Argus Low Carbon Hydrogen Strategy Report Sample

Part One: Asia-Pacific and the Middle East

Argus Low Carbon Hydrogen Strategy Report

Part 1 of 3

Part 1: Asia-Pacific and the Middle East

Part 2: Europe and Africa

Part 3: Americas

8 countries

Japan, South Korea, Australia, India, China, Oman, Saudi Arabia and UAE

~500 slides

Containing comprehensive data and insight in the form of data, analysis, charts, tables, maps, infographics, and more

Databook

Key data for demand and breakeven prices by sector

Green and blue projects

Hydrogen project pipeline by country, including developers, capacity, timelines, renewable energy generation, electrolyser details, offtake agreements

8 demand sectors

Refining, fertilizer, power generation, gas blending, road transport, steel, maritime and aviation

Breakeven analysis

Breakeven price analysis of hydrogen technologies versus sector incumbents and alternative fuels

Access to market experts

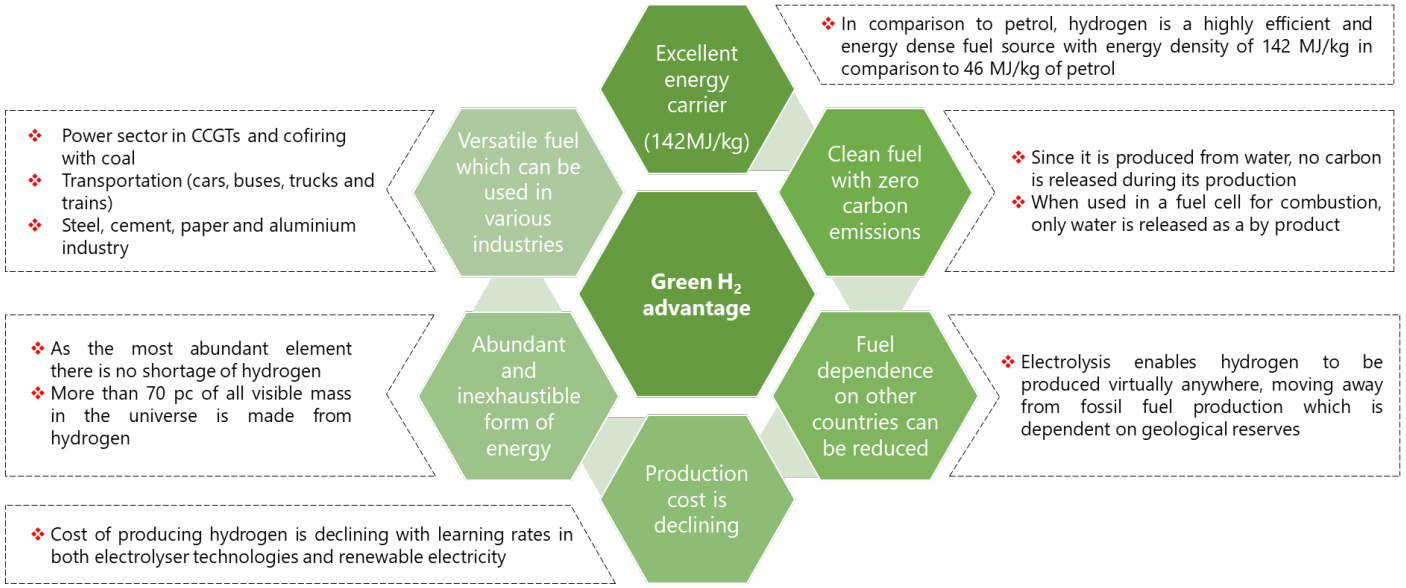
Access to the experts behind the analysis

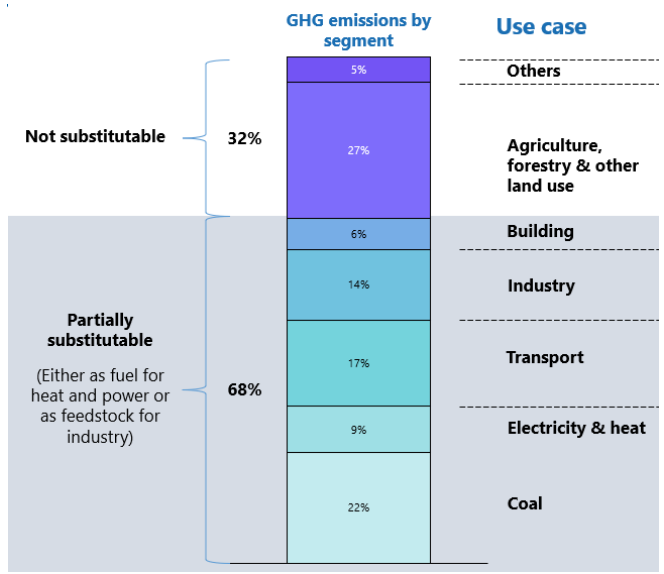
Why Hydrogen?

Hydrogen has significant potential in multiple end-use sectors (i.e. power generation, transport, steel, etc.), which are each decarbonising at different paces in different geographies of the world.

This study leverages Argus' bespoke project work and experience in numerous downstream sectors (oil products, generation fuels, chemicals, fertilisers, biofuels, transport and metals) to provide a holistic view of hydrogen's demand potential. Understanding hydrogen's drivers, possible evolution pathways and interactions across these (potentially competing) segments is key to maximizing the economic opportunity and meeting net-zero goals.

- Hydrogen is a versatile fuel that can be used in various industries.
- It has several advantages over alternative fuels that, if commercialized economically, can increase hydrogen's potential adoption as a decarbonisation fuel, particularly in sectors where emissions are difficult to abate.
- Hydrogen has the potential to substitute fossil-fuels in sectors that are responsible for over 65pc of global emissions.
- To date, 52 countries have announced hydrogen policies, and interest continues to grow rapidly.



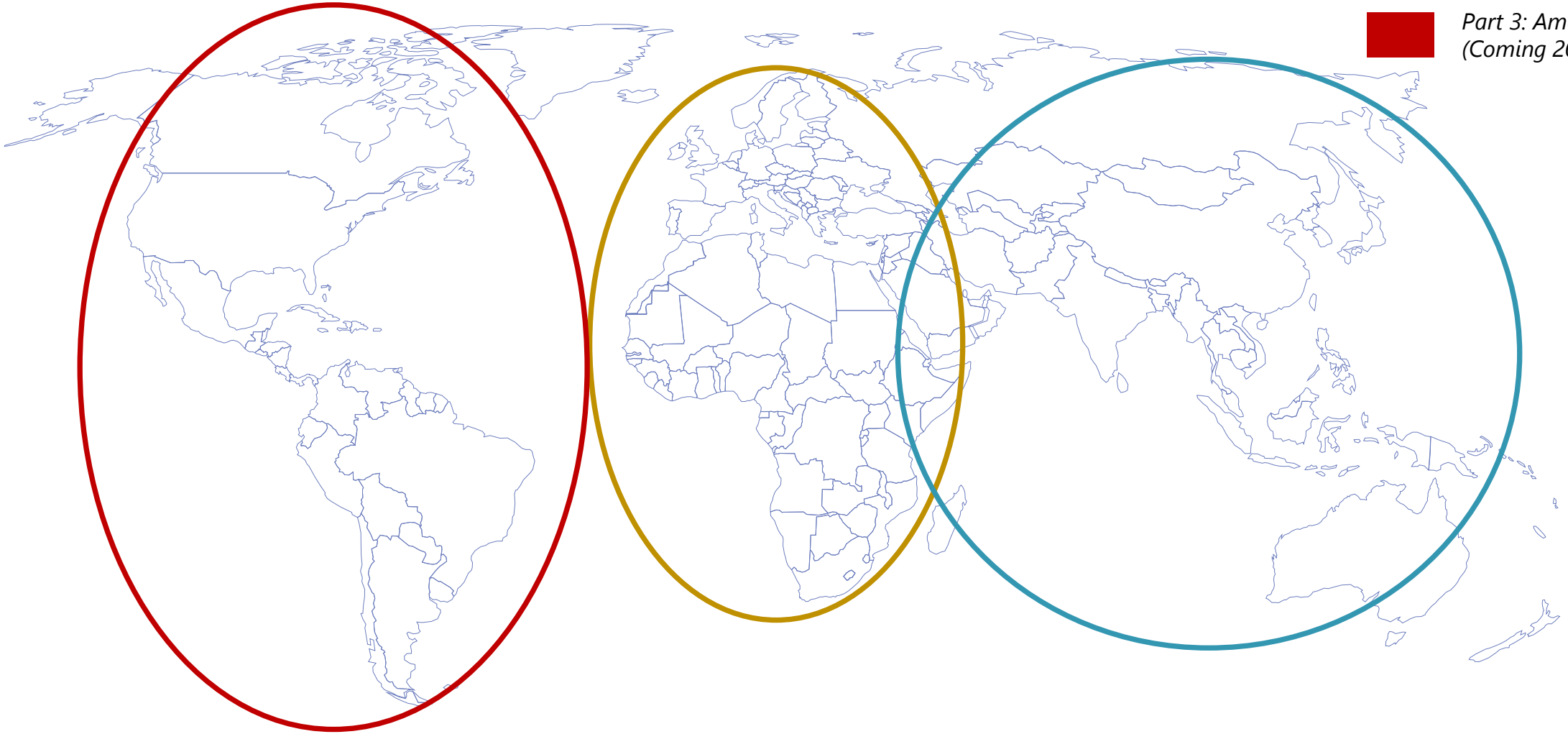


Geographies covered under this study

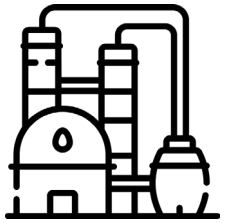
Part 1: Asia-Pac and the Middle East

Part 2: Europe and Africa (Coming 2024)

Part 3: Americas (Coming 2024)



Demand sectors covered under this study

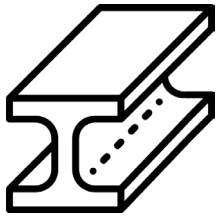


Refining

Potential hydrogen demand in the refining sector across various regions and willingness to pay for green hydrogen

Fertilizer

Potential hydrogen demand in the fertiliser sector across various regions and willingness to pay for green hydrogen

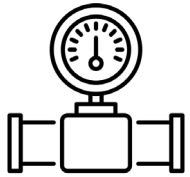


Iron and steel

Potential hydrogen demand in the steel sector across various regions and willingness to pay for green hydrogen-based DRI technology against conventional steelmaking technology

Power generation

Potential hydrogen demand in the power generation sector across various regions and willingness to pay for green hydrogen in CCGT against a conventional natural gas-based turbine



Gas network

Potential hydrogen demand in the natural gas network sector across various regions and willingness to pay for green hydrogen

Maritime and Aviation

Potential hydrogen demand in the maritime sector and SAF and corresponding hydrogen demand in aviation sector across regions

Road transport

Potential hydrogen demand in the road transport (cars, taxis, buses and HGVs) sector across various regions and willingness to pay for hydrogen powered vehicles against battery and conventional fuel vehicles

Table of Contents

Sample content

Sample data and insight for the Japanese and Australian hydrogen markets follows.

To request full and unredacted content for these and other markets contact: genfuels-m@argusmedia.com.

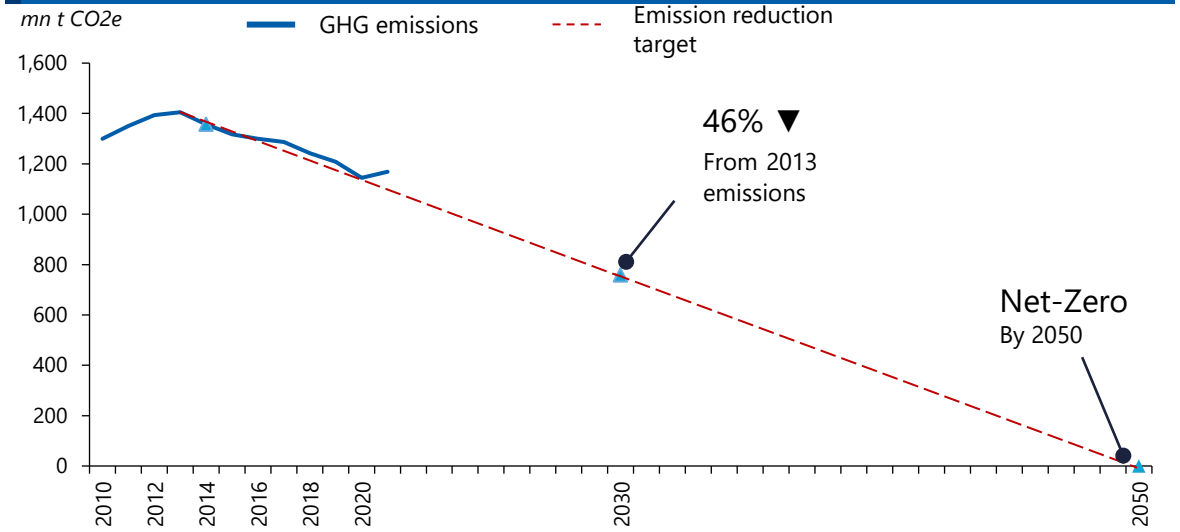
Japan

Country Overview

Japan – Emissions

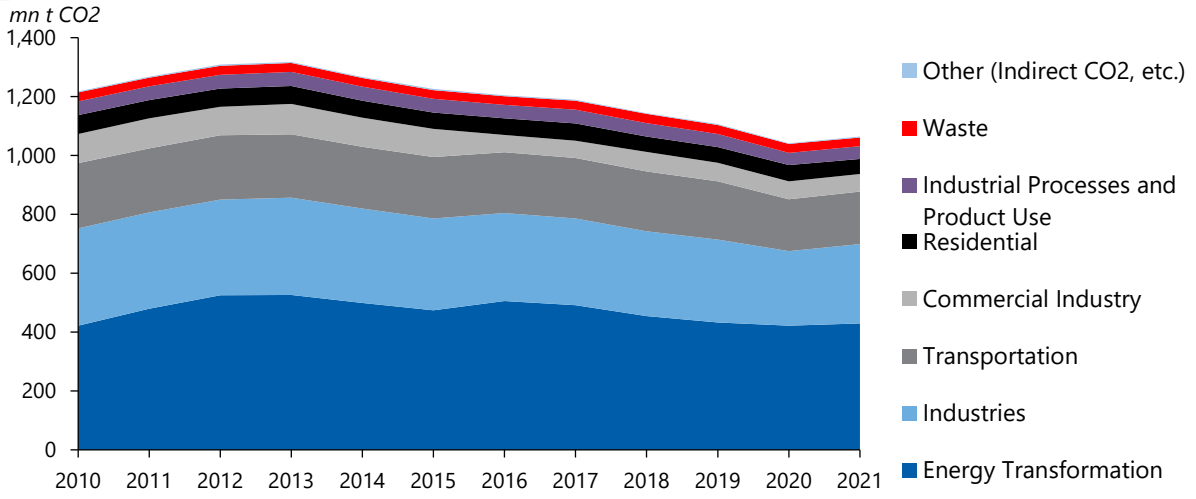
The country revised its 2030 emission reduction target up to 46pc vs 2013 and aims to achieve net zero by 2050. 40pc of Japan's carbon emissions comes from its power generation sector

Japan's GHG emissions reduction target



— *CAT, Argus Consulting*

Japan's historical CO_2 emissions by sector



— *National Institute for Environmental Studies*

- Japan revised its 2030 emission reduction target up from 26pc to 46pc of the 2013 emission level.
- To achieve these targets, the government of Japan introduced several support packages, such as the Green Growth Strategy and Green Innovation Fund.

- Japan's CO_2 emissions peaked in 2013. Emissions have declined by 19pc in 2021 vs 2013.
- The power generation sector has been the largest contributor to emissions in the country (40pc in 2021), followed by industrial and transport sectors.
- The government aims to reduce emissions across various sectors using renewables, electrification and low-carbon fuels, such as hydrogen and ammonia.
- The government considers hydrogen as a viable option for decarbonising hard-to-abate sectors, like steel and coal/gas-fired power plants.

Japan – Country Scorecard

The country will be among the largest demand centres for hydrogen, with a consumption target of 20mn t by 2050. It will rely on hydrogen imports to meet its demand

Criteria	Assessment	Rationale
Net-Zero Target		Japan has a target to achieve net-zero emissions by 2050 and reduce emissions by 46pc of the 2013 levels by 2030.
H2 Strategy		Japan is among the few pioneer countries to have a complete hydrogen strategy. In 2017, the country published its first hydrogen strategy which covers hydrogen as a vector for decarbonisation. It has also set firm hydrogen consumption targets and sector-specific hydrogen targets. It last updated it hydrogen strategy in June 2023.
H2 Project Pipeline		Japan has no sizeable hydrogen projects and is reliant on low-carbon imports of hydrogen.
H2 Demand		Japan will be among the largest hydrogen demand countries, with a consumption target of 20mn t by 2050. Sectors like power generation and road transport sector are likely to be the demand drivers.
Infrastructure		Japan's hydrogen strategy covers some aspects of support for the development of hydrogen supply infrastructure (storage and transportation) but is not detailed.
International Partnerships		Japan has several international collaborations, such as the 'US-Japan global partnership for a new era' focused on using clean energy technology to promote green, sustainable growth; and 'Japan-EU green alliance' focused on climate-neutrality, biodiversity and the circular economy.
Support / Funding		Japan has subsidy support measures in place, such as for hydrogen production and fuel cell vehicle purchase.

Japan

Hydrogen Strategy and Assessment

Japan – Hydrogen strategy snapshot

Update of Green Growth Strategy in 2021 set consumption targets for hydrogen of 3mn t by 2030 and 20mn t by 2050

2017 Basic Hydrogen Strategy

Basic Hydrogen Strategy – Japan adopted of a national hydrogen framework in 2017.

Based on the country's INDC submitted to the UN in 2016, Japan planned to **cut GHG emissions by 26pc** from FY2013 levels by FY2030 (or by 25.4pc from FY2005).

2020 PM's 2050 Carbon Neutrality Declaration Green Growth Strategy

Achieve net zero GHG emission by 2050 and becoming carbon neutral in 30 years

In December 2020, Japan budgeted **¥2 trillion Green Innovation Fund** under the Green Development Strategy for carbon neutrality in Japan by 2050.

Green Growth Strategy Through Achieving Carbon Neutrality in 2050 – Japan specified 14 promising fields that are expected to grow, including hydrogen; and provided an action plan from both industrial as well as energy policies

2021 Green Innovation Fund Revised Strategic Energy Plan

Japan's Nationally Determined Contribution (NDC) – Reduction in GHG by **46pc** in FY2030 compared to FY2013 levels, up from a **26pc** target

Updated their Green Growth Strategy to add the following targets:

- Domestic production of up to **3mn t of hydrogen** by 2030;
- **20mn t** by 2050

2022 GX investment Clean Energy Strategy

An investment roadmap for **¥150 trillion** ($1 trillion) of public-private financing over the next 10 years to transform 22 industrial sectors to meet carbon neutrality and contribute to the energy transition in Asia.

The Japanese government aims to introduce 'carbon pricing' that combines a 'carbon levy' starting in 2028, with voluntary 'emissions trading'.

2023 Revision of basic hydrogen strategy

In June, the government amended the basic hydrogen strategy to enhance its scope to include an industrial strategy to improve global competitiveness.

It seeks to increase the Japanese made electrolyser capacity to **15GW** globally. It also aims to attract public and private investment of more than **¥15 trillion** ($100 bn) into the hydrogen and ammonia supply chain.

Hydrogen targets

	2020	2030	2040	2050
Consumption	2mn t	3mn t	12mn t	20mn t
Price	¥100 /nm^3	¥30 /nm^3	-	Less than ¥20 /nm^3
Electricity generation		1%		

Hydrogen in transportation

	2020	2025	2030	Actual (Dec'22)
FCEV buses	100		1,200	120
FCEV forklifts	500		10,000	397
FCEV cars	40,000	200,000	800,000	7,457
Refueling stations		320	1,000	183

Japan

Demand and BEP

Japan – Country demand assessment

Upon assessing various parameters in a country, it is decided what elements among the demand and BEPs will be discussed further

Methodology

Country's hydrogen policy/strategy → ***Is the policy ambitious? (whether have any firm hydrogen production / consumption target)*** → ***Which sectors the policy discusses regarding hydrogen application*** → ***Does the policy / strategy state sector-specific targets?***

If all the above criteria is met

Hydrogen Demand ***Breakeven price***

If a country has a hydrogen policy which has an ambitious hydrogen production and consumption target by a certain year and has sector specific targets like fuel cell vehicle fleet deployment, hydrogen blending percentage in gas grid, hydrogen co-firing percentage etc then both the sector specific hydrogen demand and respective breakeven prices are calculated

If all the above criteria is not met completely

Breakeven price

If a country has a hydrogen policy which may or may not have hydrogen production or consumption numbers neither they have sector specific targets but have mentioned in the plan those sectors which they are willing to decarbonise then in that case only breakeven prices of hydrogen for the respective sector is provided

Based upon the methodology, the following elements and sectors will be discussed in Japan's demand section

Hydrogen Demand

- ***Power generation***
- ***Road transport***

Breakeven price

- ***Power generation***
- ***Road transport***
- ***Refinery***
- ***Gas blending***
- ***Steel***

Japan – Hydrogen targets and demand assessment in power

The country aims to use ammonia and hydrogen in coal and gas-fired power plants, respectively, generating a potential demand for hydrogen of [redacted] mn t in 2030, [redacted] mn t in 2040 and [redacted] mn t in 2050

	Target	Mandate	Is the hydrogen/ammonia breakeven price positive? (vs traditional technologies)			Commercial readiness	Hydrogen opportunity
			2030	2040	2050		
Ammonia co-firing (20pc)	Yes	Yes	Yes	Yes	Yes	Pilot Stage	Likely
Hydrogen in CCGT	Yes	Yes	Yes	Yes	Yes	Pilot Stage	Very Likely

Japan is exploring ammonia & hydrogen use in power

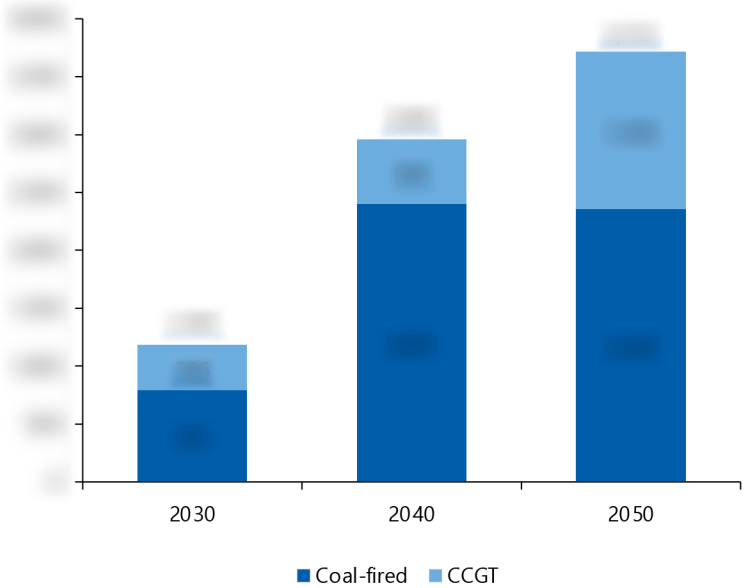
- To reduce coal usage and decrease greenhouse gas emissions, power plants for commercial and industrial sectors are **currently implementing a blend of ammonia and conventional coal at a ratio of 20/80**.
- Co-firing is currently in pilot stage. The Japanese government is allocating **¥27.9bn** in subsidies for two demonstration projects.
- These projects aim to **burn a minimum of 50pc ammonia produced from hydrogen mixed with coal at power plants by 2029**. This will gradually increase, but it will take time to develop a plant capable of burning 100pc ammonia.
- At present, traditional power plants are unable to burn pure ammonia, so future modifications are being considered to accommodate ammonia-based power plants.

JERA is making progress on co-firing

- JERA is Japan's largest power generation company with 61GW of domestic capacity. The company, along with IHI, is supporting the co-firing demonstration projects. Initial demand for ammonia co-firing in Japan is expected to start in JERA's power plants.
- By 2030, JERA plans to shut/decommission all inefficient (supercritical or less) coal-fired thermal power plants (which accounts for 2.5pc of Japan's power generation) and implement ammonia co-firing demonstrations at high-efficiency (ultra-supercritical) coal-fired thermal power plants.
- The company aims to **achieve 20pc ammonia co-firing rate** in all its coal-fired thermal power plants, which would require 4.5mn t of ammonia (791kt hydrogen)

Hydrogen demand from Japan's power sector

kt, H2

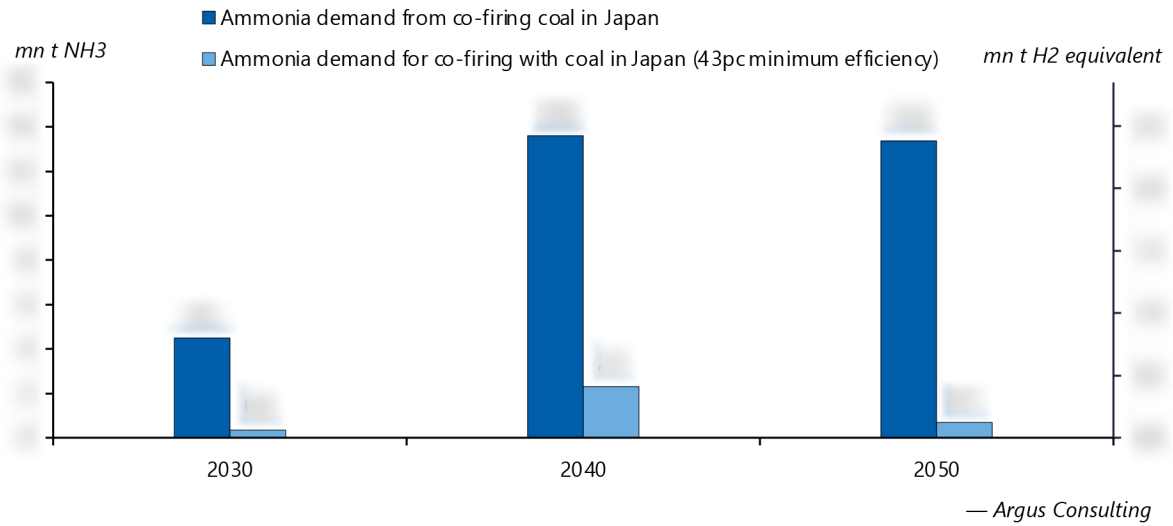


— Argus Consulting

Japan – Ammonia demand in coal power generation assets

Ammonia demand could reach [redacted] mn t by 2040 and remain relatively stable into 2050 if the government's targets are met. But if plants co-fire the minimum, demand would only reach [redacted] mn t in 2040 and fall to [redacted] mn t by 2050

Ammonia (hydrogen equivalent on right-hand axis) demand in coal co-fired power generation (target-led vs alternative scenario)



— Argus Consulting

Key Takeaways

Target Scenario

- If the government targets are met, ammonia demand for coal co-firing could be [redacted] mn t in 2030, increasing to [redacted] mn t in 2040.
- Demand decreases slightly from [redacted] mn t in 2040 to [redacted] mn t in 2050 as coal-fired power generation capacity is retired.
- This outlook takes into consideration the age distribution of Japan's coal-fired capacity, technology, efficiency rating and utilization rates.

Alternative Scenario

- Less efficient plants co-fire just enough ammonia to achieve 43pc minimum efficiency required.
- Demand falls faster compared to the target scenario, from [redacted] mn t in 2040 to [redacted] mn t in 2050, since the percentage blend for remaining plants remains unchanged,.
- Although not modelled here, in a most optimistic scenario where the government's 12.5GW of new coal-based capacity is built, ammonia demand for co-firing could reach [redacted] mn t in 2040 and increase to [redacted] mn t by 2050.

Criteria	Assumption	Additional Comments
Plant technical lifespan	40 years	In 2030, coal-fired units older than 40 years will be (if not already) retired
Technology	Subcritical, supercritical and ultra-supercritical	IGCC plants excluded – use a different process from subcritical, supercritical and ultra-supercritical coal-fired plants
Capacity	6GW of announced capacity included	Japan targets 12.5GW of additional coal-fired capacity but only 6GW announced so far
Co-firing rates	20pc by 2030-2040, 50pc by 2050	• Maximum ammonia blending percentage follows the government's targets in the Green Growth Strategy • Co-firing from new capacity only reflected from 2040 since ammonia co-firing is not expected to be implemented until mid-2030s • JERA are first-movers. Ammonia co-firing implemented in their operational plants (as at 2021) – total 9 GW capacity • After 2030, ammonia co-firing applied in all Japan's operational coal-fired plants

Japan – Total hydrogen demand in transportation

Argus analysis estimates hydrogen demand in transport to be closer to [redacted] by 2050. Demand will initially be led by HGVs ([redacted]pc in 2030 and 2040), but demand from passenger cars increases around 2050

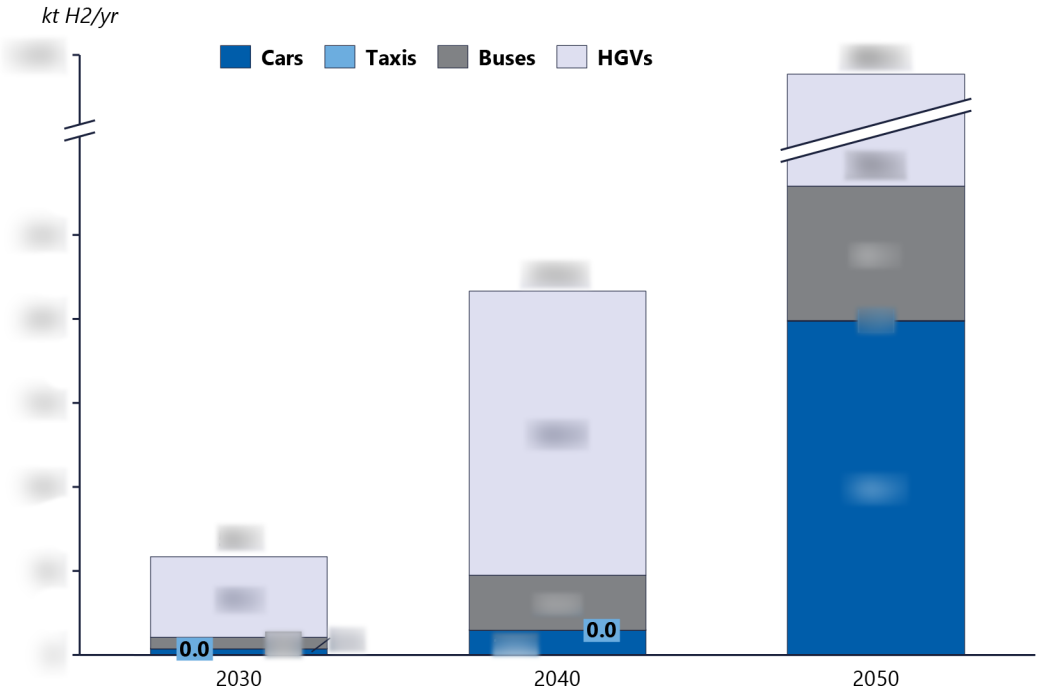
Status of Japan's FCEV target

- Japan's target of 40,000 FCEV cars by 2020 was missed. As of December 2022, only 7,457 hydrogen-powered cars were on the road (18pc of the target).
- Several factors contributed to this failure, including infrastructure limitations, high costs, limited vehicle models, competition from BEVs and the impact of the COVID-19 pandemic.
- However, Japan has set more ambitious targets of achieving 200,000 and 800,000 FCEV cars by 2025 and 2030, respectively.
- Achieving these targets may be challenging, given the inability to meet the previous target.

Hydrogen demand trends in transport

- In the mid-term (2030), buses and HGVs are expected to drive most of hydrogen demand.
  - HGVs will be the largest contributor of hydrogen demand into transport, accounting for around [redacted]pc of demand in 2030 and 2040.
  - Buses will account for [redacted]pc and [redacted]pc of demand in 2030 and 2040, respectively.
  - The value of subsidies for these vehicle classes are much higher than those offered to passenger vehicles, which helps bridge the gap between FECV and BEV/ICE technologies.
- However, by 2050, hydrogen demand penetration into passenger cars increases at a faster pace, making up [redacted]pc of demand. This is due to FCEVs cars becoming cheaper than gasoline and more developed HRS infrastructure.
- The longer distances typically travelled by FCEVs and faster refueling advantages over BEVs, but continued subsidies and an expanded HRS network are key to FECV adoption.
- The pump cost of hydrogen will also remain a key constraint unless production costs are significantly reduced.

Japan hydrogen demand in transportation sector

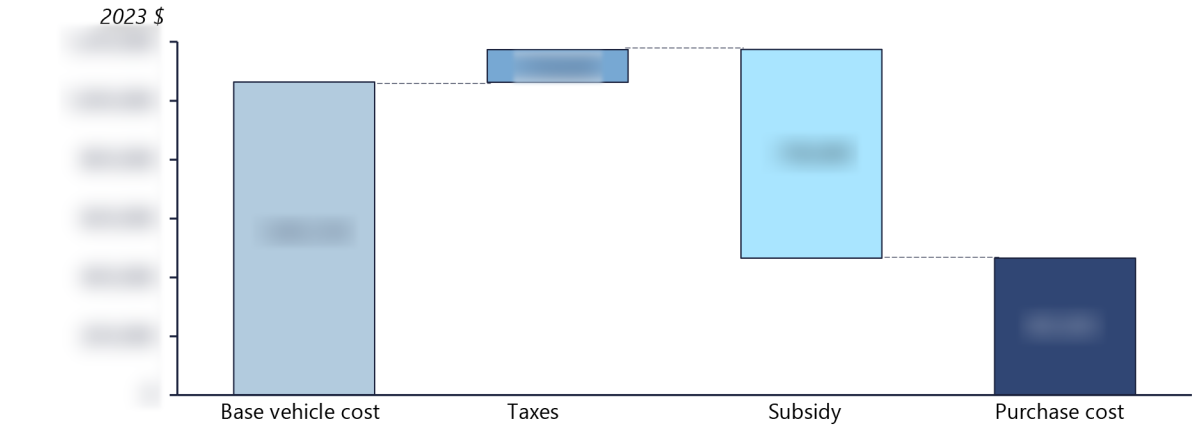


— Argus Consulting

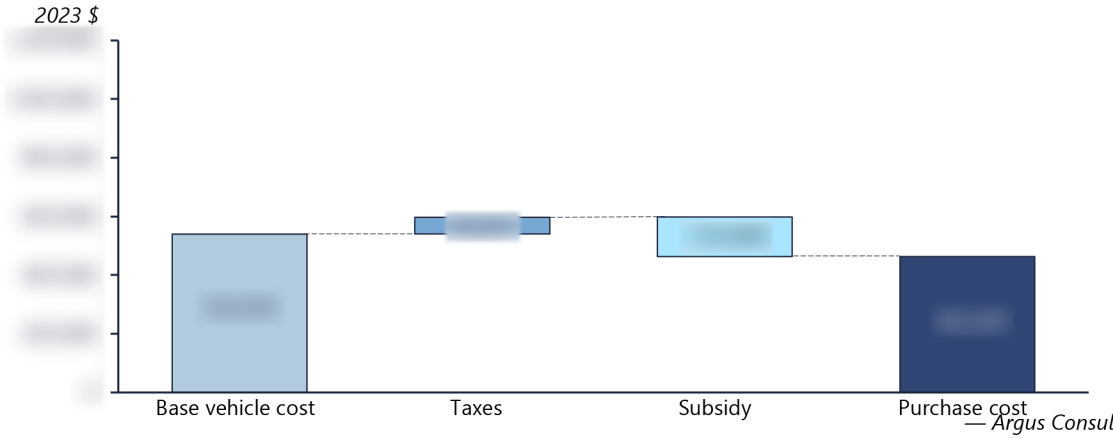
Japan – HGV purchase cost and BEP for hydrogen

With subsidies, the purchase cost of FCEVs is similar to BEVs. Argus' BEP analysis suggests FCEV HGVs can compete with both diesel and BEVs from 2040

Purchase cost breakdown of FCEV HGVs in 2023

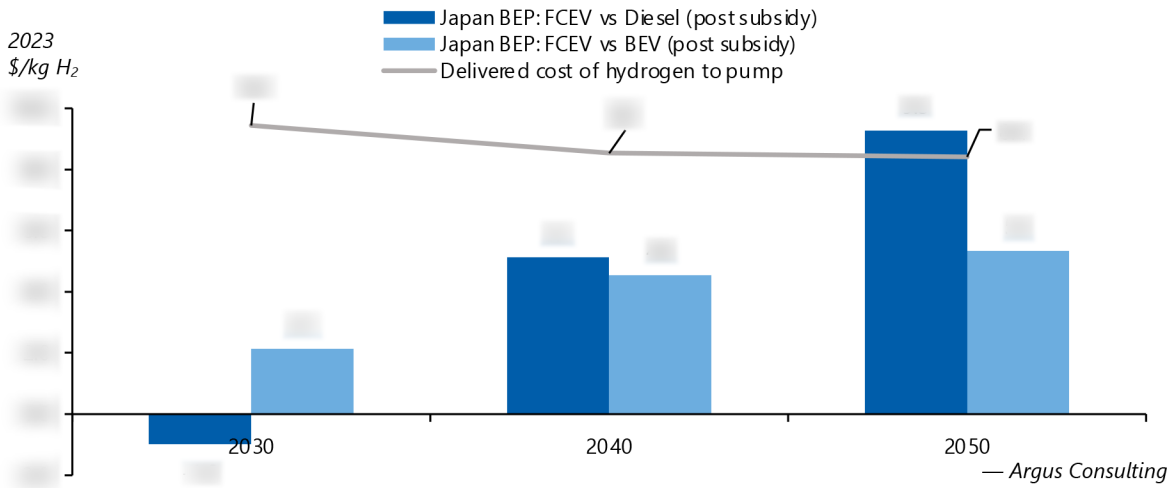


Purchase cost breakdown of BEV HGVs in 2023



— *Argus Consulting*

BEP for HGVs in Japan



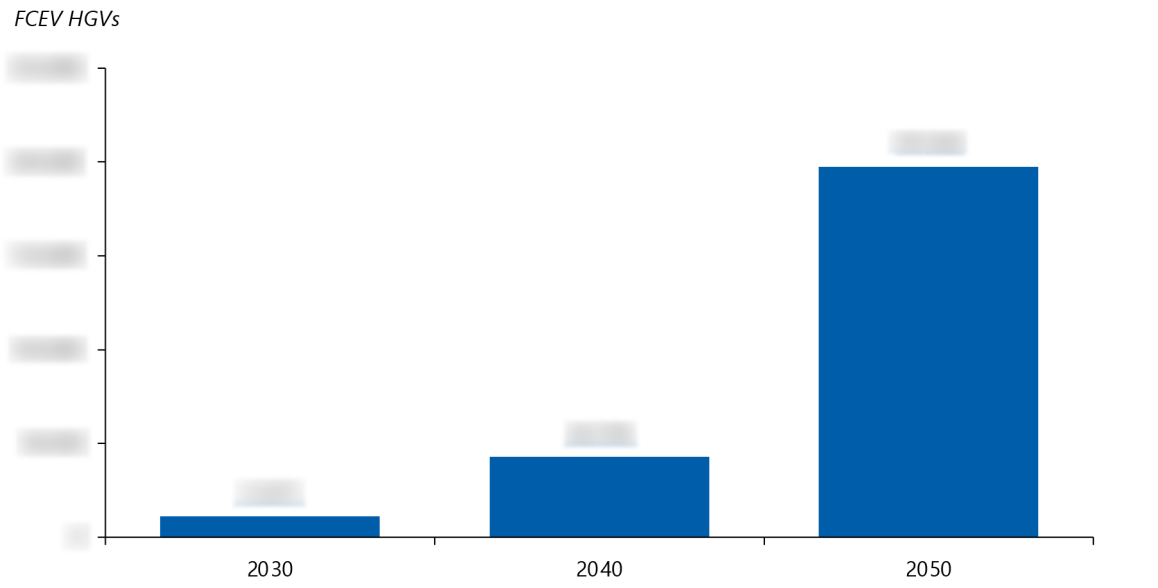
— *Argus Consulting*

- The breakeven price (BEP) analysis estimates the price of hydrogen at which an FCEV would be competitive against traditional (diesel) and competing vehicle technologies (battery electric).
- FCEV adoption for HGVs is likely to increase towards 2050 as the delivered cost of hydrogen is well above the breakeven price needed for FCEV to compete.
- The declining capital expenditure of FCEV HGV and the anticipated increase in diesel prices are the major driving force behind the trend of increasing BEPs compared to diesel.
- Breakeven prices for hydrogen compared to BEVs are positive from 2030 and increase thereafter. However, the rise is not as steep compared to diesel since the purchase price of BEVs also declines.
- The Japanese government must ensure hydrogen refuelling stations (HRS) are established across the country's major highway routes. If HRS are limited, fleet owners will be unlikely to adopt FCEVs.

Japan – FCEV HGV hydrogen demand

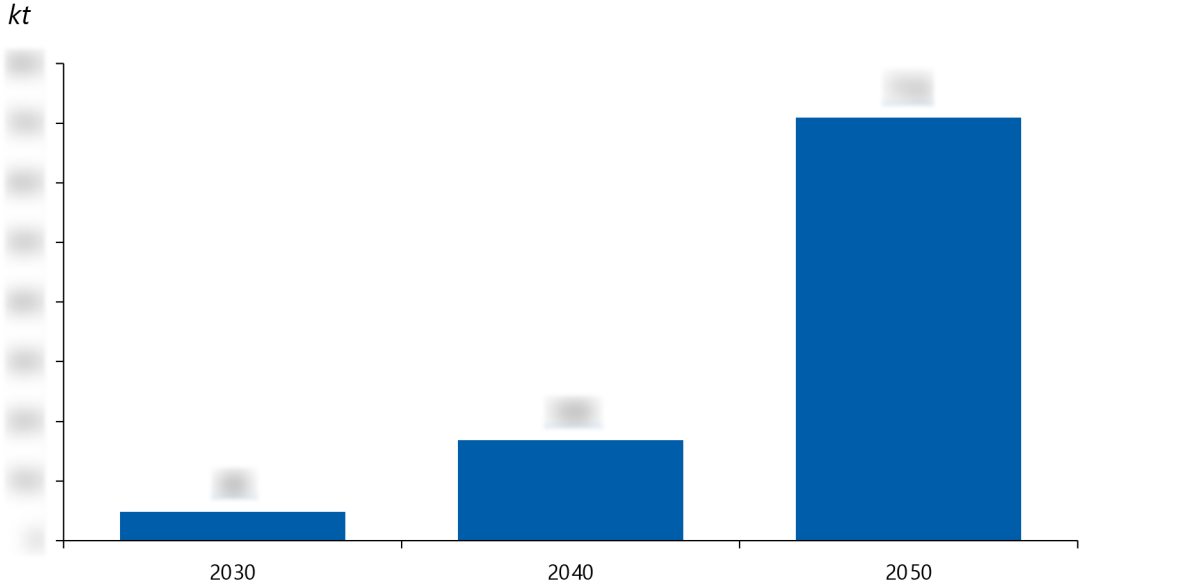
FCEV adoption rates in HGVs is likely to quickly rise from the 2040s as HRS infrastructure develops and FCEV costs fall

FCEV HGV fleet size



-Argus Consulting

Hydrogen demand in FCEV HGV in Japan



-Argus Consulting

HGV Penetration Share Assumptions

HGV	2030	2040	2045	2050
Share of ZEV* in new HGV sales				
Share of FCEV in ZEV HGV sales				

**ZEV – zero-emission vehicle*

Key Takeaways

- Currently, Japan doesn't have FC HGV targets and there are very few FC HGVs on the road.
- However, HGVs are expected to witness growth in the coming years as Japan builds out its HRS infrastructure along major highways and introduces FC HGVs on road.
- Hence, adoption rates for FCEV HGV are likely to quickly rise from the 2040s as HRS infrastructure develops and FCEV costs fall.
- FCEV HGVs have a better prospects than BEV HGVs owing to faster refueling time which allows for greater efficiency on long routes.

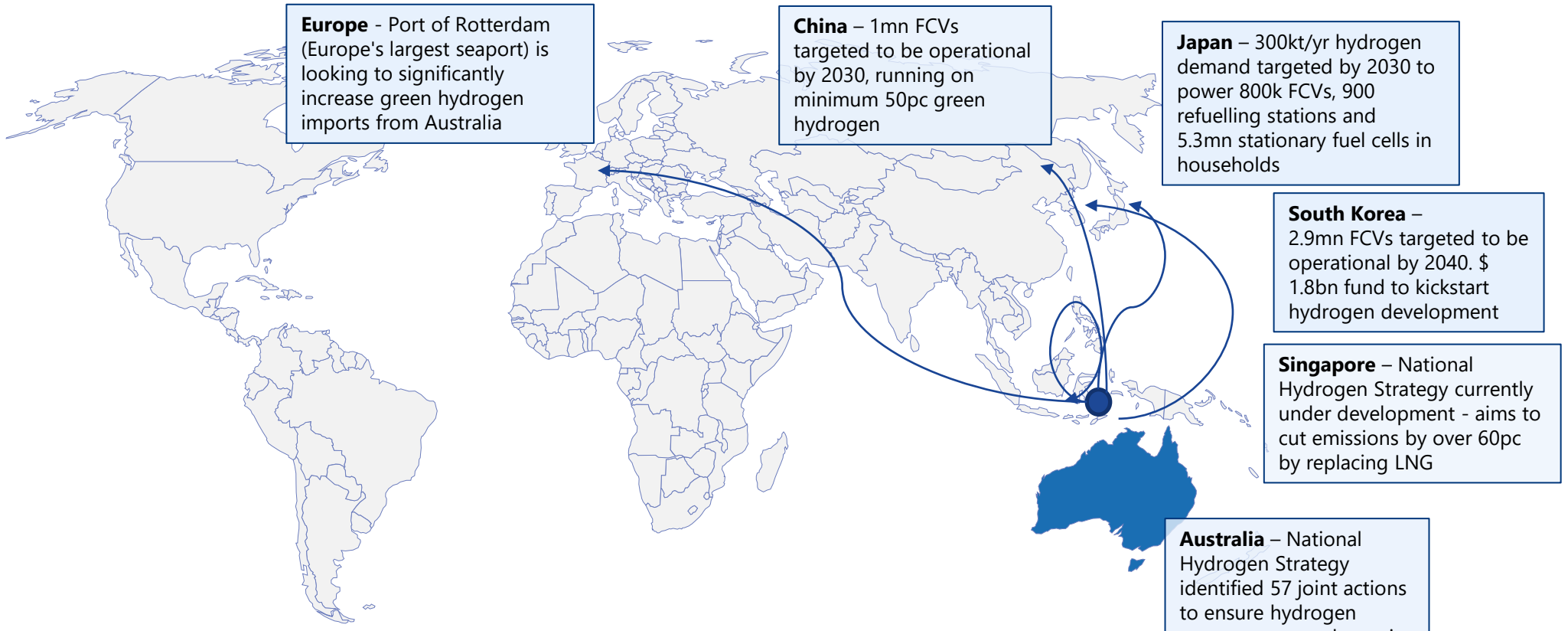
Australia

Supply

Australia – Hydrogen export opportunity

ARENA estimates Australia's 3mn t green hydrogen export potential can serve hydrogen demand in East Asia and Europe, contributing A$1.7bn to the national economy by 2030

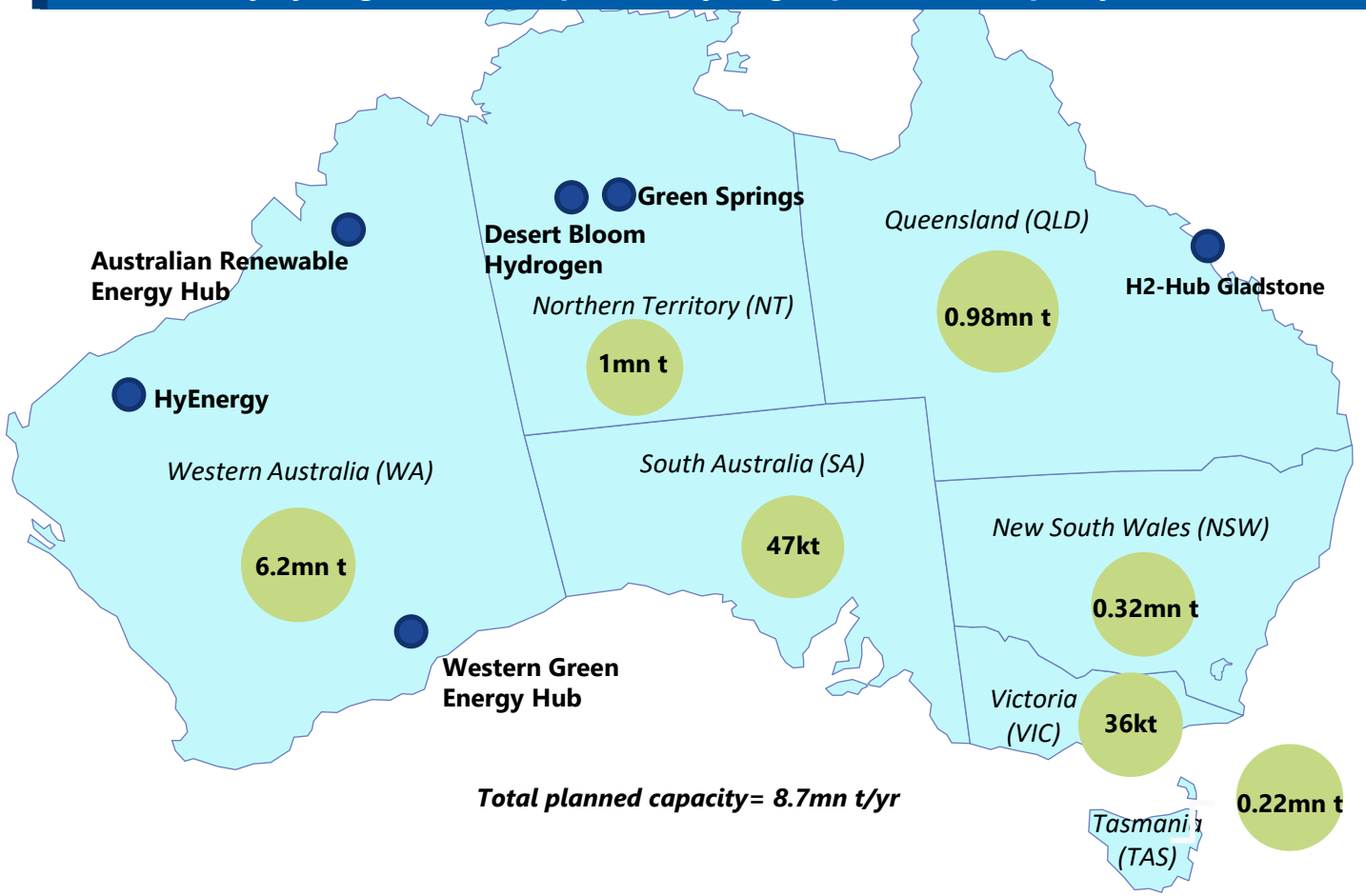
- Australian Renewable Energy Agency (ARENA) estimates hydrogen exports could contribute A$1.7bn to the national economy by 2030
- With its existing trade links, Australia is in a prime position to capitalise on high levels of hydrogen demand anticipated from its East Asian neighbours and Europe.
- Australia can become a potential export giant, as well as play a leading role in setting certification of origin guidelines, safety standards and creating trade partnerships



Australia – Planned green hydrogen projects

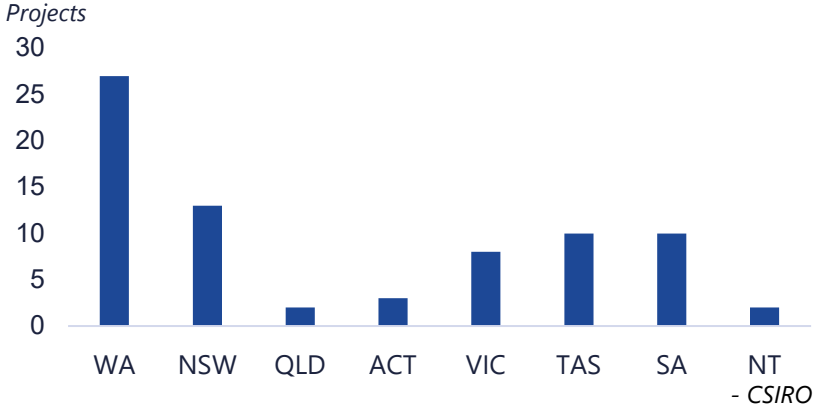
Most of Australia's projects are still in early stages of development. Western Australia is planning the highest number and largest capacity of hydrogen projects

Australia's key hydrogen hubs and planned hydrogen production capacity



Seven regional hydrogen hubs located in Gladstone, the Hunter Valley (2 projects), Bell Bay, Port Bonython, Kwinana and the Pilbara

Australia's hydrogen project count by territory



Project's target market	Hydrogen capacity (mn t)
Domestic	0.14
Export	0.62
Domestic & Export	8
Total	**8.7mn t**

- Most of Australia's hydrogen projects are still in early stages of development (pilot or feasibility), with only a few having reached construction or construction.
- At least 65 projects are green hydrogen. Natural gas is limited in the country, while Australia has abundant solar and wind resources.

Australia – Planned green hydrogen projects in Western Australia (2/2)

Region has potential to produce 6.2mn t of hydrogen for both export and domestic markets

Sr.no	Project name	Hydrogen production capacity	Description
6.	**Arrowsmith Hydrogen Project - HP1**	15.3 kt/yr	HP1 would have the capacity for up to 42t/d (42,000kg/d) of renewable-based hydrogen production. The project, which is due to be completed in late 2025, will serve the domestic energy and transport sectors in Western Australia.
7.	**H2 Kwinana**	7.9 kt/yr	The project developers are conducting a feasibility study to investigate the conversion of a portion of bp Australia's Kwinana Energy Hub site into a hydrogen hub, which would include the installation of a 75MW electrolyser, hydrogen storage, compression and truck loading facilities, as well as upgrades to bp's existing on-site hydrogen pipeline. The hydrogen produced will meet domestic and export needs, including hydrogen for bp's renewable fuels production, ammonia, metals and minerals processing, on-site petrol blending and hydrogen for heavy-duty transport.
8.	**Bristol springs solar hydrogen project**	4.9 kt/yr	Phase 1 includes a 114MW solar farm to be co-located with a 36MW green hydrogen production plant capable of producing 4.9kt/yr green hydrogen. A variety of end-uses are being considered, including in gas networks, power production, energy storage, industrial feedstock and transport.
9.	**Geraldton export-scale renewable investment**	4.0 kt/yr	The project developers are carrying out a feasibility study to explore the potential for the establishment of a renewable hydrogen and ammonia facility in Western Australia's Geraldton/Oakajee region, for both demonstration and commercial size plants. The demonstration plant would produce 4.0kt/yr green hydrogen.
Other small projects combined		5.6 kt/yr	

- CSIRO

WA: Total hydrogen production potential

6,181 kt/yr

Domestic oriented projects

Export oriented projects

Both export and domestic market projects

Meet the team

Yu Kin Yeo

Senior Vice President (Singapore)

Yeo Yu Kin heads Argus Consulting Services in Asia & Middle East. He is responsible for Argus' advisory work in the region. Under his charge, Argus Consulting Services expanded rapidly in terms of bespoke study volume and industry coverage. Today, Argus Consulting carries out market and strategy studies in virtually all energy and chemicals spaces, including oil, refined products, petrochemicals, generation fuels, renewable energy, biofuels and biomass, fertilizer and metals.

Joyce Grigorey

Principal (London)

Joyce has 15+ years of experience in research and consulting, business development, strategy and project management roles gained across the natural resources sectors, including hydrogen, power & renewables, petrochemicals, plastics, refining, gas and shipping. She holds an MBA (Honours) from Imperial College London.

Dale Hazelton

Principal (Singapore)

Dale has 15+ years of experience in a variety of leadership and content specialist roles. His areas of expertise include hydrogen, generation fuels, power & renewables, and metals & mining. Dale holds a B.S. Mining Engineering from West Virginia University.

For more information including a full table of contents

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