Green Hydrogen and Ammonia in Australia: A New Commodity for the 21st Century

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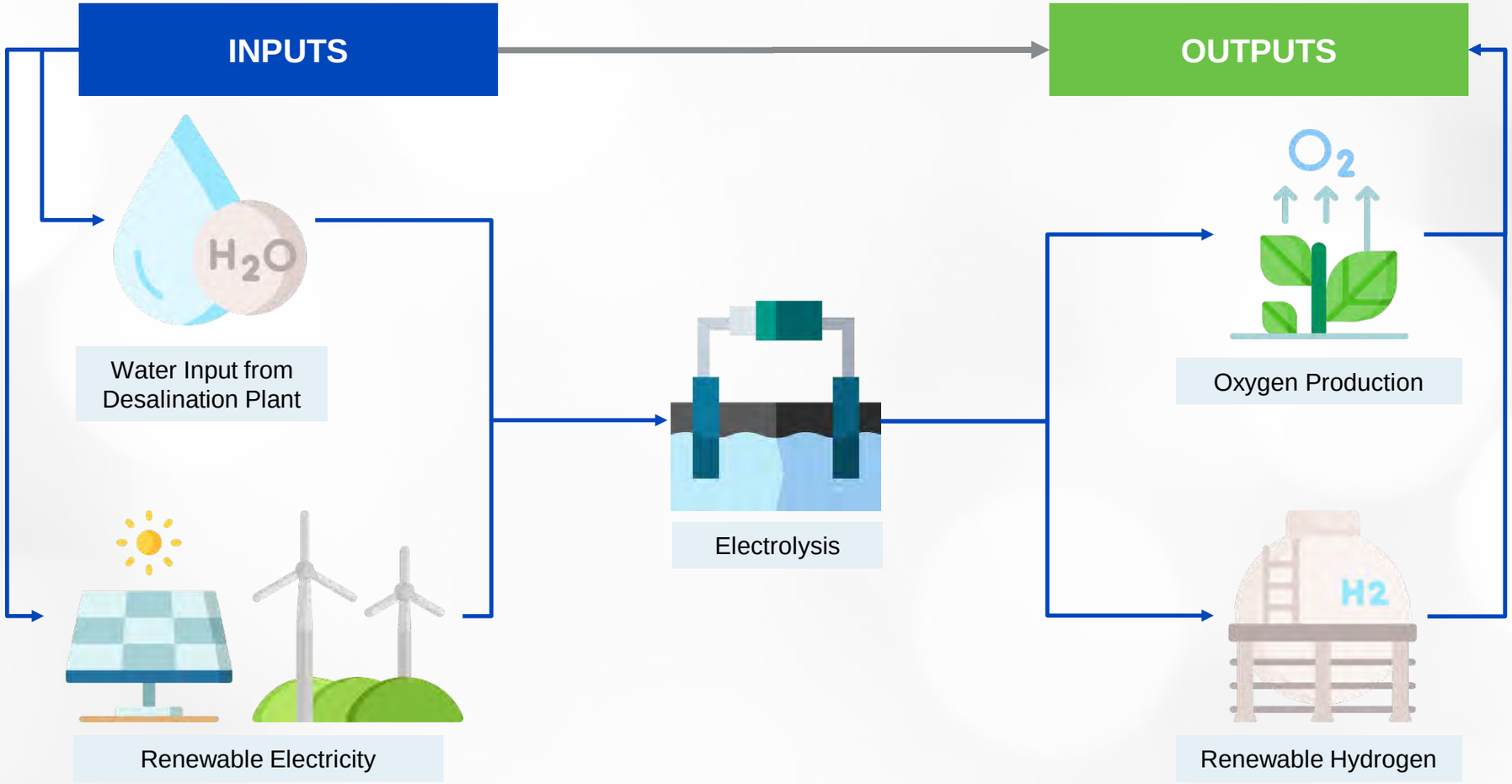
1.5 degree world

Green Hydrogen

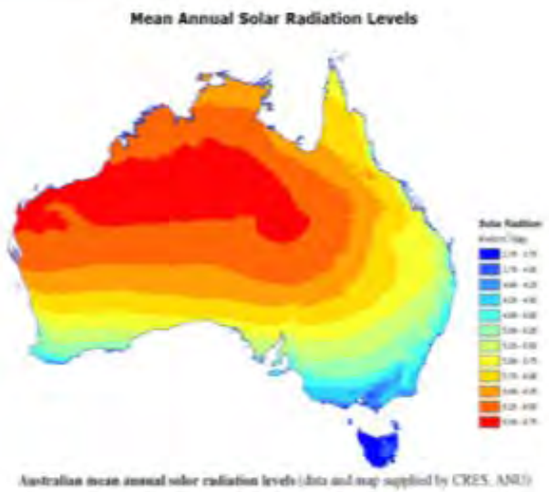


PM'S HYDROGEN VALLEYS' ARE EMPTY

Prime Minister Scott Morrison told fellow world leaders… that 'hydrogen valleys' are already being built in Australia that will literally transform transport, mining, manufacturing and energy generation.

Source: The Australian Financial Review, 24-25 April 2021

Potential of renewable energies in Australia



Annual solar radiation levels range from lowest (dark blue) to highest (red) across Australia.

Source: http://www.energyfutures.qld.gov.au/solar.cfm

Geoscience Australia & Bureau of Meteorology. 2009. *Mean Annual Solar Radiation Levels*. Available at: https://arena.gov.au/assets/2013/08/Chapter-10-Solar-Energy.pdf 2.A, P. Coppin & N. Steggel. 2003. *Wind Resource Assessment in Australia – A Planners Guide*. Available at: http://www.cmar.csiro.au/e-print/open/coppin_2003a.pdf

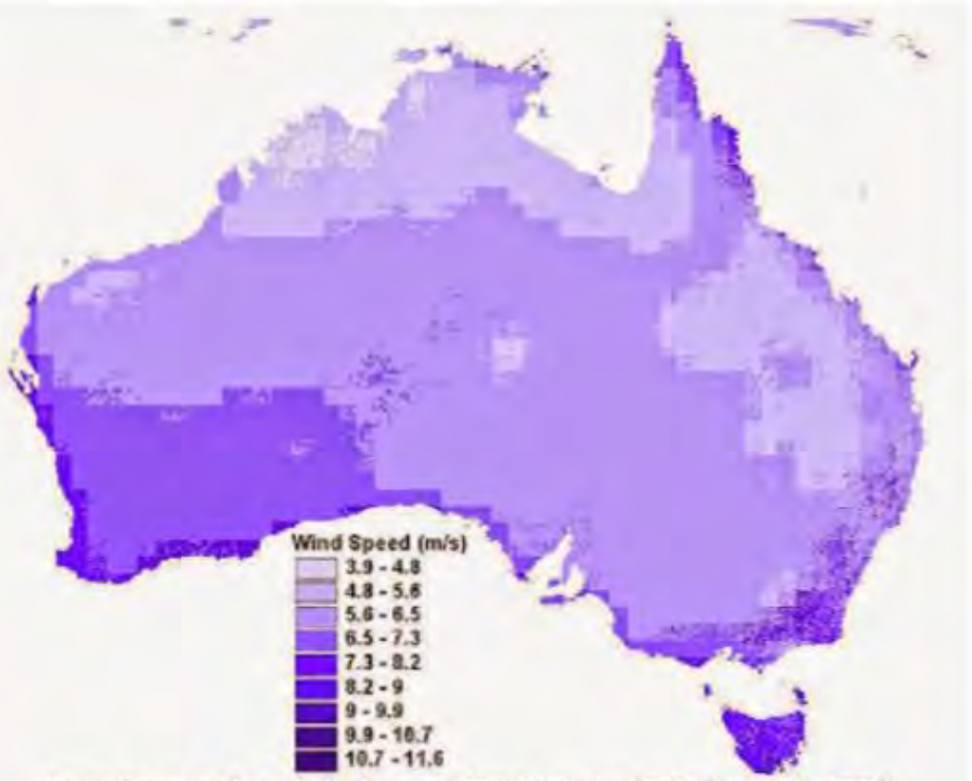
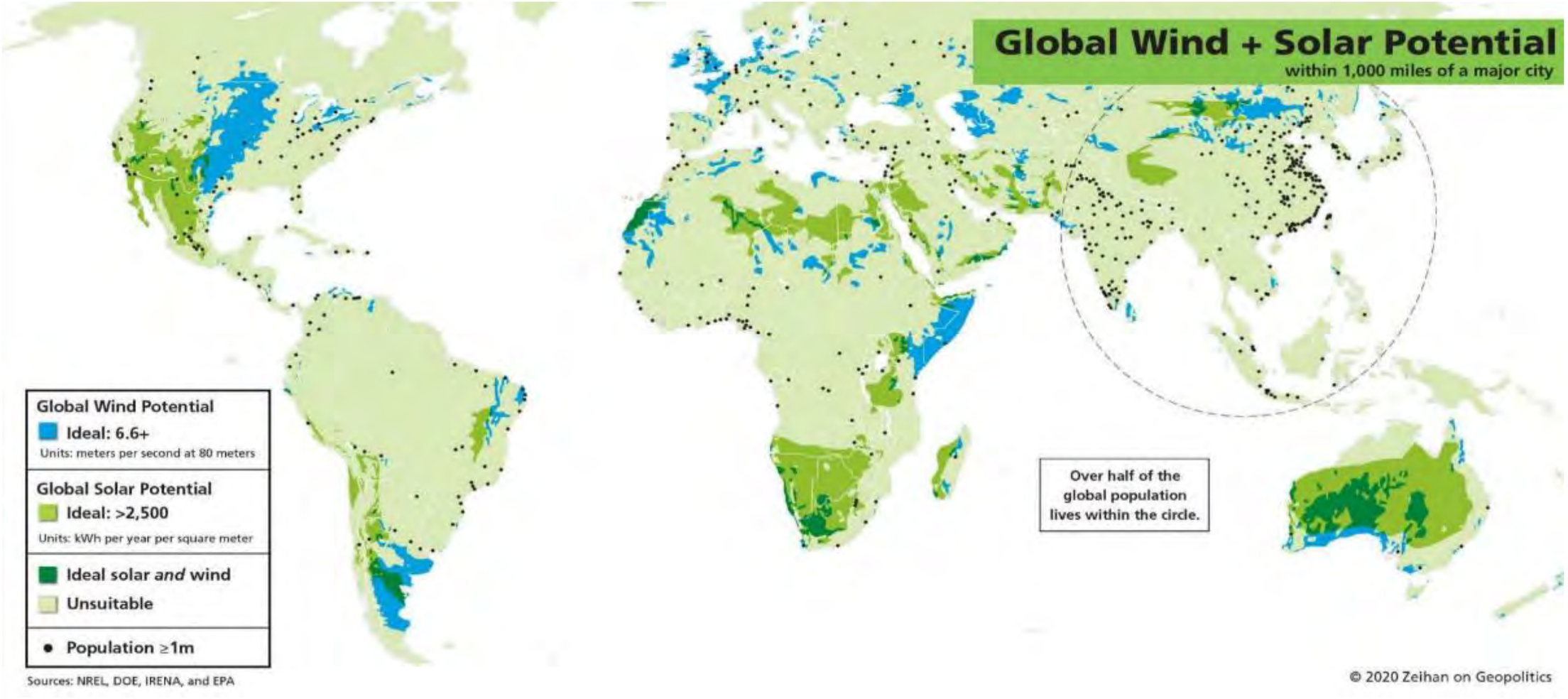


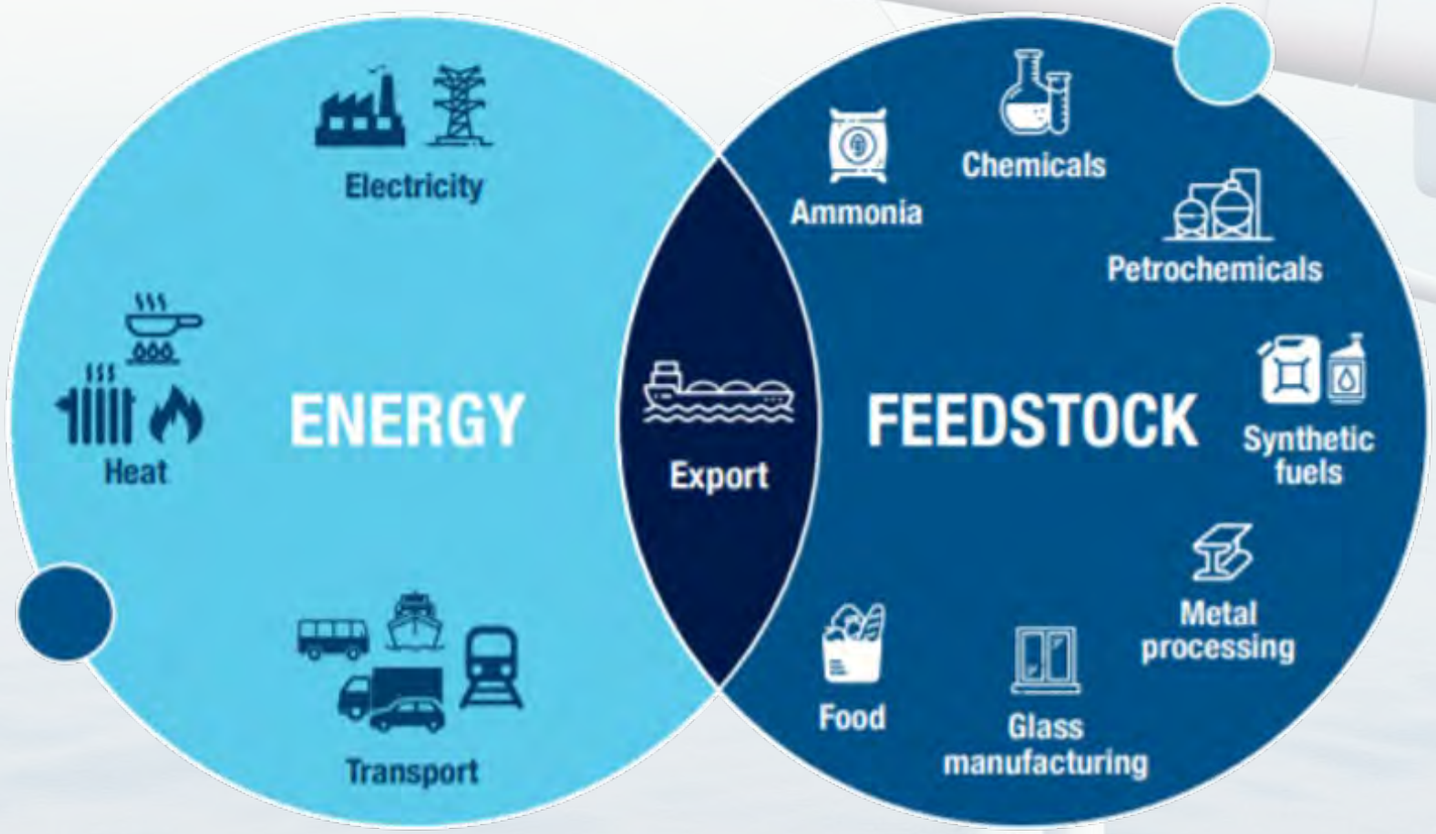
Figure 7 70m wind speeds for the period May 1997 – April 1999 (from Mills, 2001)

Green energy superpower



Zomer, R. J., Bossio, D. A., Sommer, R., & Verchot, L. V. 2017. Global Sequestration Potential of Increased Organic Carbon in Cropland Soils. Scientific reports, 7(1), 15554. Available at: https://doi.org/10.1038/s41598-017-15794-8

Green hydrogen use cases



Western Australian Renewable Hydrogen Strategy

Decarbonisation in a 1.5 degree world

- Climate inaction would cost Asia Pacific economies $96 trillion by 2070
- Strong climate action could deliver $47 trillion to Asia Pacific's economies by 2070

- (Deloitte, "*Asia Pacific's Turning Point*", August 2021).

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Green hydrogen - Australian policy and investment overview

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Content

An opportunity

“The global transition to low-emission energy sources is an opportunity to redefine Australia’s export industries and secure this country’s future. Transforming to a low-emission energy superpower will enhance Australia’s economic sustainability and support global resilience. Some work is underway. Germany and Australia are completing a renewable hydrogen supply chain study to identify how Australia can support Germany in decarbonising its heavy industry. The International Energy Agency found that, by as soon as 2030, importing Australian hydrogen could be cheaper for Japan than domestic production. The Australian Government has already committed $565.8 million to back low-emission international partnerships…”

[Infrastructure Australia 2021 Plan p 406]

The challenges

There is a global race between countries to position as major players in the “green” hydrogen industry

Australia faces some challenges:

- Need to build renewable energy facilities, hydrogen production facilities, export facilities, ports, ships, import facilities and logistics facilities to get the product to where the demand exists (e.g. Asian and European markets).
- Hydrogen exports will have to be in liquefied form which requires special purpose-built vessels and the retooling of ports and potentially pipelines.
- Building a liquefied hydrogen chain will likely take some time – in LNG it took decades.
- Investors will want to see an investment in the supporting infrastructure before committing to invest in the development of “green” hydrogen production plants.

Infrastructure Australia emphasises that national coordination is particularly important given the scaling challenges a developing hydrogen industry will face.

Australia wide competitiveness

According to Dr Alan Finkel, Australia's hydrogen ambitions will require 8 times the total annual production of electricity in Australia.

The primary consideration for hydrogen production via electrolysis is access to low cost and low emissions electricity. Western Australia, Queensland, South Australia, Victoria and the Northern Territory have a high solar PV and/or wind resources and combined with land availability, represent attractive areas for investment. Tasmania, Victoria and New South Wales also have major hydroelectric resources.

Source: CSIRO National Hydrogen Roadmap

Australia has the potential to produce hydrogen for global export at a competitive price – driven by cost of renewable energy decreasing and the abundant availability of solar and wind resources.

Three of Australia's top trading partners – Japan, Korea and China – have already made clear commitments to use hydrogen to decarbonise their energy systems. Australian Government has entered into a series of partnerships with Germany (to develop a hydrogen supply chain) and South Korea and Japan to explore the possibility of future hydrogen exports.

Australia's hydrogen strategy

2019

In 2019, COAG's Energy Council endorsed a national hydrogen strategy that aims to position Australia as a major global industry player and exporter of the fuel in its super-chilled liquefied form to Asia by 2030 ("**National Hydrogen Strategy**").

Note that the transport of compressed hydrogen is also now being considered as an alternative to transport in liquified form - whilst not ammonia, the benefit is that expensive liquids ports will not be required for export and compressed H2 may be transported and stored locally in domestic supply chains.

2020

In September 2020, the Australian Government released the First Low Emissions Technology Statement ("**Low Emissions Statement**"):

- the first statement issued under the government's *Technology Investment Roadmap*; and
- articulates a vision for Australia to be recognised as a global low emissions technology leader.

Australia's hydrogen strategy

The Low Emissions Statement:

- identifies "green" hydrogen as a priority low emissions technology of long-term strategic importance to the Australian Government - Australian Government sees a future "green" hydrogen industry in Australia as generating over 8,000 new jobs and A$11 billion a year in GDP by 2050
- notes that Australia is well-placed to become a world leading hydrogen producer
- specifies a priority technology-stretch goal of a "green" hydrogen price of under A$2 per kilogram – at this price, "green" hydrogen becomes competitive in its applications (such as producing ammonia), as a transport fuel and for firming electricity
- sets an objective of working with investors to establish Australia's first regional hydrogen hub which will co-locate domestic hydrogen users with an export focus to create global hydrogen supply chain linkages
- aim is to have 13 technology "clusters" set up around Australia to help smaller companies gain a foothold in the emerging hydrogen sector and build up national expertise.

Australian Hydrogen Council

- AHC's view is that a "grander vision" is required as the hydrogen industry is not yet commercial and considerable investment is required to get to scale.

- Recent call by the AHC for the Australian Government to create a A$19 billion Net Zero fund, aimed at cutting emissions and accelerating the rollout of green hydrogen to the steel and heavy transport industries and in the nation's gas sector by 2030:
  - fund to be managed by a newly established Net Zero Authority, covering research through to commercialisation, grants and finance and ensuring correct policy settings are in place;
  - blueprint calls for A$10 billion in seed funding and a top-up of A$1 billion annually through to 2029 to be allocated to business through grants and loans; and
  - recommends the Australian Government set a goal of 10% hydrogen in the gas network by 2030 and target sectors that face challenges to cut emissions, such as steel and aluminium.

Hydrogen hubs

- In April 2021, the Australian Government pledged A$275.5 million to accelerate the development of 4 additional clean hydrogen hubs in regional Australia and implement a clean hydrogen certification scheme.
- Funding provided for these initiatives in the 2021/2022 Federal Budget and follows initial funding in the 2020/2021 Federal Budget.
- Hydrogen along with carbon capture and storage were named among the top investment priorities for ARENA in September this year.
- Takes the number of announced regional hydrogen hubs in Australia to 7 as follows:
  - the Latrobe Valley (Victoria)
  - Darwin (Northern Territory)
  - Pilbara (Western Australia)
  - Gladstone (Queensland)
  - Hunter Valley (New South Wales)
  - Bell Bay (Tasmania)
  - Eyre Peninsula (South Australia)

NSW Net Zero Plan and Hydrogen Strategy

- NSW Government has set a goal of net zero emissions by 2050 - proposes to establish a A$450 million **Emissions Intensity Reduction Program** to support businesses to transition to low emissions alternatives.

- In August 2021, NSW Government released the "*NSW Hydrogen – Strategy and hub development*" ("**Hydrogen Strategy**") - currently developing a strategy that will detail the vision and direction for developing a hydrogen industry to 2030 and beyond. NSW Government is committing at least A$70m to the Hydrogen Hub Initiative

- Considering various policy actions to support the NSW hydrogen economy, including industry development targets, allocation of funding under the A$750m Net Zero Industry and Innovation Program, infrastructure and planning requirements and measures to achieve its aspirational 10% hydrogen gas blending target by 2030

NSW Net Zero Plan and Hydrogen Strategy

- Hydrogen Strategy includes a market platform that will match up potential producers and users and act as a catalyst to get projects off the ground - aimed at supporting the targeted development of “green” hydrogen hubs in areas such as Port Kembla and the Hunter Valley.
- Other developments:
  - Two new gas power stations proposed for NSW, EnergyAustralia’s Tallawarra plant to be built in the Shoalhaven region and Snowy Hydro’s Kurri Kurri plant, will both be able to use hydrogen in the fuel mix
  - Dr Andrew Forrest’s Australian Industry Energy also plans to use “green” hydrogen in a power station proposed to be built near its LNG import terminal under development in Port Kembla.

NSW hub investment activity

Hunter Hydrogen Network (H2N)

Consortium jointly working on a feasibility study for a fully renewable hydrogen supply chain in the Hunter Valley:

- Project would use renewable energy generated near the Hunter Valley to create “green” hydrogen.
- Hydrogen would then be transported via a dedicated pipeline to manufacturers based in the region and to the Port of Newcastle for export.
- Costs estimated at A$2 billion/US$1.56 billion.

Consortium comprises:

- Trafigura and Idemitsu (global commodity traders)
- AGL Energy (an Australian utility provider)
- APA Group (a gas infrastructure provider)
- RES (a clean energy company)
- Walcha Energy (renewables project)
- EnergyEstate (renewables developer)

Victoria's Renewable Hydrogen Industry Development Plan

The Plan sets out a blueprint for how the Victorian Government will lead and support a suite of outcomes to drive the development of a renewable hydrogen sector.

The Victorian Government has increased the Victorian Renewable Energy Target to 50% by 2030.

The Plan states that Victoria:

- has the best offshore wind potential in Australian and amongst the best in the world
- has a connected transport network which will enable the potential for hydrogen integrated, multi-mode transport

Queensland Hydrogen Industry Strategy 2019-2024

Queensland has a unique competitive advantage in the production of renewable hydrogen

Well-positioned to benefit from the global transition to a low-emission energy future due to its close proximity to Asia, established infrastructure, manufacturing capabilities and renewable energy potential.

Five focus areas have been identified:

- Supporting innovation
- Facilitating private sector investment
- Ensuring an effective policy framework
- Building community awareness and confidence
- Facilitating skills development for a new technology

QLD hub investment activity

Dalrymple Bay Infrastructure

(DBI) (coal port terminal operator) - agreement signed with Brookfield Infrastructure, North Queensland Bulk Ports Corp and Itochu to explore a potential green hydrogen production, storage and export facility

North Queensland Bulk Ports

Involved in plans to develop a hydrogen production and export facility at the Abbot Point Port near Bowen, north from the Port of Hay Point

Sumitomo Corp and *Rio Tinto*

Announced plans to study the building of a hydrogen pilot plant to help power Rio Yarwun alumina refinery in Gladstone (which has been flagged as a future hydrogen export hub to Asia) and to supply industry more broadly in Gladstone

Origin Energy

Studying the potential for “green” hydrogen and ammonia opportunities at a plant which would be located in the Port of Townsville - MOU signed with Port of Townsville to facilitate hydrogen exports to Japan

QLD hub investment activity

Qld Government announced in September this year plans for ***Ark Energy*** to ship up to 120,000 tonnes of "green" hydrogen out of the Port of Townsville to South Korea:

- parties plan to explore the feasibility of developing a "green" hydrogen facility at Sun Metal's zinc refinery at Townsville, as well as hydrogen export facilities at the Port of Townsville
- Ark and Sun Metals are both parts of Korea Zinc Co
- Qld Government has provided a A$5 million Hydrogen Industry Development Fund grant to kickstart hydrogen production in the north of Queensland
- Ark plans to persuade North Queensland transport fleet owners to transition from diesel-fuelled vehicles to green hydrogen-fuelled vehicles which it will refuel.

QLD hub investment activity

APA Group, Stanwell Corporation (Qld Genco) and Japanese corporations ***Iwatani Corp., Kawasaki Heavy Industries, Kansai Electric Power Company*** and ***Marubeni*** are conducting a feasibility study into establishing a large-scale green hydrogen project in central Queensland:

- Iwatani is Japan's largest hydrogen supplier
- would be Queensland's largest "green" hydrogen project with start-up of exports to Japan targeted from 2026
- supported by both Australian and Japanese governments – A$10.4 million feasibility study into the project, with funding support from the ARENA of A$2.17 million and from the Japanese Ministry of Economy, Trade and Industry

Consortium revamped after the Australian and Japanese governments signed a statement of co-operation on hydrogen and fuel cells in 2020 which was followed in June this year by the formation of a partnership on decarbonisation

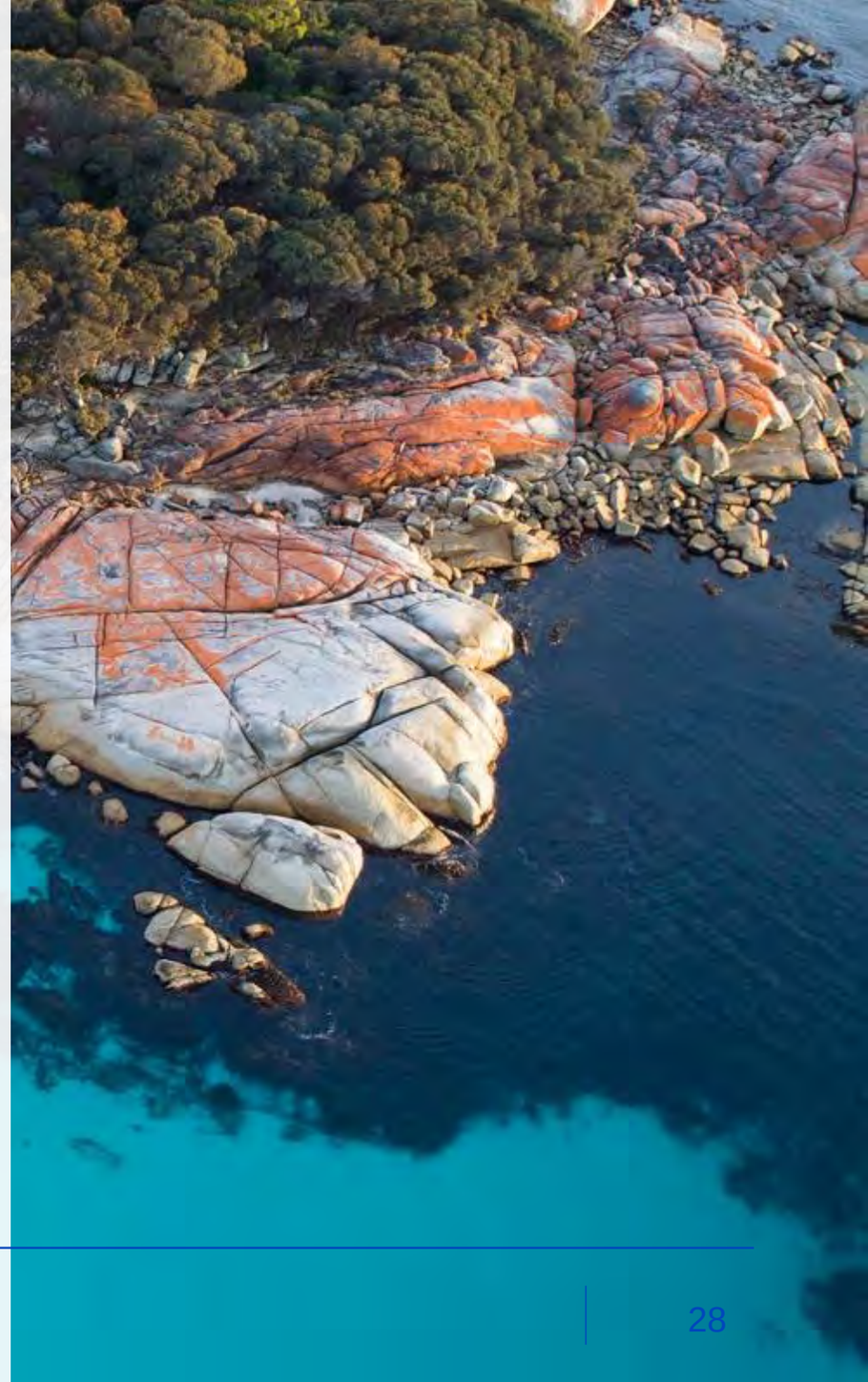
New partners – APA, Kawasaki Heavy Industries, Kansai Electric Power Co and trader Marubeni - bring expertise along different parts of the hydrogen supply chain, including renewable energy, hydrogen production, liquefaction, shipping and sales.

Tasmanian Renewable Hydrogen Action Plan

Vision - to be a significant global supplier of renewable hydrogen for export and domestic use by 2030.

The Plan identifies Tasmania's key competitive advantages, which include:

- high renewable energy contribution from low-cost reliable hydropower and wind
- access to abundant fresh water
- industrial precincts with available land and access to high quality infrastructure including ports



Tasmania hub investment activity

Fortescue Future Industries

aiming for a final investment decision this year for its 250MW “green” hydrogen plant at the Bell Bay industrial precinct in Tasmania at an estimated cost of upwards of A$500 million. Plant will have capacity to produce 250,000 tonnes of “green” ammonia for domestic use/ export. Arrangements entered into with Tasmanian Ports Corporation to exclusively negotiate all land and operating access requirements for the proposed plant.

Fortescue Metals Group

has reportedly signed development agreements around major hydro power projects in Africa with a view to supplying “green” hydrogen to Europe. Has reportedly already produced “green” iron and “green” cement in trials as part of its plans to become a major player in “green” energy and to make its mining operations carbon neutral by 2030 - has trialled the use of batteries, “green” ammonia and “green” hydrogen across its iron ore mining operations

Origin Energy

Conducting a A$3.2 million study (due to be completed by December 2021) into the feasibility of building a plant at Bell Bay to produce “green” ammonia. Has singled out transport as one of the biggest opportunities globally to reduce emissions through the use of “green” fuels such as hydrogen and ammonia and has announced a collaboration with Mitsui OSK Lines to develop a supply chain for the export of “green” ammonia from Bell Bay

Western Australia's 2022 and 2030 goals

Western Australia will be a significant producer, exporter and user of renewable hydrogen.

By 2022, a project is approved to export renewable hydrogen from Western Australia.

By 2030, Western Australia's market share in global hydrogen exports is similar to its share LNG today.

Western Australian Renewable Hydrogen Strategy

WA “green” hydrogen strategy

WA Government announced initiatives to date include:

- Spending A$900,000 on three “green” hydrogen feasibility studies, supported by its A$15m Renewable Hydrogen Fund:
  - allocated A$300,000 to ***BP Australia*** to help develop a “green” hydrogen facility at BP's Kwinana refinery facility used for “green” hydrogen and clean fuel production. Note that in September, BP and Macquarie announced they had teamed up for a feasibility study into a potential “green” hydrogen plant at BP’s former refinery site at Kwinana
  - A$300,000 to ***APT Management Services*** to study converting the Parmelia gas pipeline into a 100% hydrogen pipeline
  - A$300,000 to ***Global Energy Ventures*** to explore the commercial feasibility of exporting “green” hydrogen to the Asia-Pacific from Gascoyne.

WA “green” hydrogen strategy

- Recently awarded A$2 million from its Renewable Hydrogen Fund to ***ATCO Australia*** for a project to blend “green” hydrogen produced by ATCO at its Jandakot innovation hub into isolated sections of the WA gas network.
- Announced in September 2021 plans to invest A$61.5 million (US$45.3 million) in growing the State’s “green” hydrogen industry by:
  - creating a new A$50 million fund to stimulate industrial demand for “green” hydrogen and to drive “green” hydrogen investment
  - investing a further A$7.5 million to build a road into the Oakajee Strategic Industrial Area (SIA), where the State aims to establish a “green” hydrogen hub
  - invest a further A$4 million towards planning for Oakajee and for additional infrastructure requirements related to the SIA, as well as bolstering the Renewable Hydrogen Unit within the Department of Jobs, Tourism, Science and Innovation.

WA hub investment activity

- **InterContinental Energy, CWP Global and The Mining Traditional Lands Aboriginal Corporation**
  - proposing to develop a renewable energy hub producing “green” hydrogen and ammonia - Western Green Energy Hub would cover 15,000 sq km across the Goldfields-Esperance region in the south-east of WA and could produce up to 50 gigawatts of wind and solar power (equal to the entire capacity of Australia’s NEM)
  - Estimated to cost close to A$100 billion.
- **Lightsource bp (BP’s renewables venture)**
  - A$4.42 million feasibility study (with A$1.7 million of funding from ARENA) – WA “ideally positioned” for large-scale production of “green” hydrogen and “green” ammonia - investment still needed in ports, energy and water network
  - Study examined potential for a pilot-scale plant and a larger commercial scale plant to produce ammonia - also confirmed strong demand from potential customers in industrial sectors, and for both local/export markets

WA hub investment activity

ARENA has announced plans to grant up to A$42.5 million (US$33.2 million) to a 10 MW electrolyser project being developed by ***Engie*** and ***Yara*** in Karratha, Western Australia

Separately, Japan's ***JERA*** has agreed a memorandum of understanding with ***Yara International*** to explore improvements to the Yara Pilbara Fertilizer plant in Western Australia to allow it to create "blue" and "green" ammonia:

- will work together to develop new "blue" and "green" ammonia projects, on optimizing ammonia shipping, and on exploring new sources of demand for ammonia in Japan (including in power generation)
- aims are to decarbonize JERA's power production and provide Yara with a footprint in the Japanese hydrogen market
- group was recently expanded to include ***Idemitsu Kosan*** (a leading supplier of petroleum products) and is focused on the exploring the feasibility of establishing a domestic clean ammonia distribution network and bunkering business with a view to accelerating Japan's "green" energy transition.

SA “green” hydrogen strategy

- South Australian Government released its strategy in 2019 - “*South Australia’s Hydrogen Action Plan*”.
- SA’s abundant wind and solar resources are the launchpad for the State’s renewable hydrogen industry together with electrolyser technology advancements – “green” hydrogen seen as an increasingly viable and needed carbon-free fuel for Australia’s domestic and export markets.
- State is actively exploring the supply of renewable hydrogen to emerging Asian hydrogen export markets, as well as its use by domestic primary energy industries.
- Australian Gas Networks is also actively working with Australian Governments, SA Government and industry, to establish the Australian Hydrogen Centre – will externalise learnings from HyP SA and deliver feasibility studies related to increased hydrogen blending, and 100% hydrogen conversion

SA “green” hydrogen strategy

- ***Port Lincoln Hydrogen and Ammonia Supply Chain Demonstrator*** - Hydrogen Utility™ (H2U) is developing a facility integrating more than 30 MW in water electrolysis and distributed ammonia production, near Port Lincoln in South Australia:
  - SA Government has provided A$4.7 million through a grant and additional loan funding to deliver the A$117.5 million project.
  - Along with the SA Government, H2U joined Japan’s Green Ammonia Consortium in July 2019 - consortium comprises of more than 70 companies and institutions, the CSIRO and the ATIC.

SA “green” hydrogen strategy

- ***Crystal Brook Energy Park*** - SA Government awarded a A$1 million grant to Neoen to conduct a study on the technical and economic feasibility of a hydrogen production facility at the Crystal Brook Energy Park:
  - Proposed 50 MW Hydrogen Superhub would be the largest co-located wind, solar, battery and hydrogen production facility in the world, with the potential to produce about 25,000 kilograms of hydrogen a day using 100% renewable energy.
  - Significant potential to produce large quantities of “green” hydrogen at a competitive price.
  - SA Government also committed to provide a further A$4 million grant and A$20 million in loans should the project proceed to financial close and construction.

SA “green” hydrogen strategy

- ***Hydrogen Park South Australia (HyP SA)*** - an A$11.4 million demonstration project delivered and funded by Adelaide-based Australian Gas Networks (AGN), part of the Australian Gas Infrastructure Group (AGIG):
  - Supported by a $4.9 million grant from the SA Government.
  - Proposed facility comprises a 1.25 MW Siemens proton exchange membrane electrolyser, the largest of its kind installed in Australia.
  - Project has attracted interest from Japan, Korea and the UK – Japan and Korea will only sign up for hydrogen imports if a domestic capability exists as this demonstrates credibility
  - Project will demonstrate the feasibility of blending hydrogen into the SA gas network and inform the SA Government's planning to transition the gas distribution network. Will also show how integrating electrolysers into the electricity networks can support energy stability, as more renewable electricity generation capacity comes onto the grid.

Other “green” hydrogen initiatives

Ampol

- Announced its involvement in a “green” hydrogen energy start-up that will target the remote diesel power generation market by offering the potential for reliable energy that is clean and affordable
- A$1.5 billion spent on diesel to generate power in Australia alone which emits 200,000 tonnes of carbon into the atmosphere
- Ampol to take a 20% stake in CSIRO-backed Endua which is developing renewables - based hydrogen power units that can be used at mines, farms and residential communities that are not connected to the grid.

Sweetman Renewables

- An emerging renewables player and legacy sawmill operator
- Proposes to enter into a A$15 million joint venture with Singapore's CAC-H2 to establish a hydrogen production centre of excellence in the Hunter Valley, NSW
- Sweetman will own 20% of the new venture in exchange for providing biomass feedstock (30,000 tonnes of wood biomass pa), engineering services and land access and CAC-H2 will own 80% and will provide the initial investment for the establishment of the first two production lines at its new centre of excellence (Hunter Valley One).

Challenges for the gas industry

- Gas distributors in Australia face significant challenges as momentum and commitment to reach net zero emissions accelerates - need to adapt or face a slowly dwindling business as new gas connections are halted and the gas companies are left with only existing customers.
- Supplying renewable gas through the network needs to be demonstrated to be viable in the face of an increasing push towards electrification to meet emissions targets
- ***Australian Gas Infrastructure Group*** (owned by Hong Kong infrastructure investor Cheung Kong Group):
  - plans to transition from natural gas to renewables gases (mostly hydrogen but also biomethane) by 2040 and aims to have a 100% “green” hydrogen product available for new housing subdivisions by 2025
  - targeting all of its gas network to be on at least a 10% renewable gas blend by 2030
- ***Jemena*** - developing an A$18 million demonstration hydrogen project at Horsley Park in NSW, with the aim of injecting a blend of “green” hydrogen into the gas network

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ARENA and Australia's renewable hydrogen economy

Cameron Kelly
General Counsel, Legal and Governance
Australian Renewable Energy Agency (ARENA)

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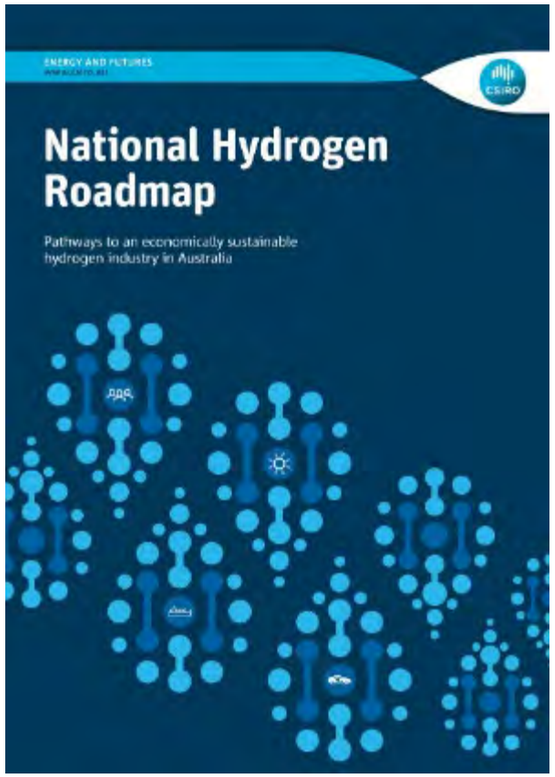
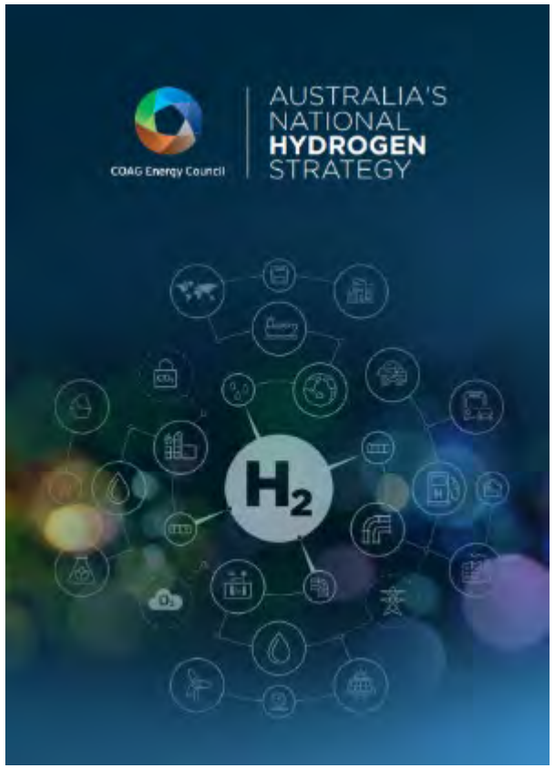
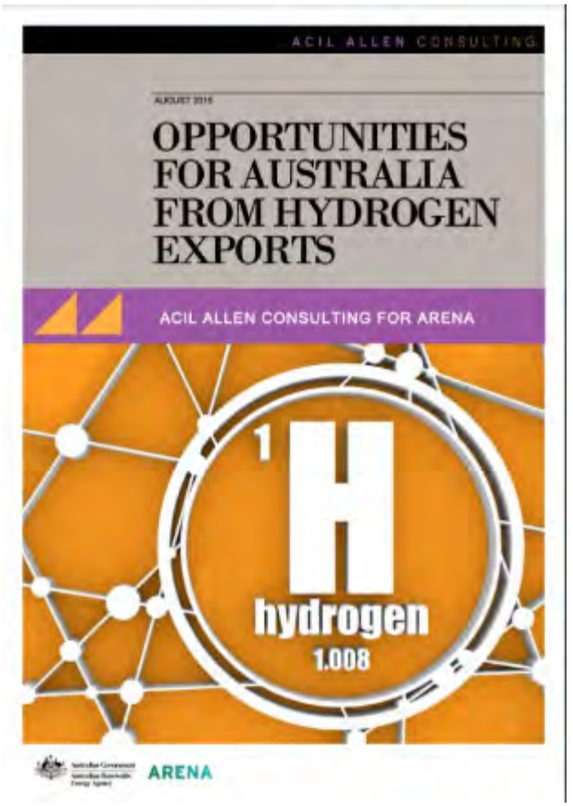
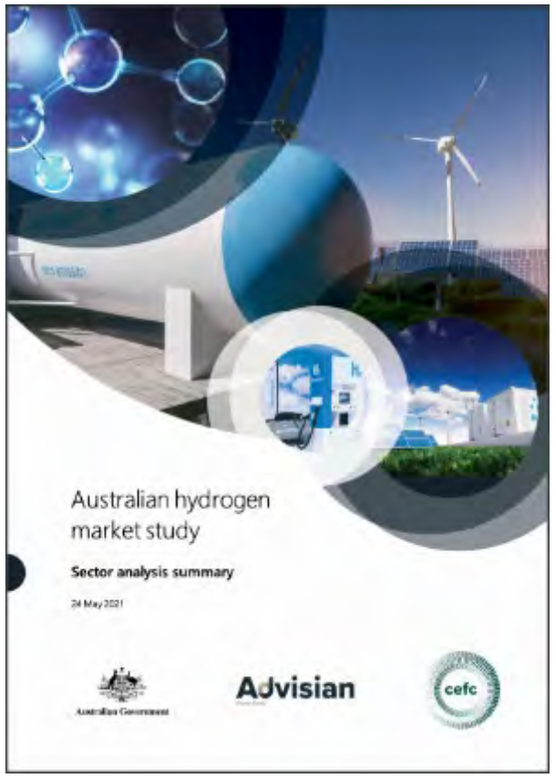
ARENA has played an important role in the evolution of Australia's H2 industry









Accelerating the uptake of renewable hydrogen

Supporting the growth of Australia's hydrogen industry for domestic applications and export

Potential **major new energy export commodity**

Opportunities for domestic use

Sector is still in its infancy - expensive with few large-scale systems

Government support needed to kickstart the industry

Image: Yara Pilbara Fertiliser's ammonia plant in Western Australia's Pilbara region

ARENA R&D HYDROGEN FUNDING ROUND PROJECTS

ARENA

INVESTED	PROJECTS	VALUE	INVESTMENT LEVERAGE
$22.1M	16	$59M	$1:$1.70

1 UWA METHANOL FROM SYNGAS R&D PROJECT
ARENA FUNDING / PROJECT COST
$1.1M / $2.9M

2 QUT HYDROGEN PROCESS R&D PROJECT
ARENA FUNDING / PROJECT COST
$3.4M / $7.7M

3 CSIRO METHANE FUEL CARRIER R&D PROJECT
ARENA FUNDING / PROJECT COST
$1.1M / $2.2M

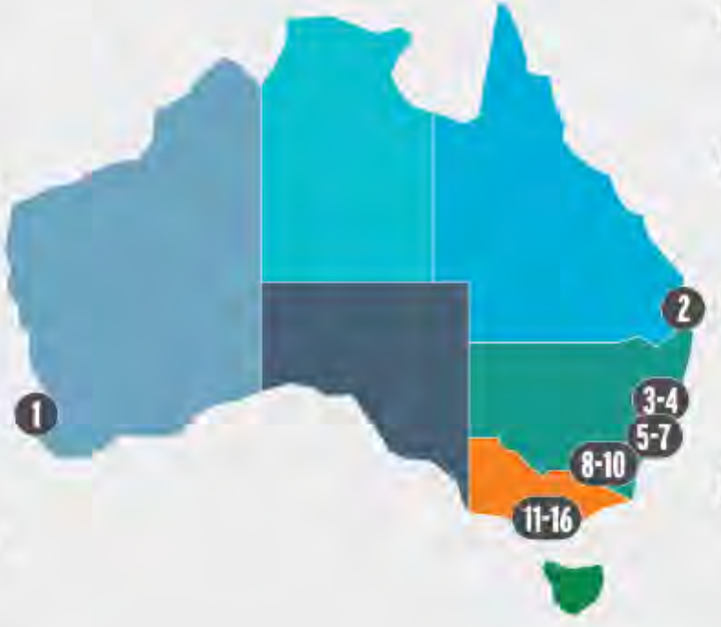
4 CSIRO SOLAR THERMOCHEMICAL HYDROGEN R&D PROJECT
ARENA FUNDING / PROJECT COST
$2.0M / $4.0M

5 MACQUARIE UNIVERSITY BIOLOGICAL HYDROGEN PRODUCTION R&D PROJECT
ARENA FUNDING / PROJECT COST
$1.1M / $2.8M

6 UNSW SYDNEY PHOTOVOLTAIC ELECTROLYSIS TO GENERATE HYDROGEN R&D PROJECT
ARENA FUNDING / PROJECT COST
$1.3M / $5.0M

7 UNSW SYDNEY WASTE BIOMASS TO RENEWABLE HYDROGEN R&D PROJECT
ARENA FUNDING / PROJECT COST
$1.0M / $2.5M

8 ANU HYDROGEN GENERATION BY ELECTRO-CATALYTIC SYSTEMS R&D PROJECT
ARENA FUNDING / PROJECT COST
$0.6M / $1.8M



9 ANU SOLAR HYDROGEN GENERATION R&D PROJECT
ARENA FUNDING / PROJECT COST
$1.7M / $4.4M

10 ANU DIRECT WATER ELECTROLYSIS R&D PROJECT
ARENA FUNDING / PROJECT COST
$1.3M / $3.5M

11 RMIT UNIVERSITY MELBOURNE HYDROGEN STORAGE AND TRANSPORT R&D PROJECT
ARENA FUNDING / PROJECT COST
$0.8M / $1.8M

12 CSIRO HYDROGEN TO AMMONIA R&D PROJECT
ARENA FUNDING / PROJECT COST
$1.2M / $2.8M

13 CSIRO LIQUID FUEL CARRIER R&D PROJECT
ARENA FUNDING / PROJECT COST
$1.0M / $2.5M

14 MONASH WATER SPLITTING ELECTRODES R&D PROJECT
ARENA FUNDING / PROJECT COST
$1.1M / $3.7M

15 MONASH AMMONIA PRODUCTION FROM RENEWABLES R&D PROJECT
ARENA FUNDING / PROJECT COST
$0.9M / $2.7M

16 UNIVERSITY OF MELBOURNE HYDROGEN FUELLED RECIPROCATING ENGINES R&D PROJECT
ARENA FUNDING / PROJECT COST
$2.6M / $8.6M

HYDROGEN FEASIBILITY AND DEMONSTRATION PROJECTS

ARENA

INVESTED	PROJECTS	VALUE	INVESTMENT LEVERAGE
$34M	13	$85M	$1:$1.51

1 YARA PILBARA RENEWABLE AMMONIA FEASIBILITY STUDY
Yara Pilbara Fertilisers
ARENA FUNDING / PROJECT COST
$1.0M / $3.7M

2 HORIZON POWER DENHAM HYDROGEN DEMONSTRATION
Regional Power Corporation
ARENA FUNDING / PROJECT COST:
$2.6M / $8.9M

3 PROJECT GERI FEASIBILITY STUDY
BP Australia
ARENA FUNDING / PROJECT COST
$1.7M / $4.4M

4 THE HAZER PROCESS: COMMERCIAL DEMONSTRATION PLANT
Hazer Group
ARENA FUNDING / PROJECT COST
$9.4M / $22.6M

5 ATCO H2 MICROGRID
ATCO Gas Australia
ARENA FUNDING / PROJECT COST
$1.8M / $3.7M

6 BLENDING HYDROGEN INTO VICTORIAN AND SOUTH AUSTRALIAN GAS INFRASTRUCTURE
Australian Gas Infrastructure Group
ARENA FUNDING / PROJECT COST
$1.3M / $4.2M

7 TOYOTA ECOPARK HYDROGEN DEMONSTRATION
Toyota Motor Corporation Australia
ARENA FUNDING / PROJECT COST
$3.1M / $7.4M

8 DYNO NOBEL EXPANSION OF MORANBAH - FEASIBILITY OF RENEWABLE HYDROGEN
Dyno Nobel Moranbah
ARENA FUNDING / PROJECT COST
$1.0M / $3.0M

9 STANWELL HYDROGEN DEMONSTRATION
Stanwell Corporation
ARENA FUNDING / PROJECT COST
$0.9M / $4.7M

10 QUEENSLAND NITRATES FEASIBILITY STUDY FOR GREEN HYDROGEN AND AMMONIA
Queensland Nitrates (QNP)
ARENA FUNDING / PROJECT COST
$1.6M / $2.9M

11 WALLUMBILLA RENEWABLE METHANE DEMONSTRATION
APA Group
ARENA FUNDING / PROJECT COST
$1.1M / $2.3M

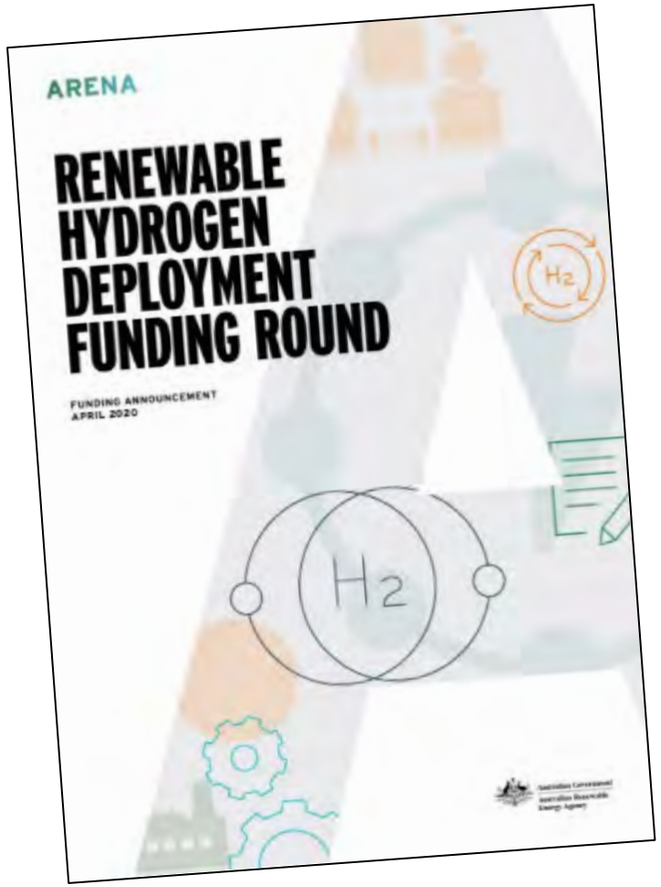
12 BULWER ISLAND RENEWABLE HYDROGEN PRODUCTION AND REFUELLING PROJECT
BOC
ARENA FUNDING / PROJECT COST
$1.0M / $4.2M

13 POWER TO GAS DEMONSTRATION
Jemena
ARENA FUNDING / PROJECT COST
$7.5M / $13.2M

FEASIBILITY STUDIES DEMONSTRATION PROJECTS

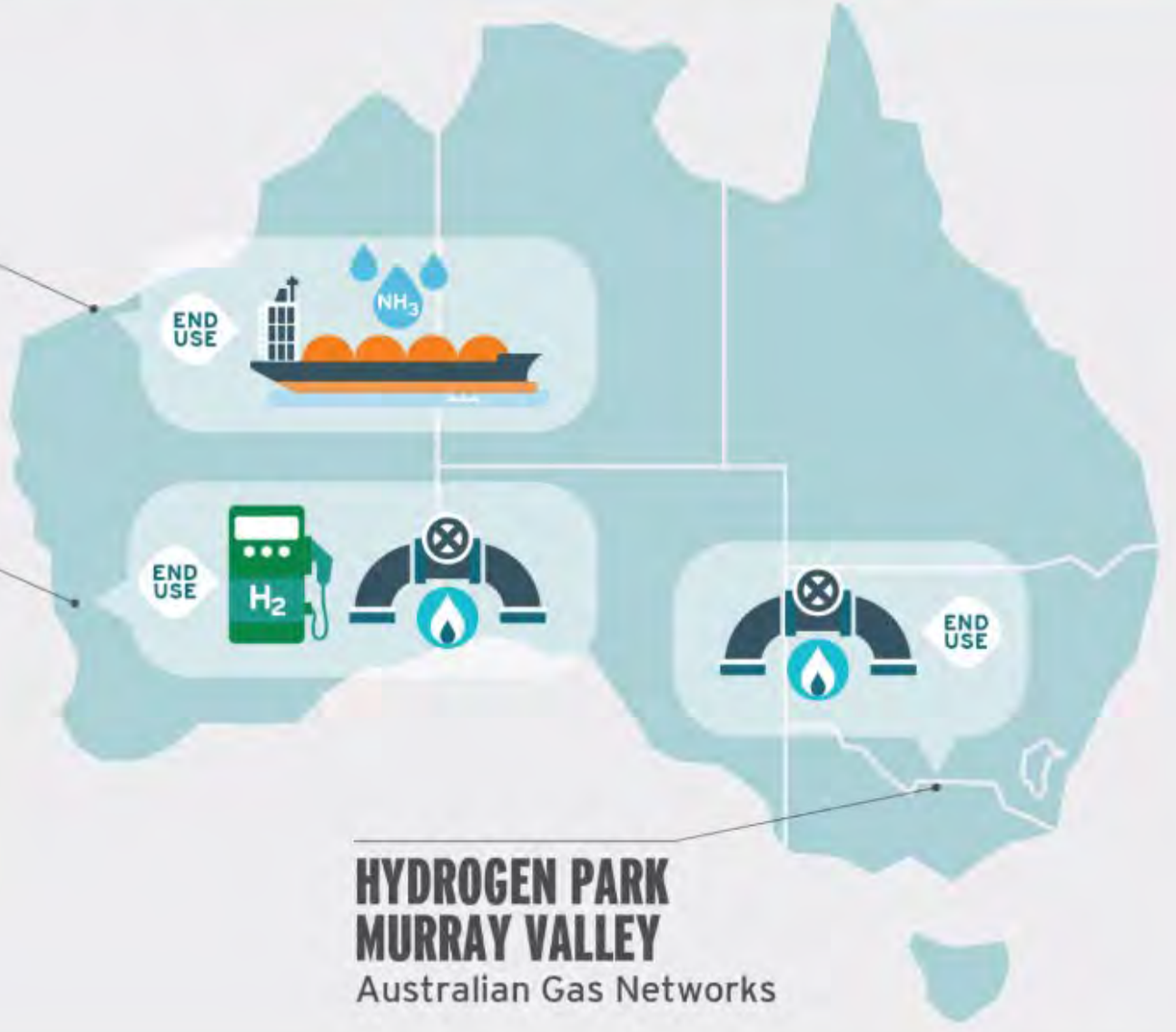
ARENA's $103m Renewable Hydrogen Deployment Funding Round

- Announced as part of **Australia's National Hydrogen Strategy**
- Objectives: price discovery and transparency, demonstration, and a pathway to technical and commercial viability
- 36 expressions of interest (from every Australian state) representing over 1 billion in total grant requests and over $3 billion in total combined project value when you account for private sector investment
- 7 shortlisted projects
    - APT Management Services Pty Limited
    - ATCO Australia Pty Ltd
    - Australian Gas Networks Limited
    - BHP Billiton Nickel West Pty Ltd
    - Engie Renewables Australia Pty Ltd
    - Macquarie Corporate Holdings Pty Ltd (Anglo American)
    - Woodside Energy Ltd



RENEWABLE HYDROGEN DEPLOYMENT FUNDING ROUND

ARENA



YURI PROJECT IN THE PILBARA

Engie Renewables Australia

CLEAN ENERGY INNOVATION PARK

ATCO Australia

HYDROGEN PARK MURRAY VALLEY

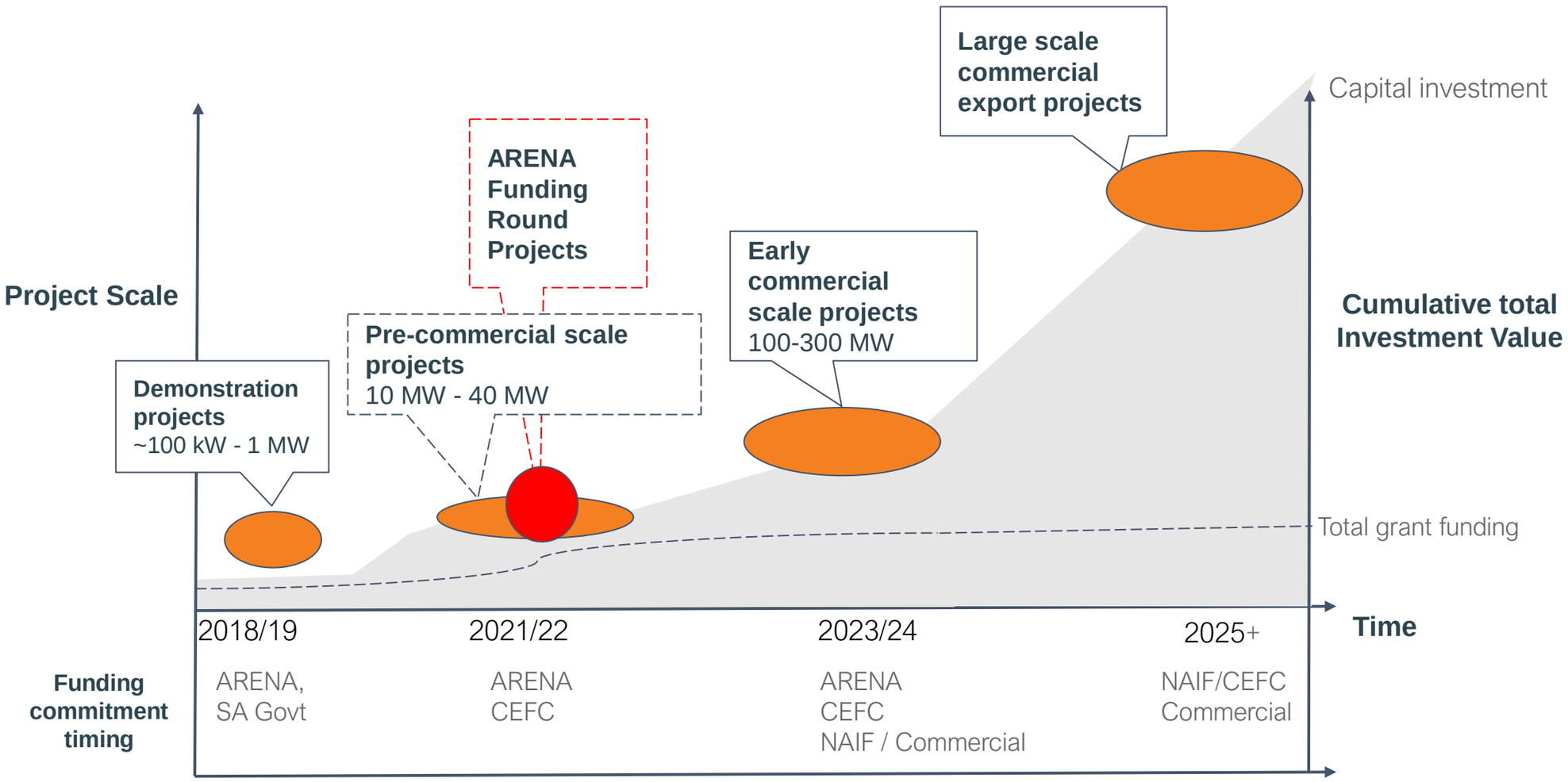
Australian Gas Networks

Conditionally approved $103.3 million in funding to 3 commercial-scale hydrogen projects.

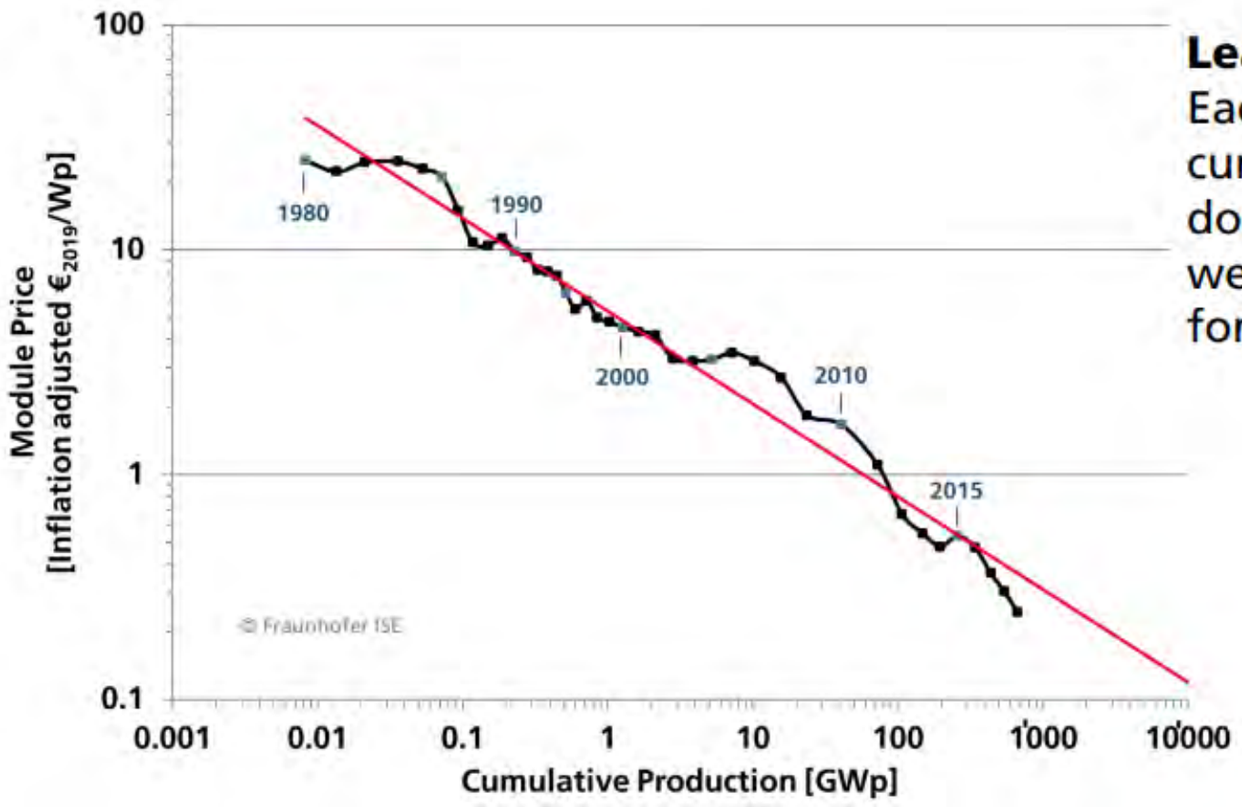
At 10 MW, the electrolysers in these hydrogen plants will be among the largest built in the world.

These projects will help progress Australia's pathway to achieving the Australian Government's goal of 'H2 under $2'.

Hydrogen outlook:
3+ years to long-term commercialisation in Australia



Renewable hydrogen could be the story of solar PV



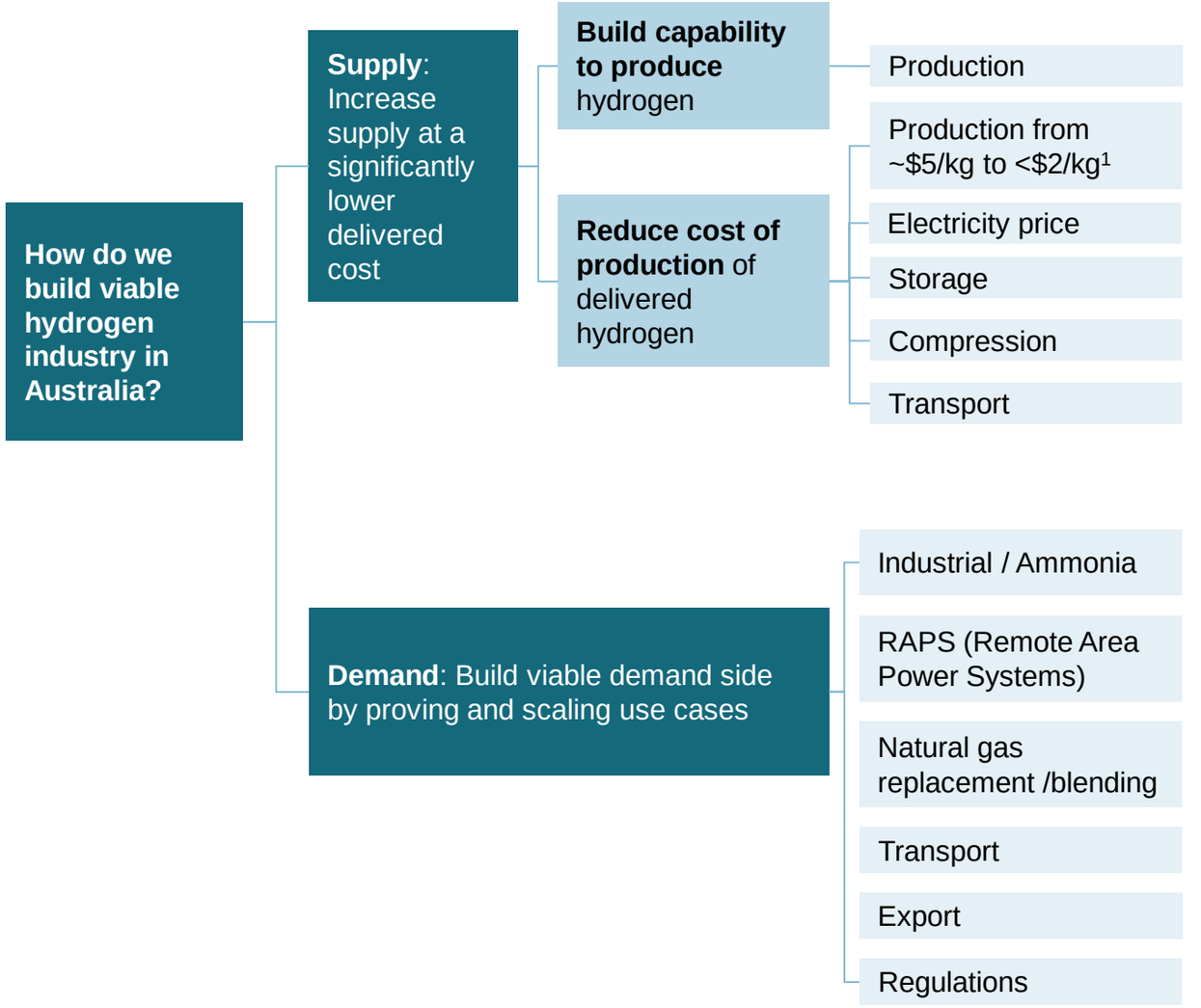
Learning Rate:
Each time the cumulative production doubled, the price went down by 25 % for the last 39 years.

Source: Fraunhofer ISE, September 2020

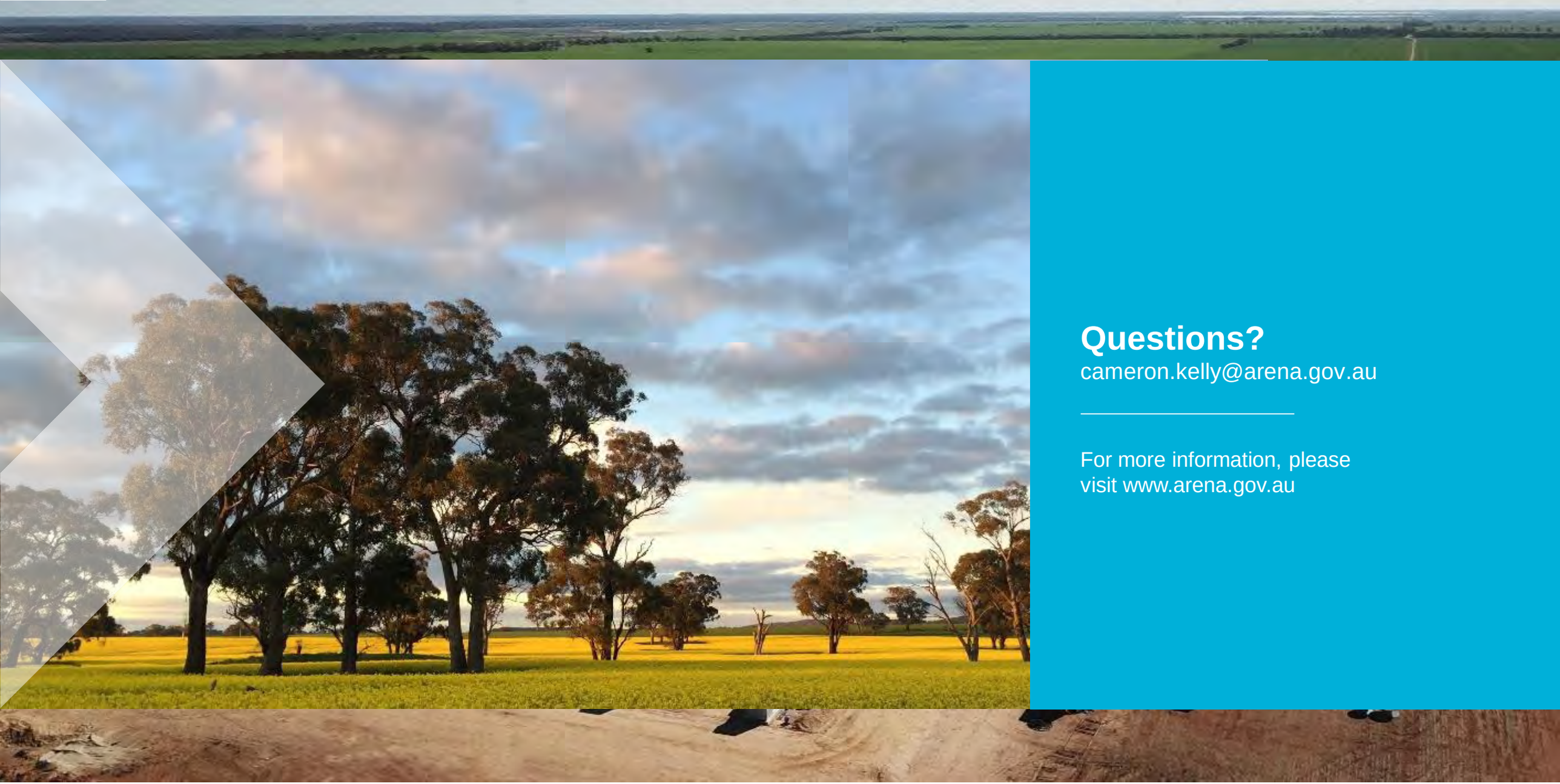
To support the commercialisation of Hydrogen, ARENA must cover both the supply and demand side of the industry

- ARENA has been working in the Hydrogen space already having committed $100M+ in projects
- Hydrogen is a large economic opportunity, well situated for Australia to capture if we start taking steps now – and is called out as a specific priority technology in the LETS
- To play a significant role in the local and global Hydrogen markets, Australia needs to overcome a number of technical and commercial challenges both on supply and demand

High-level hydrogen value chain



1. Including reducing electrolyser capex costs from ~$2-3/MW to ~$0.5/MW and reducing balance of plant costs significantly



Questions?

cameron.kelly@arena.gov.au

For more information, please visit www.arena.gov.au

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Hydrogen in Australia: the competitiveness of low carbon hydrogen

Rupert Maloney
Head of Hydrogen
CEFC

SHEARMAN & STERLING

GILBERT + TOBIN

Contents

The CEFC has a unique role as a catalyst for change: backed by the Australian Government, we invest to lead the market, putting our capital to work in new areas, building investor confidence and accelerating solutions to difficult problems.

cefc

Australia's specialist clean energy investor
Accelerating solutions to difficult problems

We are a specialist clean energy investor with a unique mix of finance and clean energy expertise.

- Proven track record in clean energy investment
- Active Australia-wide
- Independently-run
- Invest with commercial rigour
- Backed by the Australian Government

What we offer

- Tailored finance for renewable energy, energy efficiency and low emissions opportunities
- Focus on projects and sectors with the strongest potential for decarbonisation
- Commercialising proven and emerging technologies, including under the Technology Investment Roadmap
- Private sector expertise with a public policy purpose
- Access to $10 billion in capital from the Australian Government

Our investment priorities

What we look for in working with private capital

FINANCIAL OUTCOMES

Does the project or investment provide a **positive risk adjusted return**, reflecting yield and risk profile?

EMISSIONS REDUCTION

Will the project or investment deliver a **significant reduction** in expected carbon emissions?

MARKET IMPACT

Will the project or investment **catalyse additional private sector finance** to maximise emissions reduction?

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CEFC Advancing Hydrogen Fund

Investing to lead the market

The CEFC Advancing Hydrogen Fund is aiming to invest up to **$300 million** in finance to support the growth of a **clean, innovative, safe and competitive Australian hydrogen industry**.

The CEFC **debt and equity finance** will focus on projects that align with the **National Hydrogen Strategy**, including projects which have State or Territory Government financial support.

Eligible projects

1. Advancing hydrogen production
2. Developing export and domestic hydrogen supply chains, including hydrogen export industry infrastructure
3. Establishing hydrogen hubs
4. Other projects that assist in building domestic demand for hydrogen

As with all CEFC investments, **projects must be commercial**, and achieve an adequate risk adjusted return

Near term focus

ARENA H2 Round

CEFC will seek to provide finance to successful projects in the ARENA Renewable Hydrogen Deployment Funding Round

Other opportunities

Providing finance for opportunities that help catalyse investments in the Australian hydrogen industry while having an adequate risk adjusted return

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Australian hydrogen market study

Where are the economics most favourable?

- **Define key commerciality levers**
- **Identify commerciality sequencing**
- **Identify investment opportunities**
- **Australian perspective**

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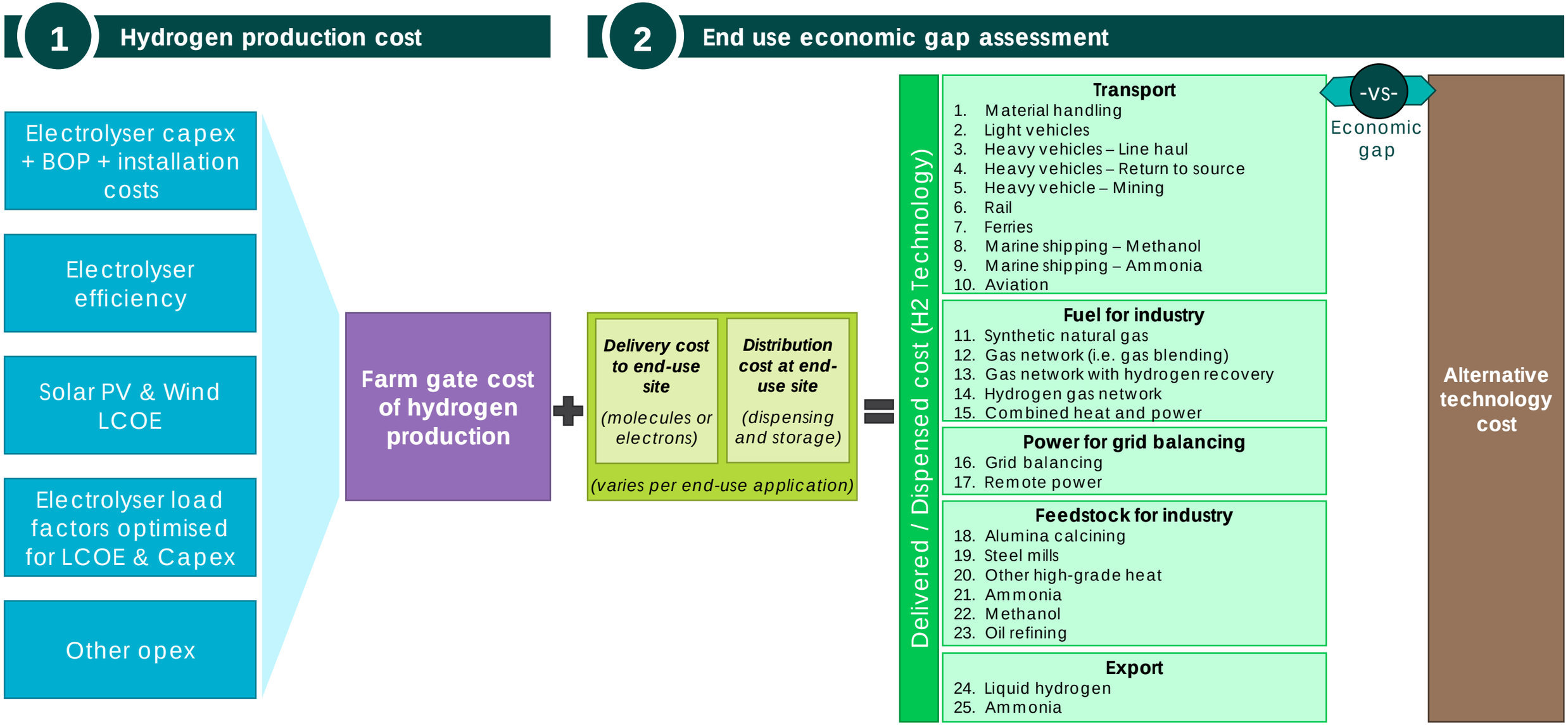
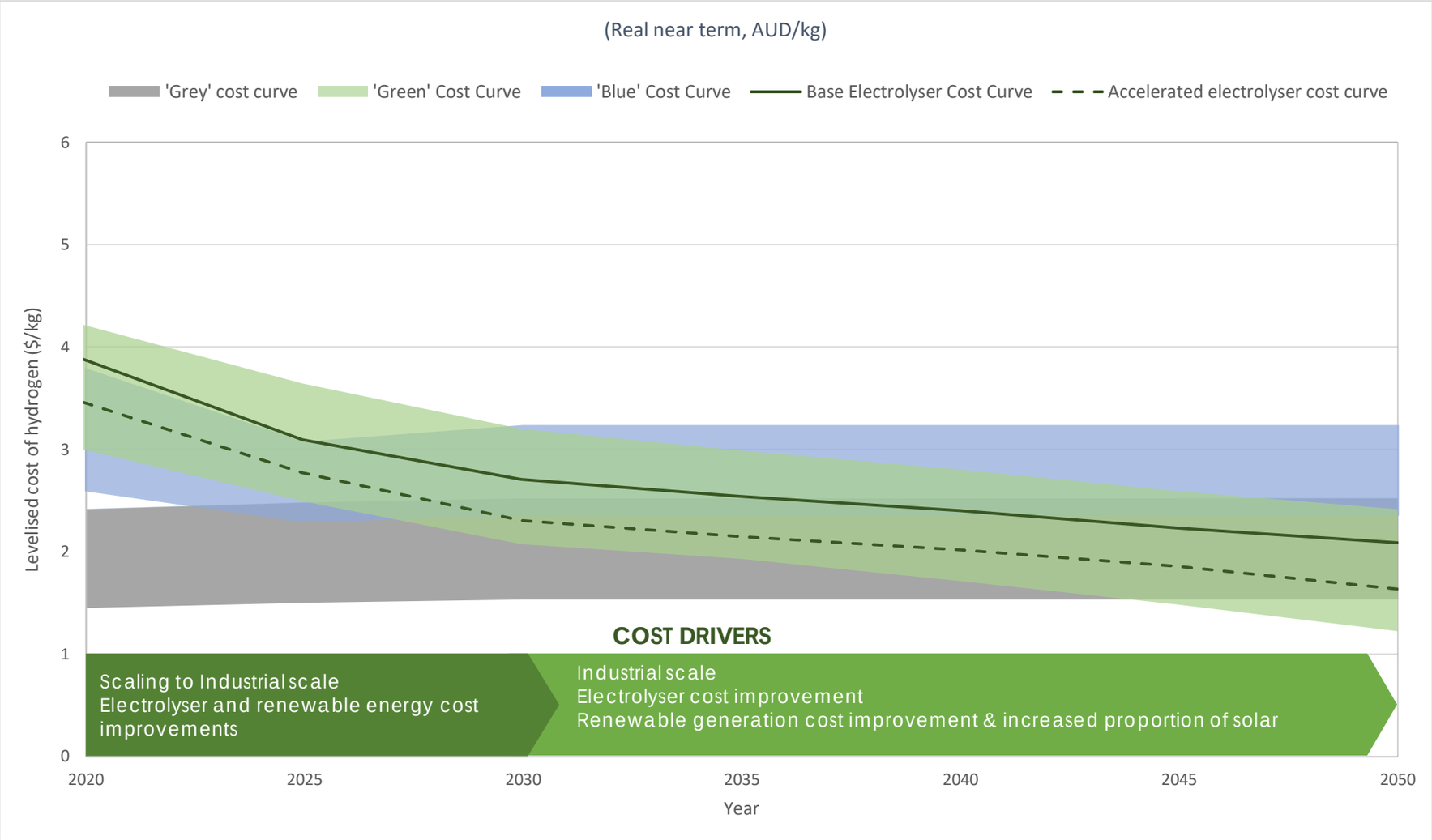
Framework of the study



1 Hydrogen production cost

Forecast 'farm gate' cost of hydrogen production



Key messages

1. Green H2 is forecast to become cost competitive with:
   - Blue H2 by around 2025 – 2030
   - Grey H2 by around 2045
2. However, assuming optimised scenarios, Green H2 can be cost competitive with east cost Grey H2 by around 2030
3. In optimised scenarios, Green H2 could be produced for around A$2/kg by around 2040

Several market commentators and OEMs are forecasting more aggressive cost-outs, resulting in achieving Green H2 cost competitiveness earlier

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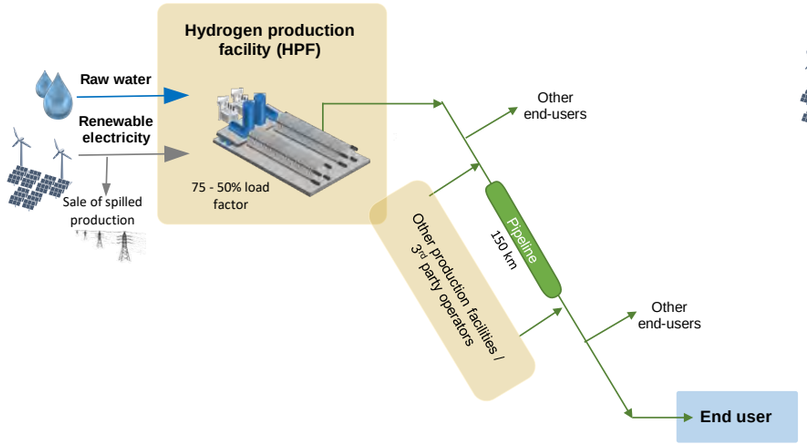
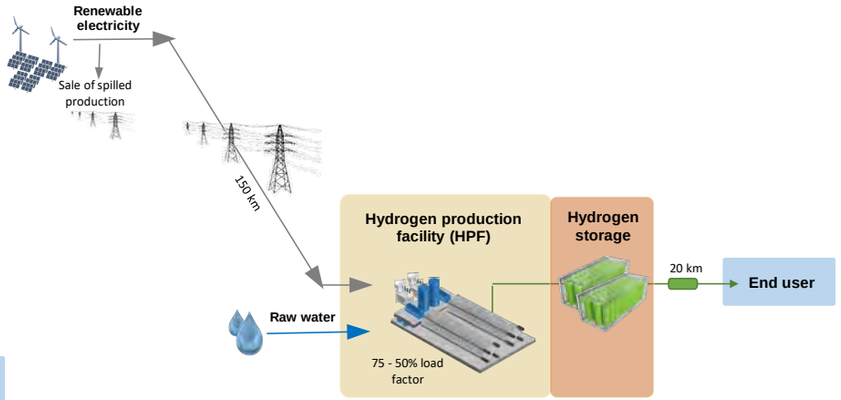
1 Delivery pathways

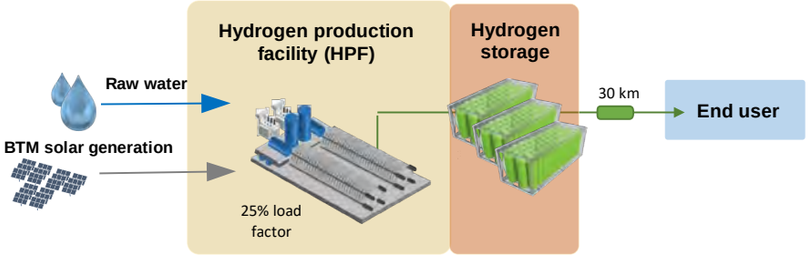
1. Move molecules from RE source



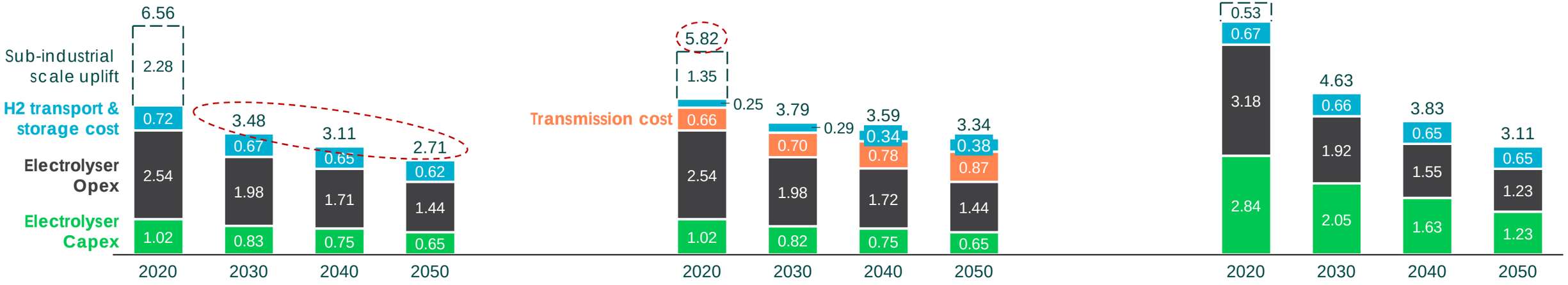
2. Move electrons to H2 production



3. BTM Solar



Levelised cost of hydrogen (A$/kg)



Favourable longer term as increased H2 volumes justify installation of pipelines

Favourable near-term due to sub-scale H2 volumes

Only becomes competitive from around 2050 when capex costs allow for low utilisation of electrolysers

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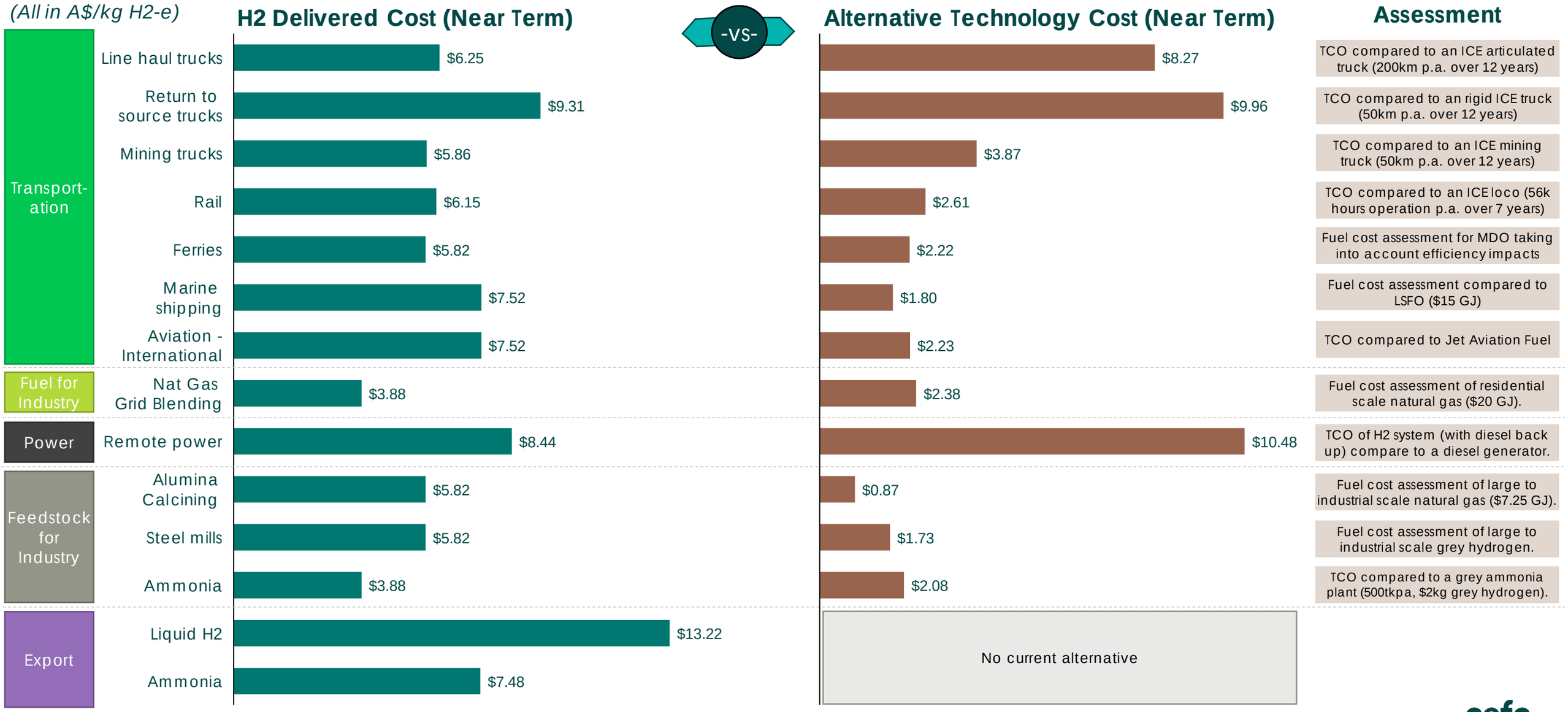
1 Hydrogen delivered cost (selected end-uses)

(All in A$/kg H2-e)



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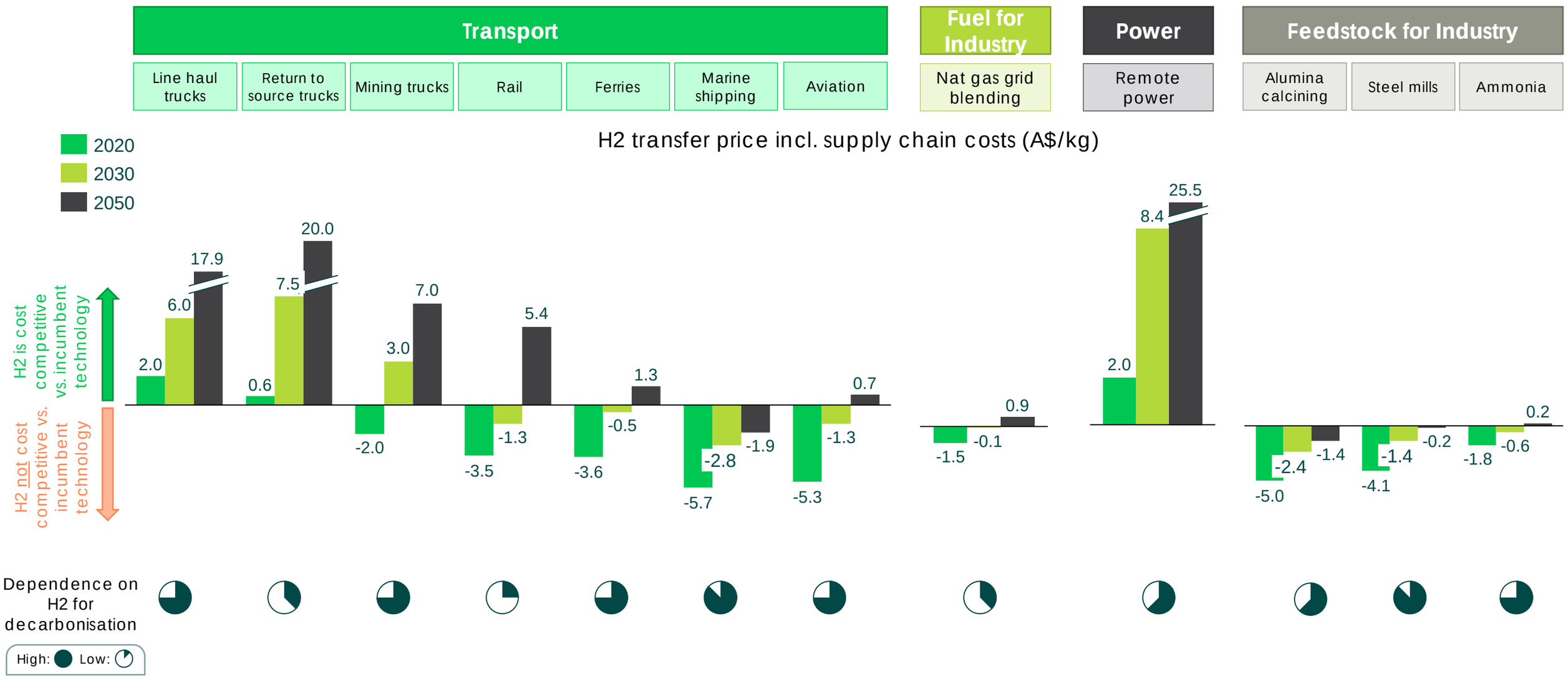
2 Economic Gap (selected end-uses)

Near term opportunities in Transportation and Power, while economics remain challenging for Fuel/Feedstock for Industry

What is an economic gap?

- Comparing the fuel costs of incumbent technology vs. the equivalent H2 based service.
- For example, in transportation, the cost of fuel per km for ICE technology vs. H2 price per km that would deliver the same total cost of ownership (TCO).



Key investment considerations for the CEFC

Opportunities across multiple end-use applications achieving different outcomes

	Displacing petroleum products	Displacing natural gas or derivatives	H2 Export
Key conclusions	• In the near term, **high utilisation heavy transportation** sectors and **remote power** are close to achieving parity • This will likely broaden to include further transport sectors by 2030	• Benefits from limited downstream supply chain cost and complexity • **Transitional use** for clean H2 in the near term to build scale around these large and dedicated demand sources	• The export of hydrogen is forecast to be a **key enabler of the global low carbon economy** • Requirement for customers to pay a premium over the mid-term
Challenges	• Truck/bus availability • Aggregating demand to optimise supply chain costs • Long term offtake to enable bankability (change of mindset required)	• Thermal value of natural gas creates an economic challenge • Nat Gas at $10/GJ = H2 at ~$1.20/kg	• The inherent low density of hydrogen makes the economics of export challenging based on current technologies

Targeted flexible financing solutions to address the challenges of each industry sector

Accelerating the Australian hydrogen industry

Investing directly and indirectly in hydrogen projects and enabling technologies

Direct investment in H2 Projects

CEFC Advancing Hydrogen Fund

- Low-cost and risk sharing financing solutions
  - Risk
  - Tenor
  - Price
- Supporting a broad spectrum of hydrogen use cases

Catalysing investment in the Australian hydrogen industry

Enabling technologies

Supporting the continued roll-out of renewable energy, through CEFC investment in **renewable energy technologies** and **grid reliability**

Supporting the **transition of industries** from carbon intensive process methods to lower carbon fuels and processes

Supporting newly developed hydrogen technologies through the **Clean Energy Innovation Fund**

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Disclaimer

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Investing in Green Hydrogen

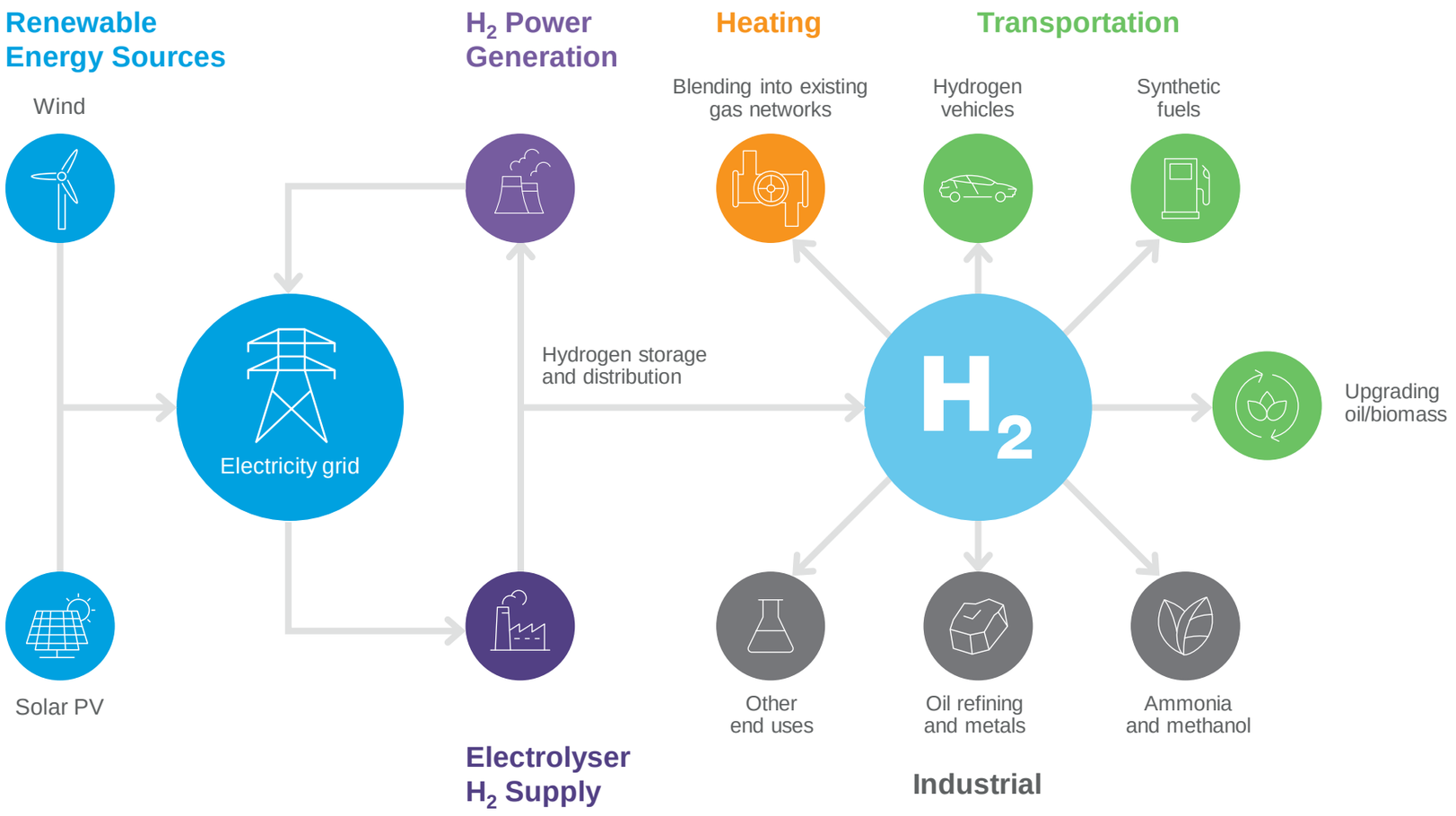
Mike McKensey
Managing Director, Industrial Transition and Clean Fuels
Macquarie Capital

SHEARMAN & STERLING

GILBERT + TOBIN

Hydrogen provides a unique way to accelerate decarbonisation

Hydrogen is complementary to renewables and can replace energy needs that do not have an alternative path to decarbonisation



1
Decarbonises 'hard to abate' sectors

2
Supports the build out of renewables

3
Leverages existing infrastructure and promotes 'coupling' of electricity and gas sectors

4
Complementary to alternative abatement technologies

The hydrogen industry will evolve over time

MACQUARIE

We see the industry developing in three distinct time horizons:

Horizon 1 – Nascent market

Hub opportunities identified

Now to 2022

- Subsidies required
- Production costs are high
- Plant and foundation offtakes are smaller
- Limited experience in market

Horizon 2 – Scale up

Momentum gathers as industry scales up

2023 – 2030

- Costs still rapidly falling driven by industry scaling up
- Certain use cases become economic (e.g. transport, ammonia)
- Plants are scaled into hubs as offtakes are aggregated
- Increasing capital and interest – first mover advantage is captured

Horizon 3 – Global commodity

H2 becomes a commoditised asset class

2030+

- Hydrogen competes with fossil fuels
- Secondary hydrogen market develops
- Gas and hydrogen markets couple
- Hydrogen has become an established asset class

SECTION 2

Project focus

Securing an end user

MACQUARIE

As the market evolves and hydrogen projects are being increasingly announced, it is important to consider the quality and horizon of the proposed offtake

What are we looking for in an end user?

Current landscape of hydrogen end users

- Historically most end users of hydrogen have been industrials who use the hydrogen as a feedstock for process or equipment
- Hydrogen suppliers need to meet strict requirements around **quantity and reliability of supply**
- **Typically price sensitive** and will be looking for:
  - price competitive with other forms of supply; or
  - is value additive to end product

Ideal end user for green hydrogen

- Counterparty that has **large volume requirements** to support a 30MW plant
- **A credible counterparty** capable of supporting a long term supply agreement
- Purchases at a **fixed price** and **has appetite to pay a 'green premium'** for low emission product
- Has **redundancy options** and does not need to rely on the output

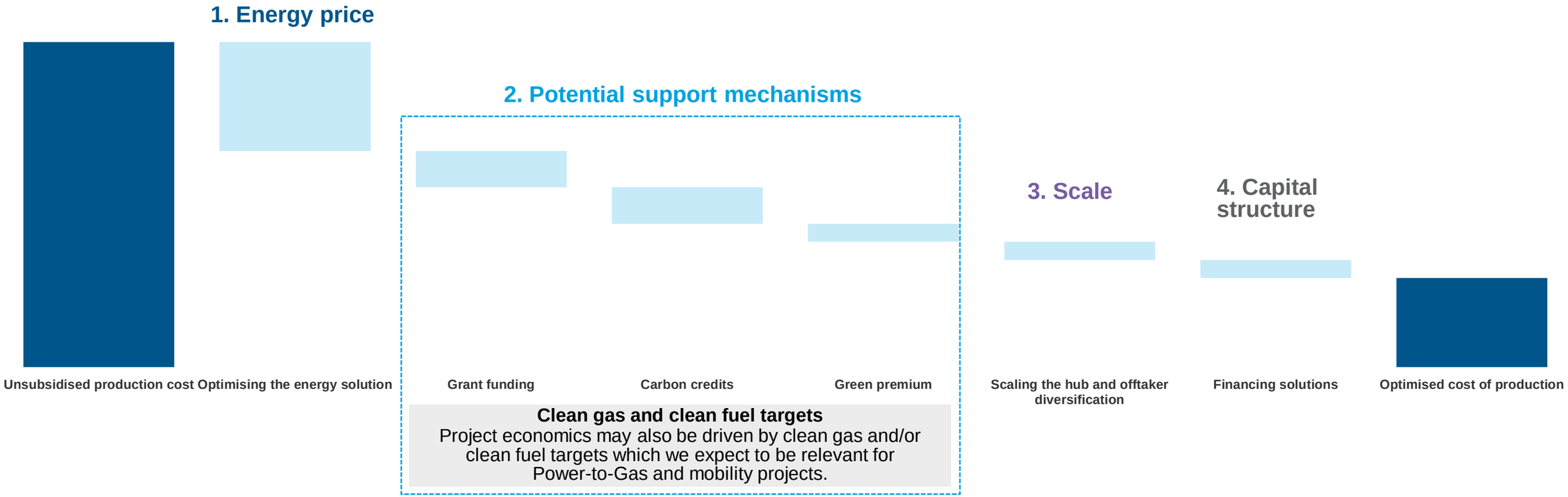
Likely end user for green hydrogen today

- **Industrial user** who wants to be seen as an early mover and who can incorporate large volumes directly into existing plants
- **Willing to consider a 'green premium'** longer term but not willing to pay one today
- **Willing to be more flexible on reliability** of supply as has some redundancy options
- Situated in an industrial park with **good potential for future growth**

Supporting project economics

Successfully developing a hydrogen project today is difficult due to high cost environment and evolving energy market; to make project economics work a range of value levers must be exercised

Key project value levers



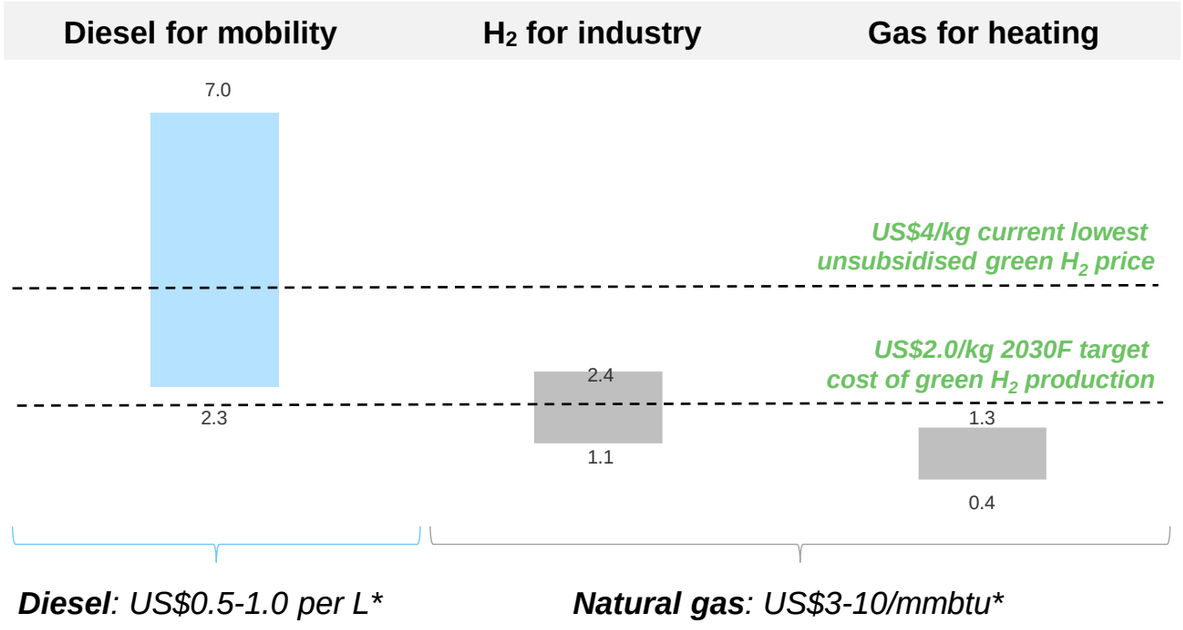
Relative economics and long term drivers

MACQUARIE

The different hydrogen use cases are at different stages of readiness which is a key driver of project and investor activity

Hydrogen becoming competitive with fossil fuels

Hydrogen breakeven cost by end use case (US$/kg)



Factors driving long term hydrogen adoption

1. **Significant cost out in H_2 production**
2. **Technology development to support demand side readiness**
3. **Enabling regulation and supportive policy environment**
4. **Development of a secondary H_2 market**

Notes: (*) Reflects current market price for diesel and natural gas, not including a carbon price

MACQUARIE

SECTION 3

The Australian context

Hydrogen in the Australian context

MACQUARIE

We see hydrogen as playing a fundamental role in transitioning Australia's energy system, onshore industry and export supply chains

1

Integrating hydrogen into our energy system

- Highly complementary to rapid growth in traditional renewables (wind/solar)
- Geographically dispersed energy networks (electricity and gas) and end users renders full decarbonisation via electrification challenging
- Strengthening domestic fuel security

2

Decarbonising our onshore industry and transport

- Energy intensive onshore industry often concentrated in high density areas presents opportunities for 'decarbonisation hubs'
- Significant heavy transport sector heavily reliant on diesel which must be displaced by clean fuels over time

3

Transitioning Australia's key exports

- Ability to facilitate end-to-end transition of extensive export supply chains (mining, agriculture) to support higher value 'green' product
- Hydrogen and derivatives present opportunity to export Australia's abundant renewable resource

Using hydrogen as a decarbonisation pathway

MACQUARIE

Entities looking to leverage hydrogen as a decarbonisation pathway should consider the following:

Developer capability

- **Hydrogen projects are complex**; while the technology is well known, there is **substantial optimisation required**
- There has been a long history of safe handling of hydrogen but **safety must remain a priority**

Scale is critical

- **It will take some time** for hydrogen to become a widely traded commodity
- While bilateral markets exist, **looking for producers that can scale** will provide access to falling commodity prices over time

Early mover advantage

- **Australian and State Governments are looking to support development of a hydrogen industry** and will reward credible early movers
- **Offtakers and developers need to work in partnership** to develop early projects
- **Aggregating of demand** (either on a geographic or industry basis) is likely to create the best outcomes

Site selection

- **Securing sites that will be key suppliers or users** of H2 has the potential to drive significant value
- **Understanding timeframes and the expected scale up path** is important for driving value

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YURI Green Hydrogen to Ammonia Project and Pilbara Hydrogen Hub

PingYang Li
Senior Vice President,
Business Development
ENGIE Hydrogen

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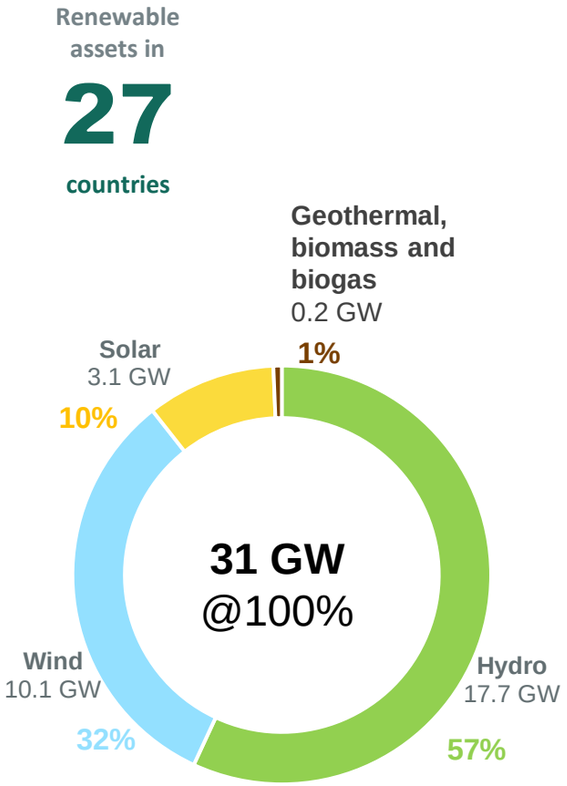
ENGIE – Lead the Energy Transition



ENGIE's hydrogen strategy

Being first-mover to maximize Hydrogen market growth potential, to increase knowledge & capability, de-risk projects and accelerate Hydrogen competitiveness.

1. Target right geographies with competitive renewable energy, supportive policies and local ENGIE presence.

2. Anchor large-scale offtakes through customer solutions in energy-intensive industries such as mining, ammonia, steel, refinery…

3. Develop domestic hubs with multi usages, aggregating other end-uses: electricity, heavy-duty mobility, process, storage ..., to increase the value of the solution.

4. Replicate the solution and leverage existing assets in storage & pipeline.

   In the long run, develop international hubs and export green energy to regions with limited RE potential.

ENGIE Hydrogen - Pipeline and Target

Strong pipeline of projects

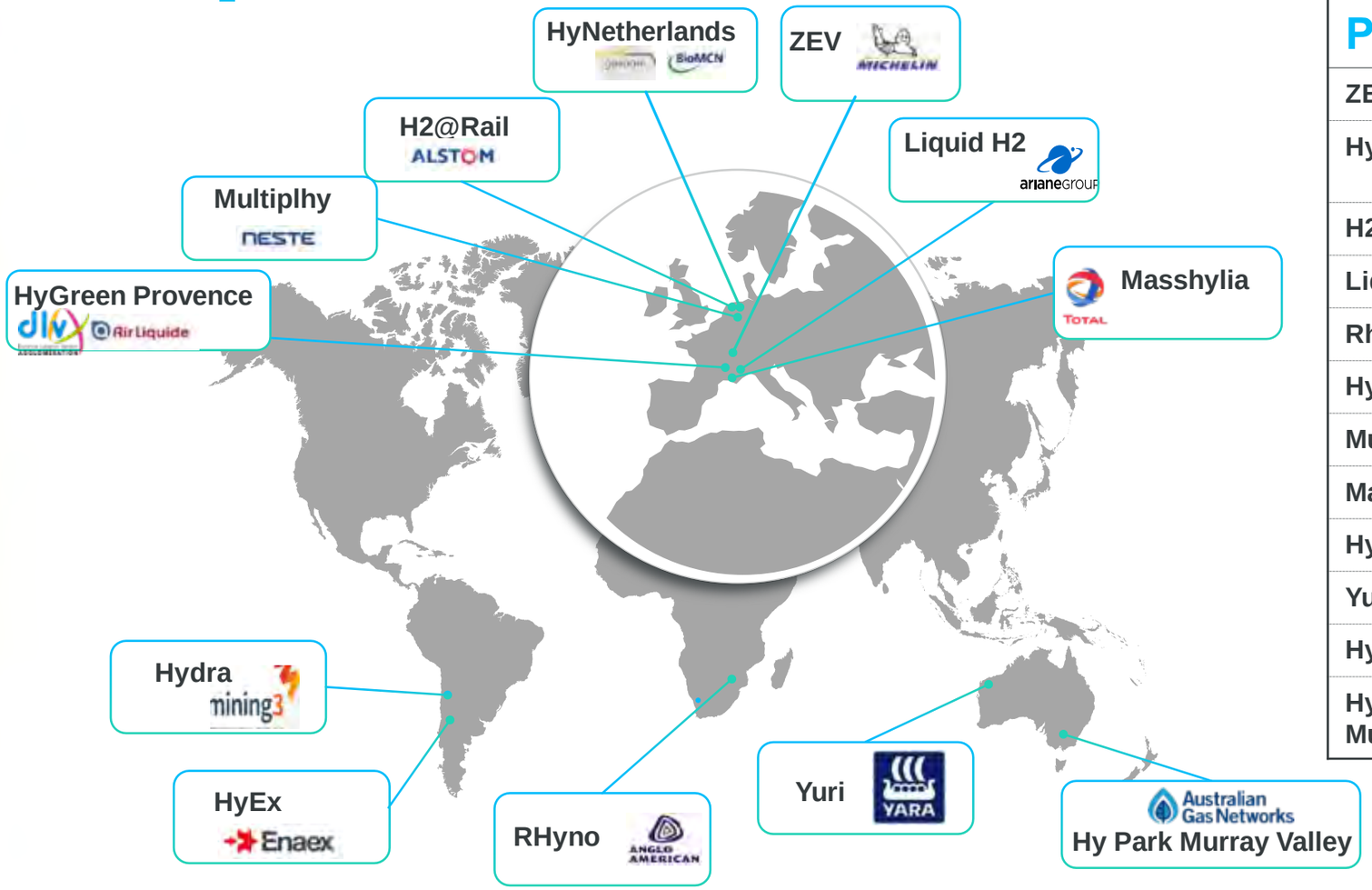
8 GW of green hydrogen capacity over 70 projects

~20 projects > 50 MW

+50 projects < 50 MW

	2025		2030
Production	**0.6 GW** Green hydrogen capacity	→	**4 GW**
Midstream	**170 km** Transmission Pipeline	→	**700 km**
	270 GWh Storage	→	**1 TWh**
Mobility	**50** Refueling stations	→	**>100**

We Operate Worldwide



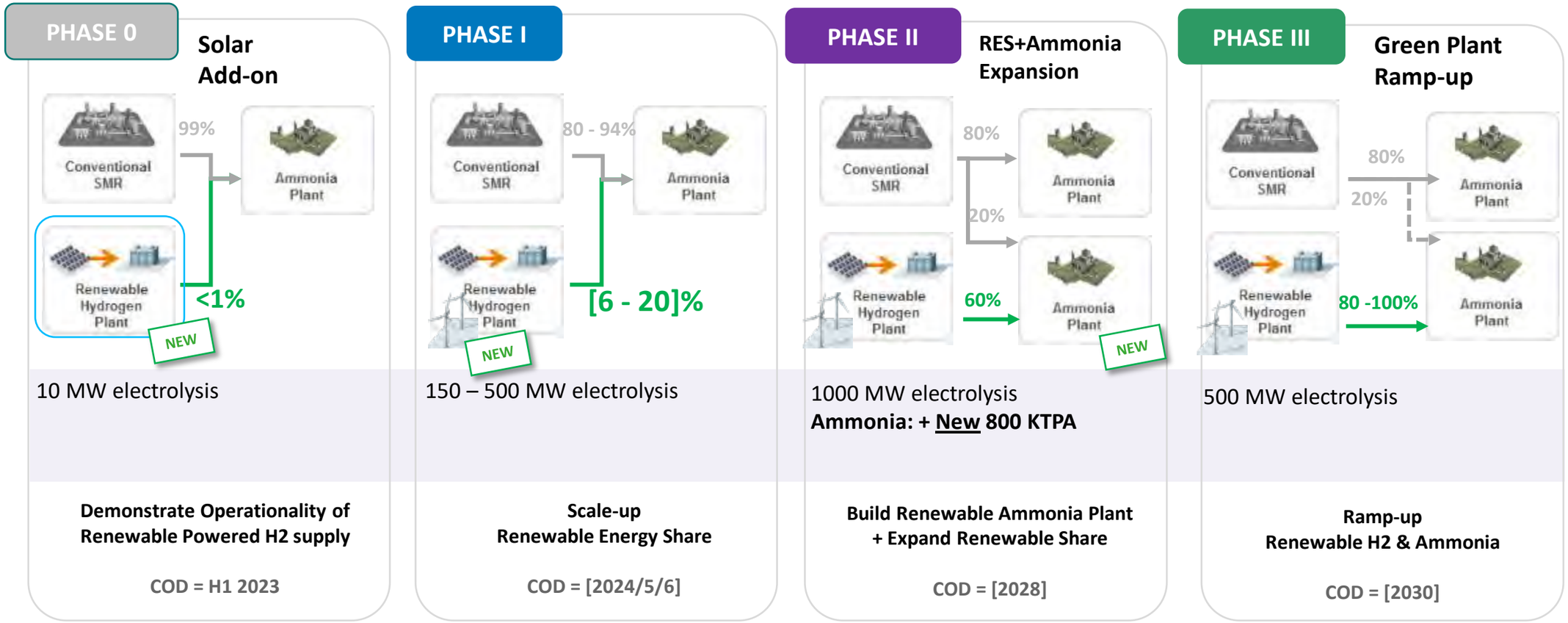
Projects	Sectors
ZEV	Mobility
HyGreen Provence	Mobility, chemical feedstock
H2@Rail	Trains
Liquid H2	Maritime and more
Rhyno	Mining
Hydra	Mining
Multiplhy	Bio-refinery
Masshylia	Bio-refinery
HyEx	Green ammonia
Yuri	Green ammonia
HyNetherlands	Chemical feedstock, fuel
Hydrogen Park Murray Valley	Natural gas network injection

Yara – Engie collaboration in Pilbara – YURI Project

Ammonia terminals in Asia Pacific and Oceania. Source Fertecon IHS Markit.

YURI has a multi-phase (Phase 0-I-II-III) roadmap (YURI Roadmap) which aims to establish a new industry value chain, harvesting the abundant renewable power in Western Australia to make renewable hydrogen and ammonia as feedstock for renewable chemical production as well as renewable fuel for power generation and shipping, to serve local and export markets.

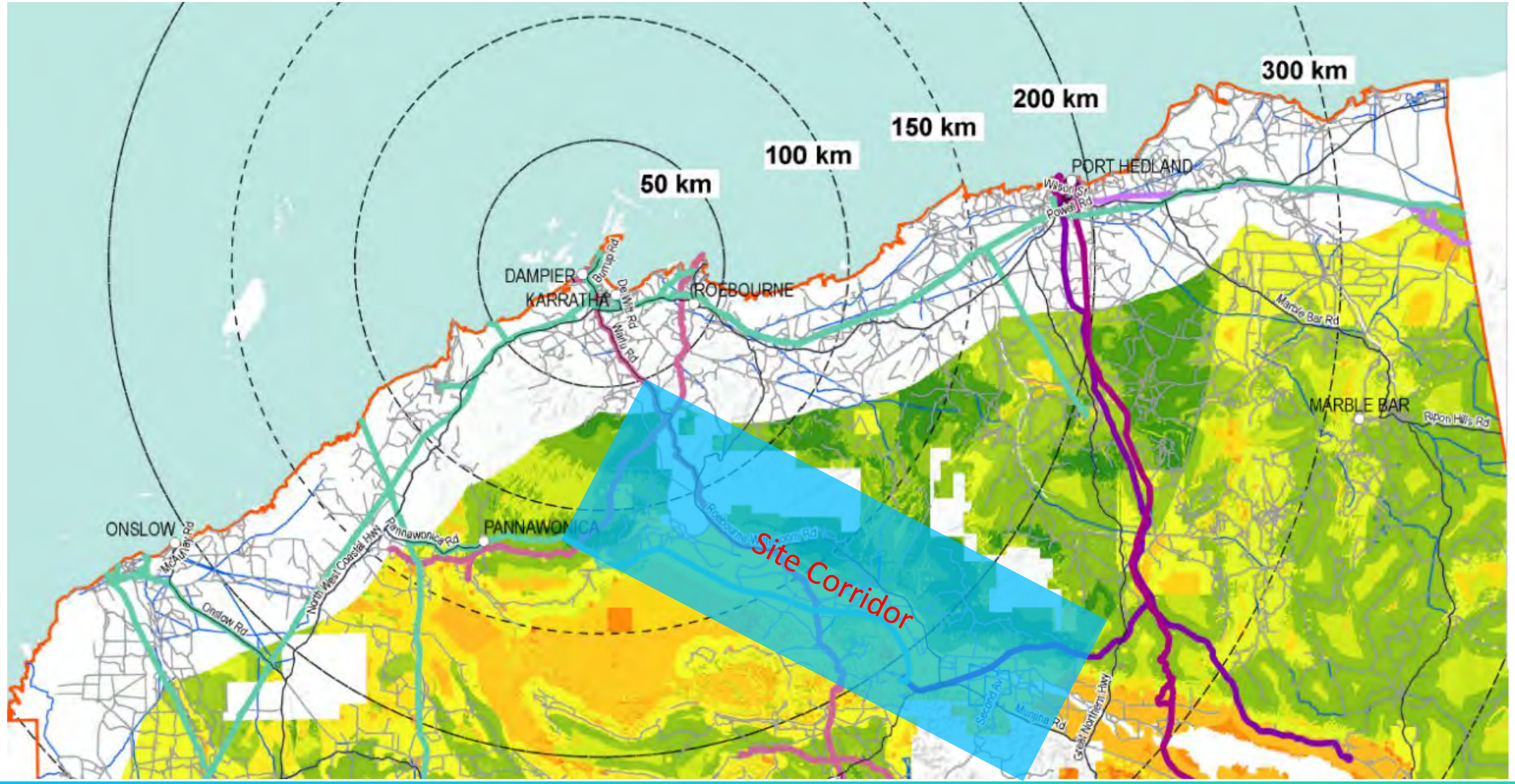
Pilbara Hydrogen Hub - YURI as a key building block



YURI primary hydrogen usage is planned to produce renewable ammonia.
"Pilbara Hydrogen Hub" can supply hydrogen to YURI project plus below options :

a. inject hydrogen into natural gas pipeline, e.g. the nearby Dampier Bunbury pipeline systems.
b. supply hydrogen to road transportation and mining trucks.
c. **export** hydrogen via Dampier port in liquid form or chemical compound.

Renewable Power Site Corridor



Dampier Port – for Export

Burrup Strategic Industrial Area

https://youtu.be/3xgJ0FFak0Q

Dampier Port on Burrup Peninsula

- One of the world's largest bulk export ports, established since mid-1960s.
- Bulk liquid wharf is around 4km from Yara ammonia plant.

Dampier Port handles the following commodities:

Anhydrous Ammonia	LPG
Condensate	Petroleum
Diesel	Project Cargo, Break Bulk
Iron Ore	and General Cargo
LNG	Salt

Port capacity - Port of Dampier

BERTHS / PRIVATE FACILITIES	LENGTH OF WHARF (M)		DECLARED DEPTH AT BERTH (M)
Patrick Marine Facility (West)	100.0		7.8
Patrick Marine Facility (East)	100.0		6.7
Floating Deck Transhipment System	45.0		5.1
King Bay Supply Base	230.0		7.2*
Mermaid Marine 1	Combined 175		7.6
Mermaid Marine 2			7.2/6.6
Mermaid Marine 3	108		5.1
Mermaid Marine 4	65		4.6
Mermaid Marine 5	Combined 95		5.2
Mermaid Marine 6			5.0
LCT (Landing Craft) Barge Ramp	-		4.0
	Minimum - Maximum Vessel Length × Beam	Berthing Displacement (T)	
East Intercourse Island (EII)	340 × 50	150,000 T	20.8*
East Intercourse Island Lay By Berth	340 × 50	150,000 T	19.7*
Dampier Fuel Berth	229 × 35	46,000 T	11.4
Parker Point Berth 2	300 × 47	142,000 T	19.2*
Parker Point Berth 3	300 × 47	142,000 T	19.4*
Parker Point Berth 4	330 × 55	142,000 T	19.3*
Parker Point Berth 5	300 × 50	142,000 T	18.8*
Mistaken Island	225 × 35	74,000 T	12.2*
Pluto Jetty – LNG and Condensate	180 – 315	110,000 T	13.5
Withnell Bay - LNG 1	190 – 300	90,000 T	12.8*
Withnell Bay – LNG 2	270 – 310	110,000 T	12.8*
Withnell Bay – LPG and Condensate	190 – 300	90,000 T	13.3*
Port Authority facilities			
Dampier Cargo Wharf (West)	209.6		9.1*
Dampier Cargo Wharf (East)	143.0		6.9*
Heavy Load Out facility	50.0		5.9
Dampier Bulk Liquids Berth	228.0	55,000 T	12.4

Q & A

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An International Perspective

Dan Feldman
Partner
Shearman & Sterling

SHEARMAN & STERLING

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By the 2030s, Hydrogen Is The New Global Energy Molecule

ENERGY earthshots U.S. DEPARTMENT OF ENERGY | Hydrogen

Overview

The U.S. Department of Energy's (DOE's) Energy Earthshots initiative aims to accelerate breakthroughs of more abundant, affordable, and reliable clean energy solutions within the decade.

Achieving the Energy Earthshots will help America tackle the toughest remaining barriers to addressing the climate crisis, and more quickly reach the Biden-Harris Administration's goal of net-zero carbon emissions by 2050 while creating good-paying union jobs and growing the economy.

Hydrogen Shot Summit

The first Hydrogen Shot Summit took place Aug. 31-Sept. 1, 2021.

Learn more

The first Energy Earthshot, launched June 7, 2021—Hydrogen Shot—seeks to reduce the cost of clean hydrogen by 80% to **$1** per **1 kilogram** in **1 decade** ("1 1 1").

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Business
Jul 24th 2021 edition ›

Burning clean

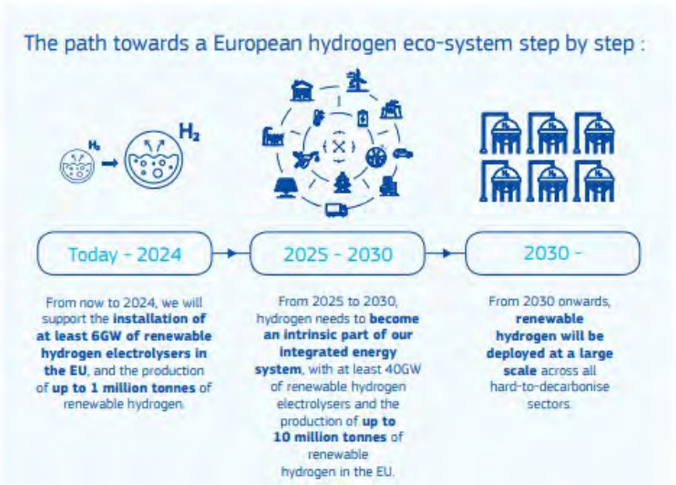
Japan Inc wants to become a hydrogen superpower

Falling short: IEA claims $1.2 trillion hydrogen investment needed by 2030 to hit net zero goals

Paris-based agency claims only a fraction of low-carbon hydrogen required to meet net zero emissions by 2050 is under development

5 October 2021 6:12 GMT UPDATED 6 October 2021 14:38 GMT
By Josh Lewis in Paris

The EU Hydrogen Strategy will give a boost to **clean hydrogen production in Europe**. Hydrogen can be used as **a feedstock**, **a fuel** or **an energy carrier and storage**, and has many possible applications which would reduce greenhouse gas emissions across industry, transport, power and buildings sectors. The Commission's economic recovery plan 'Next Generation EU' highlights **hydrogen as an investment priority** to boost economic growth and resilience, create local jobs and consolidate the EU's global leadership.



BAI YUJIE, LIU YUKUN, WEN SIMIN and DENISE JIA, Caixin
June 21, 2021 13:02 JST

财新 Caixin

China has been cranking up investments in hydrogen, a renewable and potentially clean source of energy. The country's central and local governments have inked the hydrogen industry into the 14th Five-Year Plan (2021-2025) as one of China's six industries of the future.

The China Hydrogen Alliance, a government-supported industry group, predicts that by 2025 the output value of the country's hydrogen energy industry will reach 1 trillion yuan ($152.6 billion), and by 2030 that China's demand for hydrogen will reach 35 million tons, accounting for at least 5% of China's energy system.

Modi pledges massive green hydrogen 'quantum leap' to Indian energy independence

Prime Minister says nation to become 'global hub' for renewable H2 that can ease reliance on imported fossil fuels

16 August 2021 12:03 GMT UPDATED 16 August 2021 14:20 GMT
By Andrew Lee

Prime Minster Narendra Modi put green hydrogen centre stage of India's economic policy as he claimed it can help the nation make a "quantum leap" to energy independence by 2047.

Modi prominently flagged the launch of a National Hydrogen Mission in his annual Independence Day speech, citing massive expansion of H_2 produced from renewables as a route to reducing historic reliance on imported fossil fuels.

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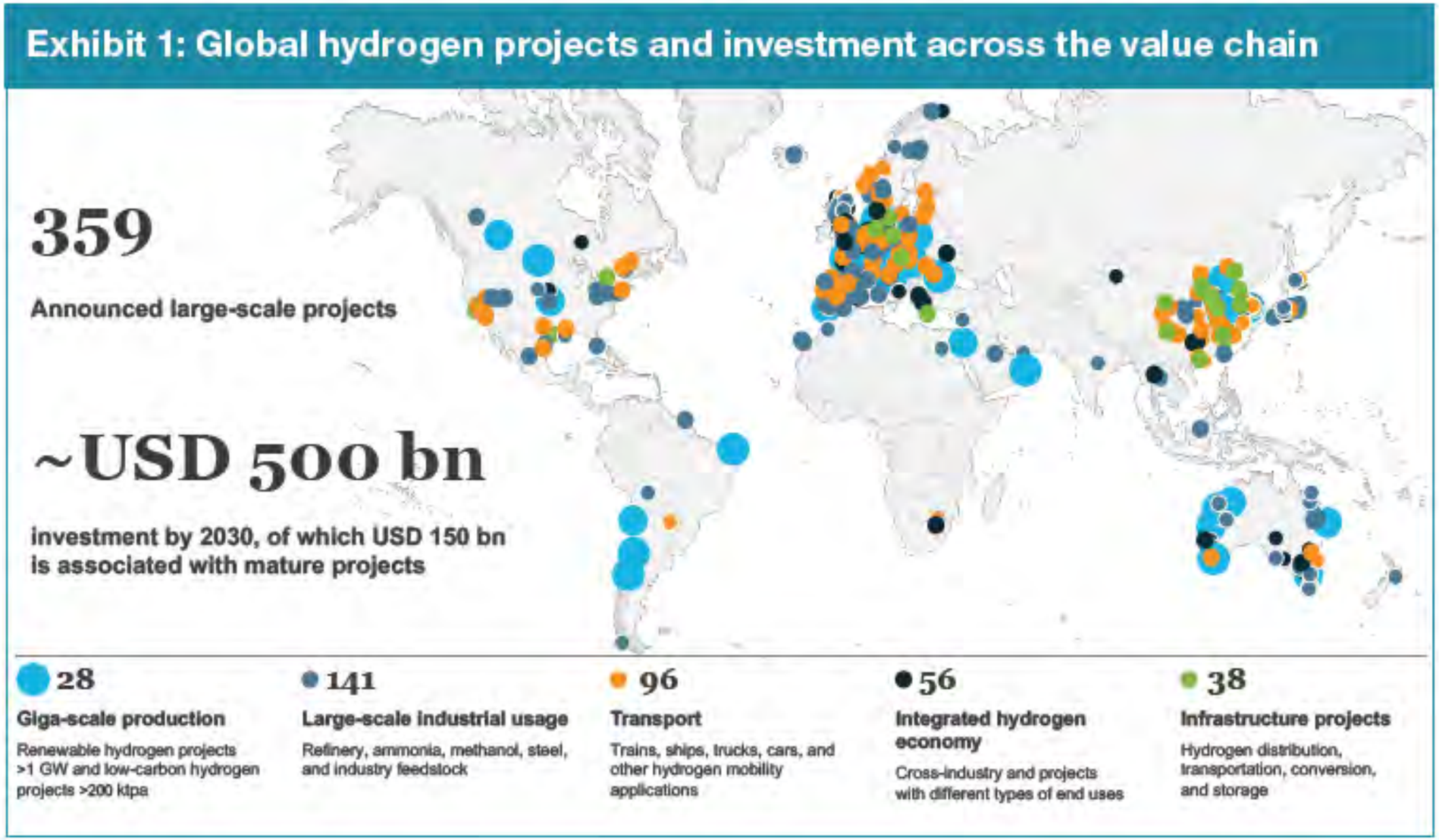
Hydrogen economy

Korean conglomerates bet big on hydrogen, launch H2 council

Five big businesses have also vowed to spend $37.2 billion in hydrogen infrastructure

By Kyung-Min Kang and Jeong-Min Nam Sep 08, 2021 (Gmt+09:00)

And There Is A Growing Pipeline Of Projects Across The Value Chain



Our Own Business Is Already Seeing This Around The World In Real-Time

Advisers on the world's first green hydrogen / ammonia export megaproject to commence construction, involving 4GW of solar and wind and a 2GW electrolyser in Saudi Arabia with Air Products (USA) and ACWA Power (KSA).
Capex is US$5 billion, plus $4 billion of downstream capex.

Advisers on the two largest green hydrogen projects (one electrolysis, the other pyrolysis) in the USA.

Advisers to a group of 25 lenders on Saudi Aramco's US$12 billion grey hydrogen and power project at Jazan, a joint venture with Air Products (USA) and ACWA Power (KSA). This is the largest hydrogen project currently in the world. The US$7.5 billion financing was signed in Ovtober 2021.

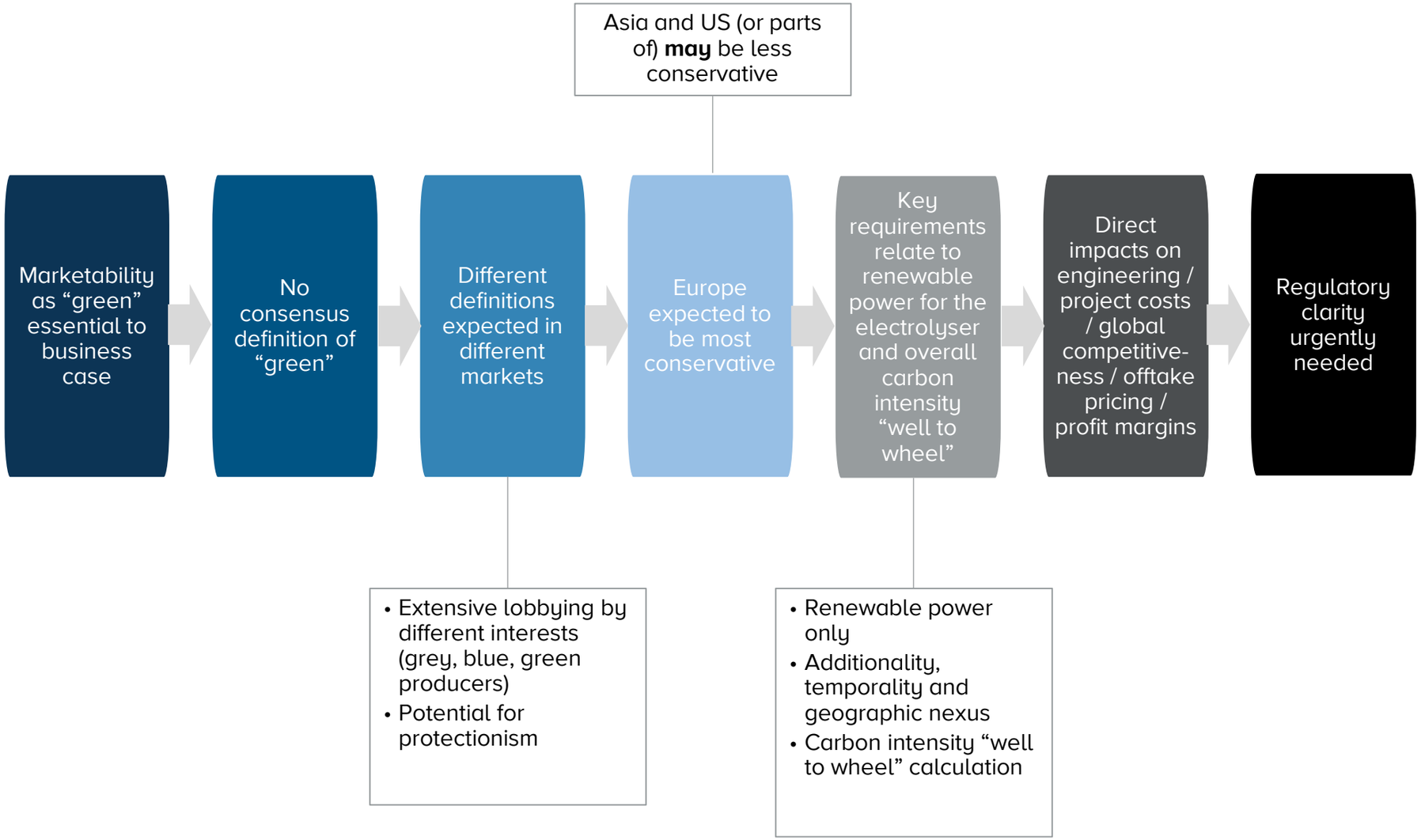
Advisers on the world's first blue ammonia megaproject, a joint venture with OCI in Abu Dhabi, UAE, combining grey hydrogen production with carbon capture and sequestration.

Drafting the world's first end-to-end, production-to-use hydrogen legislation, on behalf of a government related entity.

Déjà Vu: We Expect The Global Industry To Mirror The Evolution of LNG

	Current state of the market (2020s)	Future state of the market (2030s)
Nature of Offtake	**Higher-risk / higher-reward**	**Commodity-style risk profile**
Downstream market profile	**Downstream market risky / speculative** • Small pool of large scale consumers • Regulatory uncertainty	**Established demand centres** • Clear destination markets and consumers • Some markets "greener" than others
Trading of product	**Limited spot market / trading** • Small pool of export projects • No established supply chains • No agreed standards on specification **Zero / limited opportunities for redirection / arbitrage**	**Merchant market** • Portfolios of export projects • Established shipping, trucking pipeline supply chains **Opportunities for sophisticated marketing / trading operations**
Nature of offtake arrangements	**Long-term take or pay offtakes** - debt will struggle to take market risk	**LNG-style offtake strategies** - debt may take some market risk
Offtaker involvement in equity	**Typical -** Risk management for both offtakers and other sponsors	**Less typical** - Fewer offtakers involved in equity as offtake terms more offtaker-friendly
Features of pricing	• Price needs to cover **project costs, repay debt** and provide **acceptable IRR** • Pricing must **balance the following** (all of which overlap): - No track record on market pricing - Forecast on grey / brown ammonia demand and pricing - Competitive profile of green hydrogen project costs over life of the investment - Future natural gas and gray, blue and green hydrogen demand - Carbon pricing and other taxes - Supply chain costs - Labour costs	• Market pricing track record • Financial tools available to manage volatility
Tenor of offtake	**Longer** to cover tenor of debt	**Mix** of term and spot
Who has the bargaining power?	**Suppliers**, as there is a limited pool (both upstream and midstream)	**Buyers**

But Regulatory Uncertainty Will Challenge Development Of A Commodity Market



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