global economic and strategic landscape

Net Zero transformation Stream

- Renewable hydrogen
- Green metals
- Low carbon liquid fuels

Economic resilience and security stream

- Critical minerals
- Clean energy manufacturing



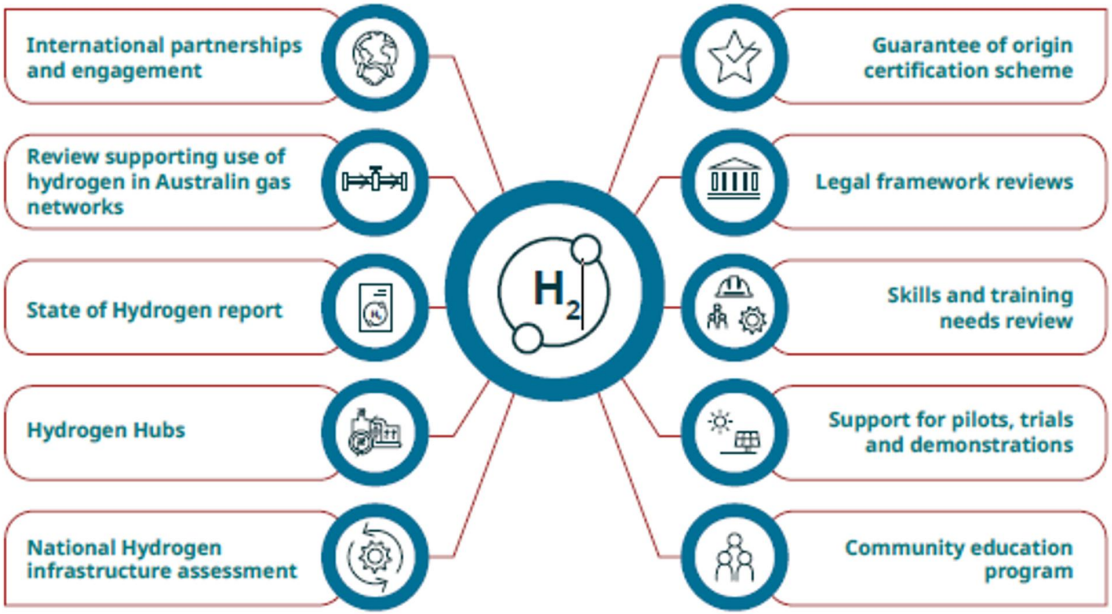
Hydrogen Production Support:

- Hydrogen Headstart Round 2 (AU$ 4bn total)
- Hydrogen Production Tax Incentive (AU $2 / kg)

Australian Government
Department of Climate Change, Energy, the Environment and Water

Australian Hydrogen Policy Outlook

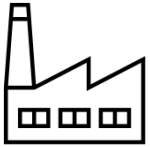
Other Federal Government initiatives



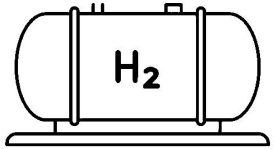
- **Greater focus on removing barriers to deployment, esp. standards and regulations**
- **International competition to drive more focussed investment in areas of comparative advantage for Australia (National Hydrogen Strategy & State / Territory strategy reviews).**
- **Deepen international partnerships where they align with Australia's priorities**
- **Develop opportunities for domestic 'value add' industries (incl. manufacturing)**

2024 Barriers and Opportunities for Australia's Hydrogen Industry Scaleup

Production costs need to come down (capex & opex)



Industrial uses will drive demand and scaleup



Large scale, low cost storage and distribution is required

Infrastructure is a critical constraint

Fit for purpose regulations and standards are needed

The devil is in the detail (eg technology reliability)

II: CSIRO Hydrogen Industry Mission

CSIRO Hydrogen Industry Mission

Supporting global decarbonisation through a commercially viable Australian hydrogen industry comprising both domestic and export value chains by 2035

Hydrogen Industry Needs

Trusted Analysis, Advice & Knowledge Sharing

Technology Deployment & Commercialization Support

Hydrogen Technology Innovation

Mission Pillars

- Hydrogen Knowledge Centre
- Strategy & International Partnerships
- Demonstration Projects
- Enabling Science & Technology

Hydrogen Knowledge Centre

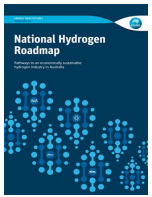
HyResource →

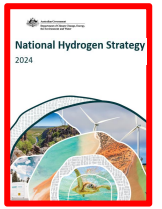
HyResearch →

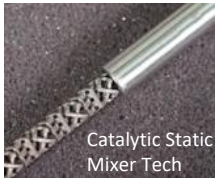
HyLearning →

AHRN Australian Hydrogen Research Network

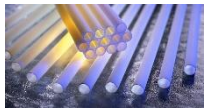
MISSION INNOVATION CLEAN HYDROGEN MISSION





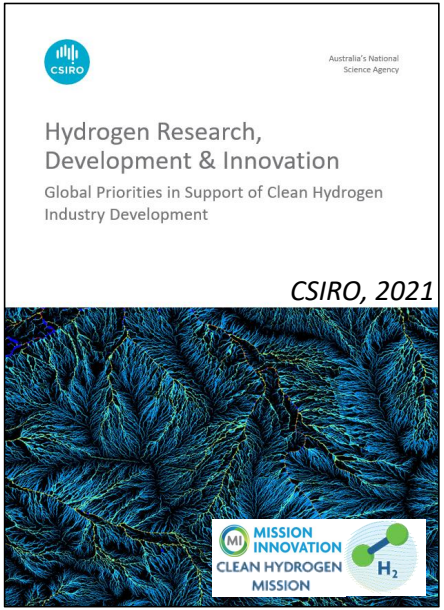


Hadean

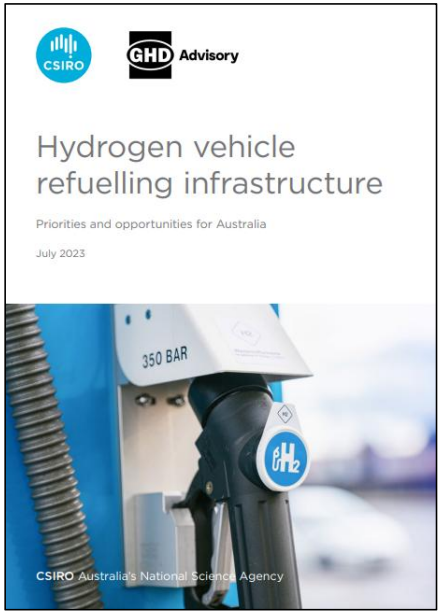


Hydrogen Knowledge Centre

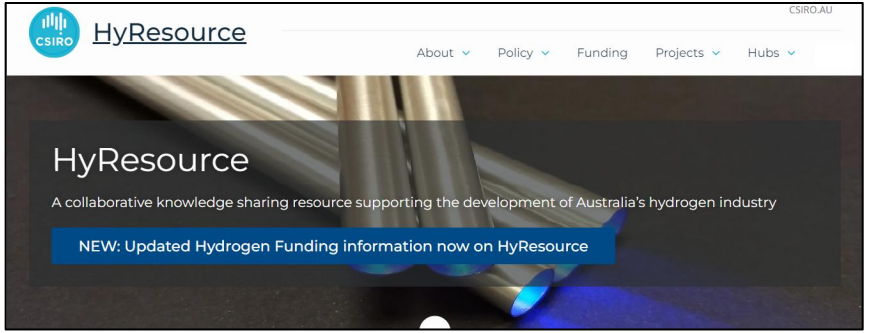
CSIRO Hydrogen Knowledge Sharing Resources



http://mission-innovation.net/wp-content/uploads/2021/11/Clean-Hydrogen-Mission-Discussion-Paper-APPENDIX-2.pdf



https://www.csiro.au/en/about/challenges-missions/hydrogen/hydrogen-vehicle-refuelling-infrastructure



https://research.csiro.au/hyresource/

https://research.csiro.au/hyresearch/

Strategy & International Partnerships

Hydrogen RD&D International Collaboration Program

Enabling International Research Collaboration in support of Australia's hydrogen industry

International RD&D Scans

	Germany
	UK
	Japan
	France
	USA
	Republic of Korea
	Canada
	Singapore
	China
	India

Scans available via Mission Innovation
http://mission-innovation.net/missions/hydrogen/

International Research Delegations

Germany	UK	France	USA
			
26th September 2022	*3rd October 2022*	*3rd Oct 2022*	*10th October 2022*

Japan	Singapore	Korea	India
			
5th December 2022	*19th June 2023*	*4th September 2023*	*Q4 2023*

International Research Travel Fellowships

International Hydrogen Research Collaboration Program
RESEARCH FELLOWSHIPS

~40 Research Fellows
selected to conduct research across Canada, China, France, Germany, India, Japan, South Korea, Singapore, UK, and the USA.

MISSION INNOVATION
CLEAN HYDROGEN MISSION

Australian Government
Department of Climate Change, Energy, the Environment and Water

AHRN
THE AUSTRALIAN HYDROGEN RESEARCH NETWORK

CSIRO

Strategy & International Partnerships

India – Australia Green Hydrogen Taskforce

Terms of Reference

India-Australia Green Hydrogen Taskforce

The Prime Ministers of India and Australia in their Joint Statement of 11 March 2023, acknowledged the proposal to establish an India – Australia Hydrogen Taskforce.

A Green Hydrogen Taskforce (Taskforce) will be established to advise the Department of Climate Change, Energy, the Environment and Water (DCCEEW), Government of Australia and the Ministry of New and Renewable Energy (MNRE), Government of India on opportunities for Indian and Australian collaboration on green hydrogen production and deployment.

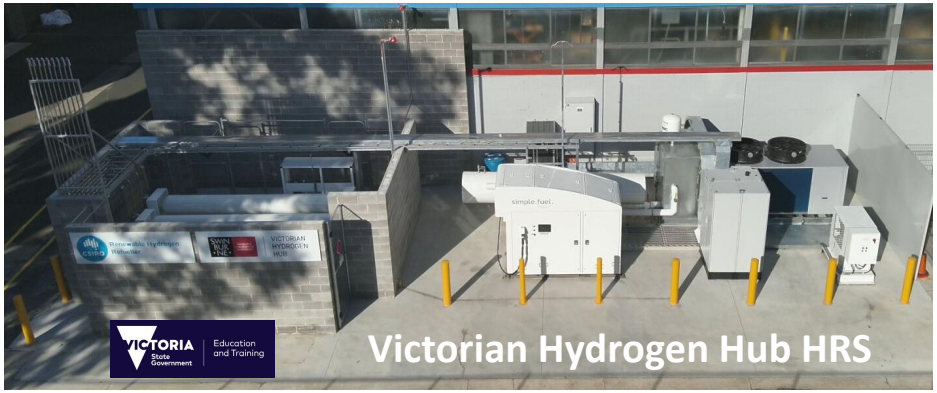
The Taskforce will report to the Co-Chairs of the Joint Working Group on New and Renewable Energy of the India and Australian Ministerial Energy Dialogue (JWG).

Purpose and outcomes

The purpose of the Taskforce is to provide expert advice and guidance on focus areas that have been identified by the JWG. The intended outcomes are to accelerate and drive trade, commercial and research opportunities between the two countries through the manufacture and deployment of green hydrogen.

India - Australia Green Hydrogen Taskforce co-chairs
Dr. Patrick Hartley (CSIRO) & Dr. Ashish Lele at CSIR NCL Pune, 22/11/2023

CSIRO Hydrogen Technology Demonstration Facility (HTDF)



Located at CSIRO Clayton (Melbourne)

- CSIRO operated facility (infrastructure, expertise, safety systems)
- Supporting hydrogen technology development, commercialization & demonstration partnerships

CSIRO Hydrogen Research Project Portfolio

Enabling Science & Technology

Hydrogen Production

Novel hydrogen production

- Natural Hydrogen
- Photocatalysis
- Electrolysis

Ammonia production

- Distributed Synthesis
- Membrane Systems
- Biological Synthesis

Hydrogen Storage and Distribution

Novel hydrogen storage options

- Geological Storage
- Hydrogen Liquefaction
- Ammonia & LOHC Conversion

Hydrogen handling

- Hydride Compression
- Hydrogen Embrittlement
- Handling Materials

Hydrogen Utilisation

Hydrogen use

- Methanol Production
- Hydrogen Burners
- Ammonia Reduction of iron ore
- Ammonia decomposition

Cross-Cutting Value Chain Projects: Supporting hydrogen industry development

- Environmental impacts eg Air / Water
- Techno-economic evaluation
- Social license to operate
- Regulatory requirements

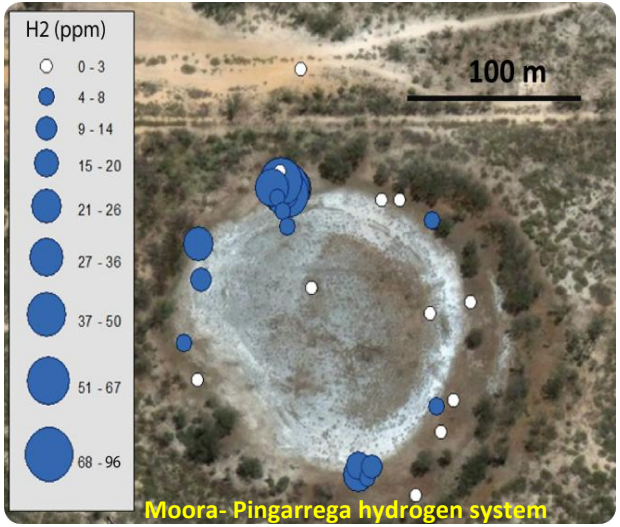
CSIRO Electrolysis Technologies

- **PEM Electrolysis**
  - kW scale PEM electrolyser technology with stack efficiencies of over 87% and system efficiency up to 75%.
  - Cell/Stack design that allows high pressure H_2 generation.
  - Technology development and commercialisation via CSIRO's spinoff company Endua (2021)

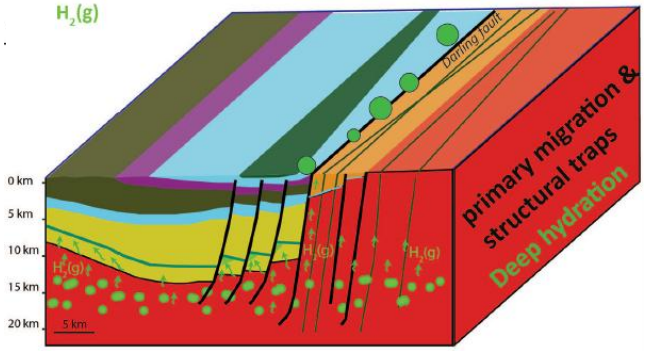
- **SOE Electrolysis**
  - Unique tubular SOE technology using novel low cost ceramic materials and rapid fabrication methods.
  - Utilization of industrial waste heat to replace 30% of electricity required for H_2 production
  - Technology development and commercialisation via CSIRO's spinoff company Hadean (2023)

Enabling Science & Technology

Natural Hydrogen Research



- First discovery and field measurement of natural hydrogen seeps in Australia
- Original hypotheses on natural hydrogen generation, migration pathways and entrapment
- Linkage of hydrogen seeps with the structural geological system



Frery, E. et al. *Natural hydrogen seeps identified in the North Perth Basin, WA* International J Hydrogen Energy, 46 (61) (2021) Pages 31158-31173, https://doi.org/10.1016/j.ijhydene.2021.07.023.

CSIRO

Enabling Science & Technology

Securing Water for an Emerging Australian Hydrogen Industry

Securing water for an emerging Australian hydrogen industry

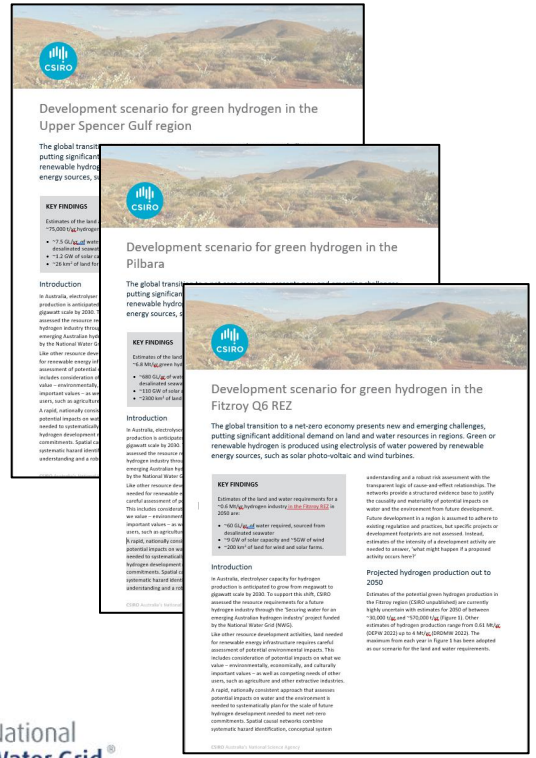
- Mapping hydrogen resource availability (land, water, wastewater) & potential impacts on resources and users
- Causal models of potential impacts.

Stakeholder engagement

- Establish relationships with representatives from First Nations, community, industry, and government groups
- Workshops with community, industry and regulators in Pilbara WA, Upper Spencer Gulf SA, Gladstone Qld

Development Scenario Case Studies

- Fitzroy Basin, QLD
- Pilbara, WA
- Upper Spencer Gulf, SA



Australian Government

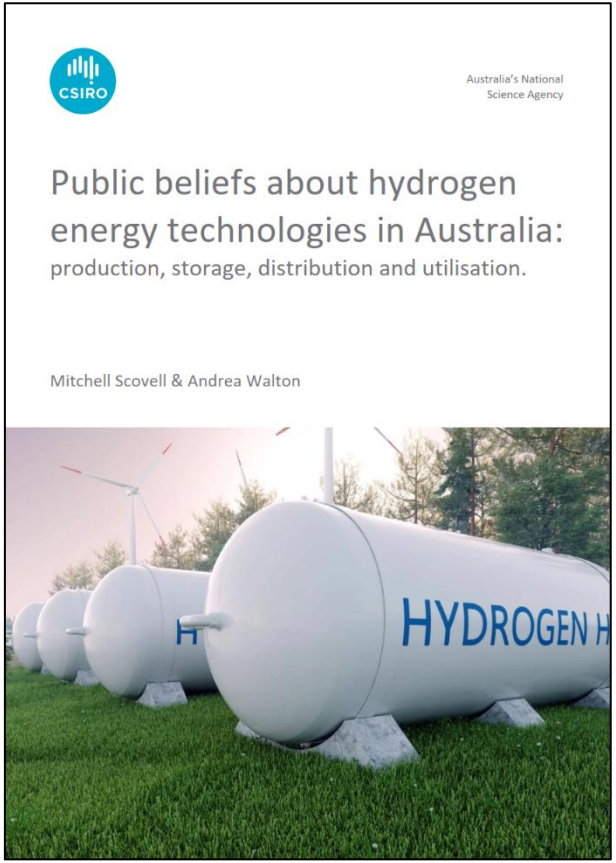
National Water Grid

CSIRO

Enabling Science & Technology

Social, Economic & Governance Research

- Social acceptance, risk perception, and responsible innovation
  - Understanding public perceptions to hydrogen technologies to help mitigate risks of deployment
- Market demand
  - e.g. A study of Japan as a market for Australian H2 exports
- Resource and environmental economics
  - Studying barriers & risks to hydrogen industry development
- Indicators and Data framework
  - Identifying data and measures for tracking H2 industry development in Australia



Summary Observations

CSIRO Hydrogen Industry Mission Pillars

- **Global developments will address many hydrogen market activation challenges; *but***
- **RD&D is required to overcome barriers such as cost and infrastructure rollout, and to help stimulate demand**
- **R&D focussed on cross cutting areas such as regulations / standards, community & environmental impacts will be key to understanding risks and developing effective industry policy**
- **Australia's Hydrogen RD&D ecosystem is making valuable contributions through informing policy, regulation and market development, providing a domestic hydrogen tech IP pipeline, identifying risks, developing skills and supporting international collaboration**

Thank you

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