

MUFG TRANSIT

APAC Low-Carbon Energy

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ESG Finance Department

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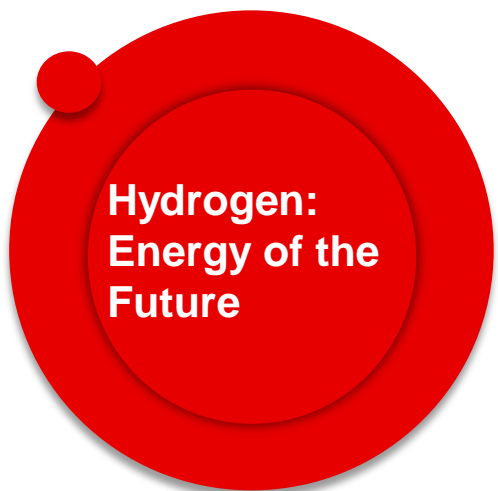
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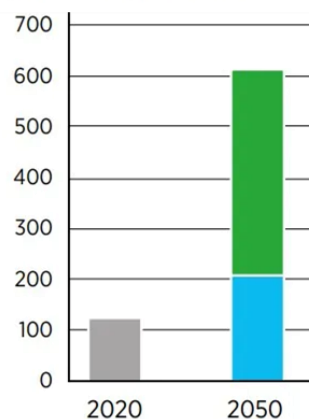
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Premise

Potentiality of low-carbon hydrogen to supplement tradition energy sources raises hopes for achieving global net-zero commitments with less dependency on fossil fuels in the future



Hydrogen production (Million tonnes)



International Renewable Energy Agency (IRENA) released a 1.5C Scenario which envisages global clean hydrogen to meet up to 12% of final energy consumption by 2050

■ Grey hydrogen
■ Blue hydrogen
■ Green hydrogen

■ Percent of final energy demand

0%

12%

Action

"There are growing signs that hydrogen will be an important element of the **transition** to an **affordable, secure & clean** energy system, **but there are still major advances in technology, regulation & demand needed for it to fulfil its potential.**"



Cleaning & Greening

- International Energy Agency (IEA) Executive Director Fatih Birol, following release of IEA's Global Hydrogen Review 2022

"Hydrogen provides an option for the ASEAN Member States (AMS): it would not only **green the energy supply**, but it would also enhance indigenous energy supplies, thereby **improving the region's energy security.**"



- ASEAN Centre for Energy in Hydrogen in ASEAN Report 2022

Decarbonisation

"We recognise low-carbon & renewable hydrogen & its derivatives such as ammonia to **advance decarbonisation** across sectors and industries, notably in **hard-to-abate sectors.**"



- G7 statement during the G7 conference in April 2023

Transition

"Low-carbon hydrogen can have a significant role in countries seeking to accelerate their **clean energy transition.**"

- David Malpass, President of the World Bank Group during COP27



Are we ready for the future?

Global Hydrogen Landscape | Low-Emission Energy as Future Game-Changer

The gap between global consumption and production capacity paves the way for strategic expansion of low-emission hydrogen for the future

(*all units indicated in Million Tonnes per Annum of H₂)

North America			
Region	2022	2040	
Production	0.3	14.1	
Consumption	0.3	16.3	

Self-sufficient, IRA's incentives potentially makes H₂ cost very competitive, but domestic demand is rising

Favourable PV & wind conditions with strong push from government to become H₂ export hub

LATAM			
Region	2022	2040	
Production	-	5.8	
Consumption	-	1.5	
Chile			
Production	-	0.3	
Consumption	-	0.3	

Europe			
Region	2022	2040	
Production	0.1	15.7	
Consumption	0.1	21.3	

Major importer: limited renewables resources and pressed by diversification needs for energy sources

Favourable PV conditions, with expertise in energy project development

Favorable PV conditions, with large domestic demand

Middle-East			
Region	2022	2040	
Production	-	9.0	
Consumption	-	4.1	
Saudi-Arabia			
Production	-	3.9	
Consumption	-	1.4	

Well-positioned to become H₂ export hub utilizing a matured renewables market & supportive government policies

Japan/ Korea Major importer: resource/space constraints limit ability to produce H₂ locally. Strong government support to build value chain for securing long-term supply

Self-sufficient, scaling up production capacity to support a rising domestic demand

Global			
Region	2022	2040	
Production	0.7	90.7	
Consumption	0.8	98.1	

APAC			
Region	2022	2040	
Production	0.2	34.4	
Consumption	0.1	48.2	
China			
Production	0.1	18.1	
Consumption	0.1	21.0	
Japan			
Production	-	0.6	
Consumption	-	4.5	
Korea			
Production	-	0.4	
Consumption	-	4.6	
India			
Production	-	3.1	
Consumption	-	7.5	
Australia			
Production	0.1	10.5	
Consumption	-	2.3	

Latest Global Developments | Nascent but Promising Developments

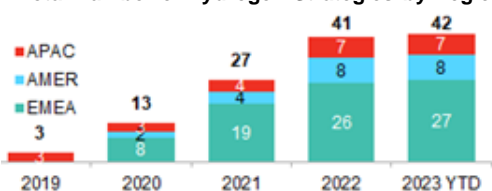
Net-zero commitments & energy security drive a need for low-carbon hydrogen by industrial nations, while the pace of adoption relies on the ability to bring down hydrogen cost by renewable resource-rich nations coupled with the standardisation of market frameworks

Demand Creation

1. Global decarbonisation imperatives

Legislation of net-zero emission targets has pressured the advancement of national/regional H₂ strategies

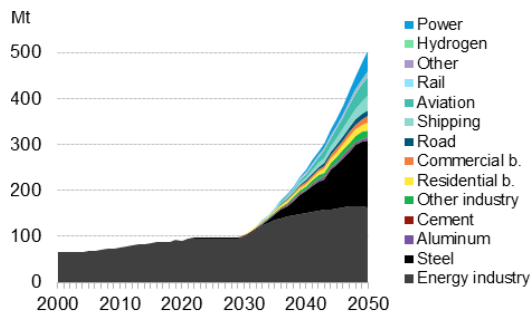
Total Number of Hydrogen Strategies by Region



Source: BNEF Global Hydrogen Strategy Tracker, Feb 2023

2. Scaling up of hydrogen across end-use sectors factoring in governmental push on industry standards

Global Hydrogen Demand by Sector



Source: Global Hydrogen Demand, BNEF 1H 2023 Hydrogen Outlook

Supply Chain Establishment

1. Industry enforcement and mandates to steer local supply build-up of hydrogen

- Subsidies to create supply-side push for hydrogen by promoting cost-competitiveness

Major National Policies for Hydrogen Economy



2. Drop in the Levelized Cost of Hydrogen

- Decreasing cost of renewables** will lower cost of H₂ for regions with favourable solar conditions

2030 (f)	2050 (f)
<USD 1.5/kgH ₂	USD 1/kgH ₂

- Increased economies of scale**

- New & cheaper materials for polymer electrolyte membrane (PEM) electrolysis

Today	2050 (f)
\$800-\$1,400 /kW	\$200/kW

Source: Strategy&, PwC

- Yearly additions to electrolyser capacity
- Larger project sizes result in reduction in project capital costs

Standardised Market and Energy Legislative Frameworks

Current Premise

No international standards or universal methodologies implemented to determine amount of GHG emissions from H₂ produced

Majority of governments have yet to implement specific H₂ trade policies necessary for off-take and importing arrangements.

Nascent but promising developments

- EU's establishment of rulebook as global standard for renewable H₂ to create consistent standard to calculate emission intensity of H₂ production
- Netherlands legislated EU's 1st Guarantee of Origin (GO) scheme*, Australia targets to follow suit in 2024

See also MUFG's [ESG in the EMEA region – The corporate and investor guide to the pillars for the next phase](#) P.56-68, Significance of Hydrogen

(https://market-research.bk.mufg.jp/distribution/49561_ext_01_en_0.pdf)

*GO is defined as a world-class assurance scheme designed to track & verify emissions associated with hydrogen, renewable electricity & potentially other products

Source: MUFG compiled from BNEF, Clean Energy Wire and various public sources

Major National Hydrogen Policies | A Push for Implementation

Government policies to unlock hydrogen potential via subsidies and investment supports create **long-term certainty**, a critical factor for project bankability with regards to the upcoming low-carbon hydrogen projects



USA

Inflation Reduction Act – landmark clean energy policy, 2022

Fiscal budget: ~US13 billion on H₂ out of USD391 billion through 2032

Production & investment tax credits (PTC, ITC) under Section 45V could **cover >half of total production cost**, making both blue & green H₂ more cost-competitive economically

- 10-year PTC for H₂ produced of up to USD3/kg
- ITC for green H₂ produced of up to 6% lump-sum under a “qualified clean H₂ production facility”
- Option to claim ITC in lieu of PTC

ITC for energy storage technologies

- Expanded scope to include “energy storage technologies” eligible for credit including H₂

Clean vehicle credits

- Section 30D tax credit extended to EVs & H₂ FCEVs



Europe

Net Zero Industry Act – scale-up regional clean energy growth, 2023

Subsidies

- Fixed premium/kg of H₂ for max 10 years of operation paid out as subsidies to European H₂ producers (1st EUR800m pilot auctions in 2H 2023)

Green Deal Investment Plan

Subsidies

- \$872.9 m in EU funding through fixed premium payouts in 1st auction for clean H₂ production in 3Q 2023

Founding of EU Hydrogen Bank

- European Hydrogen Bank to utilize **contracts for differences (CfDs)** in H₂ & carbon projects as subsidies to incentivize deployment

H2Global Initiative



Import Subsidies

- Germany launched world’s 1st green H₂ subsidy scheme using CfD mechanism with import tender of €900m in 1st tranche to galvanize green H₂ imports
- A **breakthrough mechanism** for investment risk mitigation policy. CfDs act as subsidy incentive to compensate the difference between supply & demand prices

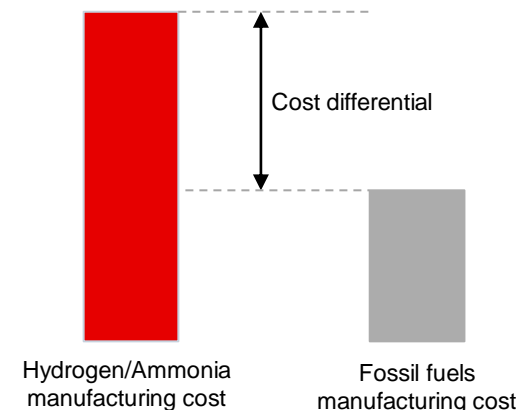


Japan

Basic Hydrogen Strategy, 2017

New Legislation under PM Kishida Fumio, May 2023 (expected)

- New subsidy system (called nesahtoten in Japanese) to **subsidize difference in price** between clean energy (H₂ and ammonia) & existing fossil fuels for 15 years



GX Implementation Council

- 7 trillion yen in subsidies to be offered over the next 10 years to establish a H₂ & ammonia supply network

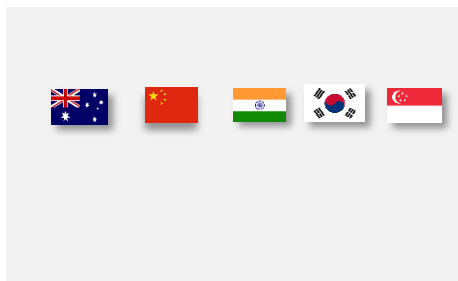
Unlocking Hydrogen Potential in APAC (ex-JP)

Section I: Market Landscape

Unlocking Hydrogen Potential in APAC (ex-JP) | National Hydrogen Policies

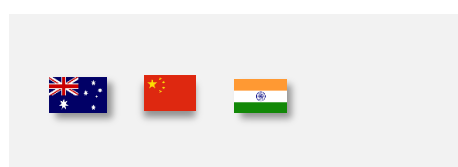
APAC markets with an actual national hydrogen strategy enacted provides a backdrop of greater certainty for the development of hydrogen projects

Countries with hydrogen strategy enacted at national level



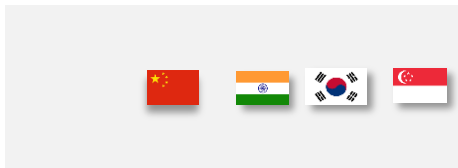
- South Korea and Australia released a national H₂ strategy in 2019 targeting at different sources, South Korea from natural gas by 2030 and Australia from clean H₂.
- Singapore, the most recent to enact a national H₂ strategy in 2022, seeks longer-term diversification of its energy mix owing to limited potential for producing renewable energy locally.
- Majority of other APAC countries have yet to enact a hydrogen policy at national level.

Clear production target specified



- A concrete target clarifies each market's priorities for H₂ and enables measurable progress in key areas e.g. import/export of H₂, storage/distribution/utilization of H₂ with specific targets being set.

Demand creation mechanism



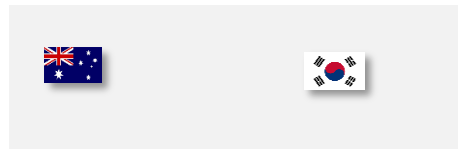
- Demand-side policies that either set a mandatory industrial utilization of H₂ in hard-to-abate sectors or commit to a minimum utilization of H₂ within national energy development plan help to unlock adoption of H₂ across sectors.

Supply-side policy



- Supply-side policies via subsidies and investment incentives play a part in investment risk mitigation and greatly boost production capacity & infrastructure development.

Legislative framework for hydrogen passed



- Having a consolidated legislative framework for H₂ in areas like import/export, storage, sale & production provides certainty in both domestic & export contexts as opposed to overlapping legal frameworks that are governed by separate regulatory bodies & authority stakeholders.

Unlocking Hydrogen Potential in APAC (ex-JP) | Low-Carbon Hydrogen Energy Projects

National hydrogen policies drive an actual development of H₂ projects in APAC (ex-JP)

Announced Low-Carbon Hydrogen Energy Projects in APAC (ex-JP) as of 2022 (cumulative)

	Australia	China	India	Indonesia	Malaysia	New Zealand	Singapore	South Korea	Taiwan	Thailand	Total:	
Concept	32	17	5	3	1	1	1	1	3	0	0	63
Demonstration	4	4	1	0	1	4	0	1	0	1	1	16
Feasibility Study	58	10	3	1	5	4	0	4	0	0	0	85
FID	8	11	4	0	1	1	0	3	0	0	0	28
U/C	6	4	1	0	0	0	0	0	0	1	0	12
Operational	7	15	8	0	1	1	4	0	0	1	1	37
Total:	115	61	22	4	9	11	5	11	1	2	241	

Source: IEA Hydrogen Projects Database, Low-carbon (2022)



>4 in 5 APAC H₂ projects originate in **markets which have enacted H₂ strategy at a national level**

>60%

APAC H₂ projects in **feasibility study & concept stage**

>70%

Production capacity of APAC H₂ projects is from **Australia**



>3 in 5 H₂ projects in Korea are dedicated to the **mobility sector** for end-use

- Majority of low-carbon H₂ projects are originated from Australia, China, India, Singapore, South Korea
- New Zealand, another active market, has been working on a national hydrogen strategy since 2019. Its H₂ roadmap is due to release by 2024

- A **greater push from regulations** is needed to **move projects towards FID stage & beyond**

- Australia, the **largest market for low-carbon H₂ projects in APAC**, bearing the largest normalized production capacity of **12,728 kt H₂/year**

- A clear reflection of translating national hydrogen policies into action

Unlocking Hydrogen Potential in APAC (ex-JP) | Announced Partnerships

Amidst nascent technology and infrastructure, investors are tapping on know-how of partnership to unlock hydrogen potential

Announced Low-Carbon Hydrogen Energy Partnerships* in APAC (ex-JP) during 2019 - 2022 Q4 (non-exhaustive)

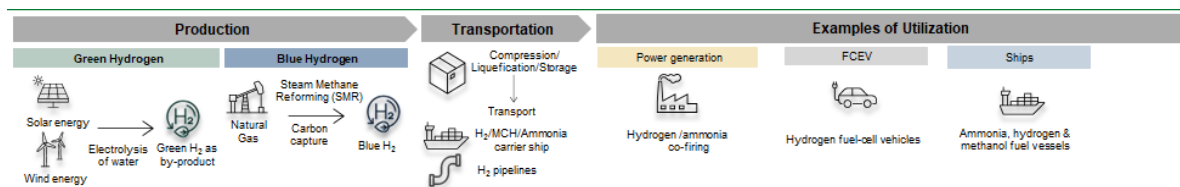
	Australia	China	Hong Kong	India	Indonesia	Malaysia	New Zealand	Singapore	South Korea	Taiwan	Thailand	Total:	
Production	22	3	0	9	2	2	2	2	2	5	0	2	49
Transportation	2	1	0	1	0	1	0	3	3	3	0	0	11
Utilization	10	5	1	3	0	0	5	2	7	1	0	34	
Hub/Value-chain	9	0	0	2	5	2	2	4	4	1	0	29	
Total:	43 (23)	9 (7)	1 (1)	15 (7)	7 (7)	5 (5)	9 (6)	11 (11)	19 (14)	2 (2)	2 (2)	123	

* Partnerships include Acquisitions, Consortiums, Framework Agreements, Investments, Joint Study Agreements, Joint Ventures & MOUs

** () marked are the number of partnerships which have involvement of at least one foreign player

1

67% of announced partnerships focus on production & utilization. Transportation saw the least number of partnerships as infrastructure & regulations concerning it are nascent



2

Foreign Participation



Australia : Strong local collaborations

Opportunities & know-how built locally as seen from 46% of announced partnerships are between domestic entities attract global players ranging from clean-technology providers, utilities companies, strategic investors targeting both domestic & international hydrogen markets.

Others: Open to foreign collaborations

Majority of the partnerships (78%) are between domestic conglomerates and major power companies with global partners reflecting an eagerness to explore the industry and a need to tap on foreign expertise.



65.4% Japanese partnerships in ASEAN markets

3

Common Area of Partnership



Prominent partnership/interest in Hub/Value-chain reflects an ambition to connect H₂ production/utilization with overseas markets



South Korea: fuel cell



India: green hydrogen, electrolyser



Singapore: hydrogen supply chain



China: fuel cell vehicles



Indonesia: co-firing

Unlocking Hydrogen Potential in APAC (ex-JP)

Section II: Hydrogen Policies in the Region

Hydrogen Policies #1 | Australia

Australia



International H₂ market

Export Target:

- H₂ exports to reach A\$10 billion by 2040
- Generate H₂ at below A\$2/kilo, pledging to produce cheapest clean H₂ in the world

Legislation:

- A Guarantee of Origin trial scheme eventually allowing the certification of H₂ exports as “green H₂” commenced in 2022. This could serve particular significance to Japanese & Korean importers that consider H₂ a key part of their decarbonisation imperative

Domestic H₂ market

Fiscal support:

- Since 2018, government committed A\$146million in investments for H₂-related projects

Subsidies:

- New South Wales' government offered a bumper A\$3 billion of subsidies for green H₂ production to commercialise H₂ supply chains & reduce its cost by ~\$5.80 per kg
- A 90% exemption from electricity network charges applied if H₂ projects connect into areas of grid with spare capacity

Sector:

- No specific sector singled out but “H₂ hubs & sector-coupling” e.g. co-location of electrolyzers & wind turbines for electricity, transport & heating

Legislation:

- Australia's national gas regulatory framework was recently amended at federal & state level by its energy ministry to address H₂ under the National Gas Law

Key partnerships

Desert Bloom Aqua Aerem, Osaka Gas

- JV to develop an \$10.75 billion worth green H₂ project (10 GW)
- Osaka Gas, back the project by providing technical support in the plant's FEED & construction

Australian Renewable Energy Hub BP, InterContinental Energy, CWP Global

- BP plc agreed to buy 40.5% stake & become operator of the project, one of the world's largest renewable energy hubs
- Capable of producing 1.8mtpa of green H₂ & ~10mtpa of green ammonia
- Enable export of H₂ derivatives and for local use in Pilbara region to enable large-scale mine electrification & replacement of diesel fuels with H₂

Western Green Energy Hub (WGEH)

Consortium includes InterContinental Energy, CWP Global, Mirning Traditional Lands Aboriginal Corporation

- 3.5 million tonnes per year (Mtpa) of green H₂ to be produced
- Maximise untapped renewable solar & wind energy for electrolysis

Key Projects

Hydrogen Energy Supply Chain (HESC) Project World's 1st shipment of liquified H₂

- Liquify & ship clean H₂ from Port of Hastings in Victoria, Australia to Port of Kawasaki in Japan
- Progressed from pilot phase in early 2022 to commercial demonstration phase in Mar 2023

Darwin H2 Hub Significant hydrogen project earmarked for the Northern Territory of Australia

- Export-focused hub development
- Full-scale, 1 GW electrolyzer capacity capable of producing >80,000 tonnes of renewable H₂ per annum
- Northern Territory Government & TotalEren to jointly develop hub

Yuri Green Hydrogen Project One of the world's first industrial-scale renewable hydrogen projects

- Construct 10 MW electrolyzer to produce renewables-based H₂, replacing a portion of H₂ produced via SMR process at Yara Fertilisers' existing liquid ammonia plant
- Engie announced FID of 1st phase development in Sep-22 & Mitsui agreed to acquire a 28% share from Engie in the project SPV

Hydrogen Policies #2 | China

China



Domestic H₂ market

Hydrogen Industry Development Plan (2021-2035)

- Production Target: 100-200k tonnes of annual green H₂ production by 2025
- Almost all provinces and regions in China have included H₂ into their development plans, more ambitious than the national target e.g. Inner Mongolia alone targets to produce 500k tons green H₂/year by 2025
- Governmental pressure on large State-Owned Enterprises to prioritise green H₂ initiatives



Sector: HFCV

- Target 50,000 H₂-fuelled vehicles on the nation's road by 2025
- Subsidies offered to local governments: e.g. Beijing government announced in Aug 2022 to offer subsidy of ~\$741,000 for each new H₂ power charging station meeting certain capacity standards
- China introduced strict specific fuel-cell vehicle targets on a provincial level, capturing >90% of global sales for the H₂-fuelled commercial vehicles market in 2022



International H₂ market

- Not targeting export of H₂ due to vast gap between domestic consumption needs & production e.g. Commercialize H₂ for self-sufficiency in industrial uses like transport & real estate

Key partnerships

Hydrogen fuel cells Bosch, Qingling Motors

- Formed a joint venture in China named Bosch Hydrogen Powertrain Systems (Chongqing) Co. Ltd.
- Equip all Chinese vehicle manufacturers with fuel cell systems

HFCV for transportation sector Great Wall Holdings, Sinopec

- Framework agreement for H₂ technology & research & development capabilities
- Support Sinopec's target to build 1,000 H₂ refuelling stations & 7,000 distributed PV power stations by 2025

Hydrogen Industrial Park Air Liquide China, Shenergy, SCIP Investment

- 3-party joint venture to build largest-scale H₂ filling center in Shanghai & accelerate deployment of H₂ energy in the city & Yangtze River Delta

Key Projects

Ordos Inner Mongolia project World's largest green hydrogen project from fossil fuels

- 30,000 metric tons per year production capacity of hydrogen through electrolyzed water
- 288,000 standard cubic meters of H₂ storage capacity
- Objective to promote integrated development of traditional synthetic materials chemicals industry & H₂ energy industry, while expediting the clean & efficient use of coal in China

Baofeng, Ningxia Solar Hydrogen Project World's largest hydrogen project in operation as of Feb 2022

- 150 MW alkaline electrolyser + 200 MW solar array
- Held world record for largest operational electrolyser since early 2021

Hydrogen Policies #3 | India

India



International H₂ market

Export Target:

- 10 Mtpa Green Hydrogen by 2030
- Aim to transform into global hub of green H₂



Domestic H₂ market

Production Target: 5 Mtpa Green Hydrogen by 2030



Fiscal support:

- Jan 2023: Initial outlay of \$2.5 billion covering green H₂ incentives + funds to support R&D, pilot projects & skills development

Demand-creation target (legislation):

- Green Hydrogen Consumption Obligations (GHCO) 2035:
 - **Compulsory** consumption targets to incentivise demand
- ✓ Oil refineries required to replace 30% of fuel usage with green H₂
- ✓ Fertiliser production should run on 70% green H₂
- ✓ Urban gas distribution networks should replace 15% of fuel volume with green H₂
- ✓ Extend similar measures to steel industry in near future

Supply-side subsidies:

- Production-linked incentives (PLI) for electrolysers to cover manufacture of 60 GW capacity by 2030
- Waiver of inter-state transmission charges for 25 years from green H₂/ammonia projects commissioned before Jun 2025

Sector:

- H₂ to help decarbonise hard-to-abate industries, like oil refineries, fertilizers, steel & transport

Key partnerships

Adani Power Mundra Coal Fired Power Plant IHI, Kowa & Adani

GAIL green hydrogen project Cummins & Marie Tecnimont

Fully-integrated green hydrogen projects Fortescue Future Industries & Therman

- MOU for technical feasibility study to achieve 20% liquid ammonia co-firing/up to 100% mono-firing in India
- Collaboration to power India's largest proton exchange membrane (PEM) electrolyzer in its GAIL green H₂ project
- Produce ~4.3 tons of green H₂ per day
- MOU to explore opportunities to jointly develop fully integrated green H₂ projects for commercial and industrial customers in India

Key Projects

Rajasthan World's 1st integrated pilot project for Green Hydrogen & Green Ammonia plant

NTPC Kawas Township project Commissioned India's 1st green hydrogen blending project

- Production capacity of 365,000 tonnes per annum Green H₂ & Green Ammonia
- State-of-the-art H₂ facility in India with an integrated hybrid renewable power complex
- Joint effort of NTPC & Gujarat Gas Ltd (GGL)
- Petroleum and Natural Gas Regulatory Board, has given approval for 5% green H₂ blending, to be scaled up to 20% in future

Hydrogen Policies #4 | Singapore

Singapore



Domestic H₂ market

National Hydrogen Strategy

Target: 50% of power needs fulfilled by H₂ by 2050

Sectoral:

Power generation, industry, maritime, aviation, land transport pathfinder projects in ammonia power generation and maritime bunkering



Fiscal support:

R&D

Low-Carbon Energy Research (LCER) Funding Initiative:

Phase 1: S\$55 million awarded to H₂ include development of catalysts for ammonia cracking & methane pyrolysis

Phase 2: Additional S\$129 million earmarked for development of low-carbon H₂



International H₂ market

- Active international outreach in the form of collaborations with industry consortia especially in the area of ammonia bunkering & the maritime sector
- Such collaborations would be the enabling factor for Singapore's role in establishing H₂ supply chains

Key partnerships

Trial First Hydrogen Fuel Cell For Ships In Singapore Sembcorp Marine, Shell

- Feasibility study to demonstrate the applicability of H₂ & fuel cells on ships for decarbonisation
- Develop & install an auxiliary power unit PEM fuel cell on transport between mainland & Shell's Pulau Bukom Manufacturing Site

Cooperation in Green Hydrogen EDF, ITOCHU & Tuas Power

- Create an ammonia supply chain derived from green H₂, extending to use for power generation & as a marine fuel
- Build an international value chain for marine ammonia fuel including Singapore

Feasibility of a Liquid Hydrogen Supply Chain Woodside, Keppel, Osaka Gas

- Study feasibility of long-term, stable supply chain of sustainable liquid H₂ from Western Australia to Singapore & potentially Japan

Key Projects

"SPERA Hydrogen™" Jurong Island project Becoming the single largest decarbonised hydrogen import project in Asia

- Utilise a proprietary liquid organic H₂ carrier technology to transport decarbonised H₂ from offshore locations like Australia & the Middle East to Singapore
- Progressing to pre-FEED study following strategic MOU in 2021 between Sembcorp, Chiyoda & Mitsubishi Corporation, targeted commercial operational date of project is 2026

Keppel Sakra Cogeneration Plant Singapore's 1st hydrogen-ready high-efficiency combined cycle gas turbine power plant

- 600MW "hydrogen-ready" natural-gas power plant in Singapore that could one day run on 100% H₂ following its opening in ~2026
- Project follows Keppel New Energy Pte Ltd's earlier MOU with Mitsubishi Heavy Industries to carry out a feasibility study on development of a 100% ammonia-fuelled power plant on a selected site in Singapore

Hydrogen Policies #5 | South Korea

South Korea 

Domestic H₂ market



Hydrogen Economy Roadmap 2040

No overall target



Sector:

Green New Deal: ambitious target of deploying 200,000 FCEVs by 2025



Legislation:

Passed world's 1st H₂ Law, Economic Promotion & Safety Control of Hydrogen Act

- H₂ vehicles: bring transparency to nation's H₂ pricing system
- Operators of 21 kinds of facilities must comply with installing H₂ charging stations/fuel cells
- Safety assurance framework for H₂ equipment
- Grade-based H₂ certification system for clean H₂

Clean H₂ Energy Portfolio Standards (CHPS) mandate introduced in 2022 separate from RPS: suppliers receive mandatory quotas for H₂ production, takeoff & power conversion

Demand: Kepco(nation's largest power company) & district heating firms in South Korea mandated to procure certain amount of H₂-generated power via auction in 1H 2023 based on CHPS for power sector



International H₂ market

Clean hydrogen produced in Malaysia & the UAE would be imported in 2027, targeting 600k & 200k tons a year respectively

Key partnerships

Joint pursuit of Hydrogen & Ammonia projects Sumitomo, LOTTE Chemical

- Jointly explore business development opportunities related to H₂ & ammonia e.g. joint investments in Australia, Chile, establishment of value chains & development of ammonia storage terminals in Japan/ Korea

Hydrogen Business Cooperation Hyundai Motors, POSCO

- MOU to explore conversion of POSCO vehicles to H₂ alternatives & construction of charging station
- Hyundai to look into commercial H₂ trucks, POSCO to use by-product H₂ for steelworks

Hydrogen & fuel cell JV Plug Power, SK Group

- JV to accelerate the expansion of H₂ fuel cell systems, refuelling stations, electrolyzers in addition to green H₂ in Asian markets - starting with gigafactory in SK by 2024

Key Projects

SK Ulsan Complex

Becoming world's largest green hydrogen town

- Converting the gas turbine at Ulsan Combined Cycle Power Plant into a 270 MW hydrogen-gas turbine by 2027
- Ulsan city developed a safety manual with the Korea Gas Safety Corporation & installed fuel cells, supply pipes & gas control system to be compliant

Changwon City pilot project 1st blue hydrogen project & largest hydrogen complex in the nation

- Used at a new adjacent H₂ filling station — largest in the country — to refuel buses & trucks
- provide up to 300kg per hour of H₂ fuel




Low-Carbon Hydrogen Energy Landscape in ASEAN

Regional Hydrogen Strategy in ASEAN

Premise:

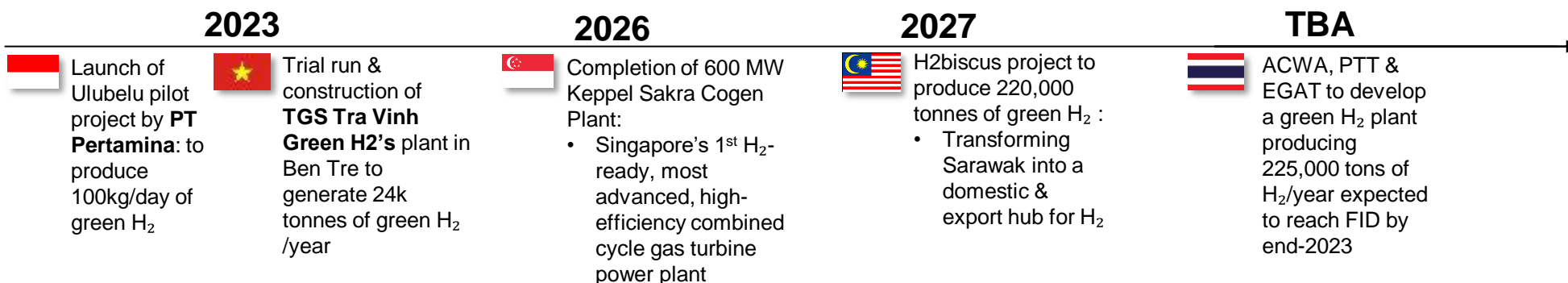
Given majority of countries in the region have yet to enact a national hydrogen strategy, the following three-phased roadmap from ASEAN developed in September 2021 could aid policy makers and industrial stakeholders to construct relevant policy frameworks addressing hydrogen development.

ASEAN roadmap of hydrogen energy development:

-  **Phase I: 2020-2025**
Scale up existing infrastructure to produce/export grey H₂ to form economies of scale first
-  **Phase II: 2026-2030**
Shift to blue H₂ production/exports with help of CCS/CCUS
-  **Phase III: Beyond 2030**
Green H₂ production as LCOE of renewables would have significantly declined plus riding on existing H₂ infrastructure



Key ASEAN Hydrogen Projects in the Pipeline



MUFG's Value Proposition

Creating a Hydrogen Economy | MUFG's Credentials in Hydrogen

Case study: MUFG's Equity Investment in First Element Fuel (2021)

Project Description

- First Element Fuel Inc. (FEF) is California's **largest developer & distributor of hydrogen fuel stations**
- Nov 2021: **MUFG invested USD25M preferred shares in FEF** to support further expansion of its business to H₂ stations for heavy duty vehicles & associated H₂ supply infrastructures
- Mar 2021: MUFG previously initiated the relationship with FEF by supporting its development of H₂ stations for light duty FCEV by extending USD50M loan

Key Success Factor 1

Robust regulatory landscape in California, USA for FCEVs

- ✓ Sales of new gasoline cars prohibited in CA by 2035 due to Zero Emission Vehicle (ZEV) regulation
- ✓ To achieve the above scenario, CA government has been promoting the installation of hydrogen station networks, targeting 1,000 stations by 2030 (48 stations as of Nov 2021)

Key Success Factor 2

Robust regulatory landscape in California, USA for carbon credits

- ✓ In 2010, CA introduced a carbon credit framework with an aim to reduce CO₂ emissions by 20% (vs 2010) in the transportation sector by 2030.
- ✓ Credits are issued by CA when CO₂ emission is below the benchmark set by the government, while penalty is charged when above the threshold. Credit is tradable via the open market as well as via bilateral transaction.
- ✓ Emissions from fuel consumption and fuel manufacturing are subject to the regulation.

Key Success Factor 3

Strong commercial landscape for FCEVs in California, USA

- ✓ Incentive programs driven by the California Energy Commission and the California Air Resources Board have transformed California into the world's largest market for hydrogen FCEVs
- ✓ MOU between Japan Bank for International Cooperation (JBIC) & California State Government to expand opportunities for US-Japan cooperation & boost Japanese business growth in various fields of sustainability, including environmental protection
- ✓ FEF is one of the world's largest hydrogen retailers & its H₂ fuel stations are also funded by institutions like Mitsui & Co., Ltd., JBIC & Japan Infrastructure Initiative Company Limited
- ✓ MUFG is a shareholder of the latter

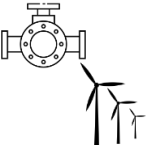






Purpose of Investment

- Acquire knowledge & expertise in H₂ business, contributing to development of H₂ value chains by investing in an industry trailblazer like FEF
- Support business expansion of Japanese FCEV automakers & H₂ equipment suppliers in the region
- Enhance MUFG's presence in global H₂ market, through acceleration of new supply & demand of H₂ to achieve a low-carbon society

MUFG | The Emerging Hydrogen Economy























As a leading energy & natural resources bank globally, MUFG's dominant position and involvement in most of the recent innovative project financings provides us with an unparalleled position in the emerging hydrogen sector – our experience, depth of resources and creativity are optimally suited to finance the hydrogen economy

<p>Structuring Excellence in Renewables & Natural Resources</p>		<ul style="list-style-type: none"> MUFG has one of the largest Project Finance portfolios of any bank globally, funding c. \$19.4bn in Project Finance Loans as well as ranking 2nd in project bonds in 2022¹ We have extensive experience in structuring & negotiating efficient and attractive financings through our Financial Advisory and Mandated Lead Arranger roles on some of the most high-profile and complex “first of a kind” energy & natural resources transactions to-date
<p>View of Hydrogen as a Key element of the Energy Transition</p>		<ul style="list-style-type: none"> Key player in the natural resources & renewable energy sectors, MUFG sees hydrogen as a key element of the transition We have published our views on the hydrogen sector as part of our “Low Carbon Series”², and will also shortly be publishing our views on decarbonising marine transport where we see ammonia as having a key role to play MUFG is an active member of the Clean Energy Council, who provides a regular opportunity for members to engage and collaborate, shaping the Clean Energy Council’s advocacy efforts to accelerate the growth of a new renewable hydrogen industry for Australia
<p>Established Relationships with Relevant Stakeholders</p>		<ul style="list-style-type: none"> MUFG is a global financial institution which puts client relationships at the heart of its business model, and as one of the largest banks globally, has established relationships with the key stakeholders across the hydrogen value chain We are actively discussing opportunities in the hydrogen sector globally with offtakers, developers, governments, funders, sponsors, regulators & other major players, allowing us to have exceptional visibility on the global pipeline of projects in the sector
<p>Depth & Breadth of Resources</p>		<ul style="list-style-type: none"> With a far-reaching cross-product expertise including top-in-the-class specialized DCM, lending, advisory, structured finance, M&A, hedging, commodity, trade & ECA-DFI financing teams, MUFG offer a comprehensive range of products to meet the continually evolving needs of our clients MUFG has c. US\$3.56tn. in assets, a global network of offices in over 50 countries, and benefits from a credit rating of A1 / A / A-
<p>ESG Coordination Capabilities</p>		<ul style="list-style-type: none"> MUFG has established footprint in both arranging and structuring green, social, sustainability and sustainability-linked loans and bonds In 2022, MUFG underwrote 30 Green, Social, Sustainability, Transition and Sustainability-Linked loans in APAC (ex-Japan) for over USD 4.4 billion equivalent, ranking #2 MLA and Bookrunner for Sustainable Finance Loans³

Footnotes: 1. Source: PFI League Tables (Full Year 2022) // 2. Low Carbon Financing Series | MUFG EMEA // 3. Source: Refinitiv Jan-Sep 2022..

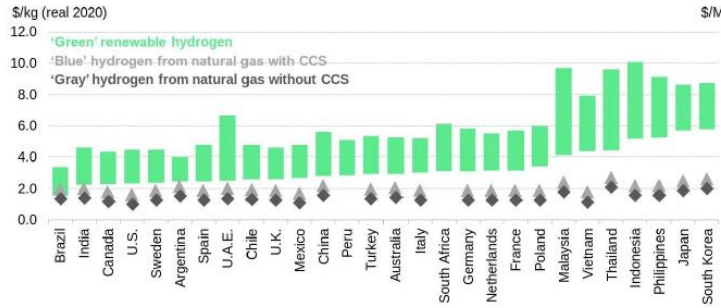
Appendix

Enabling Factor - APAC National Policies for Hydrogen Economy

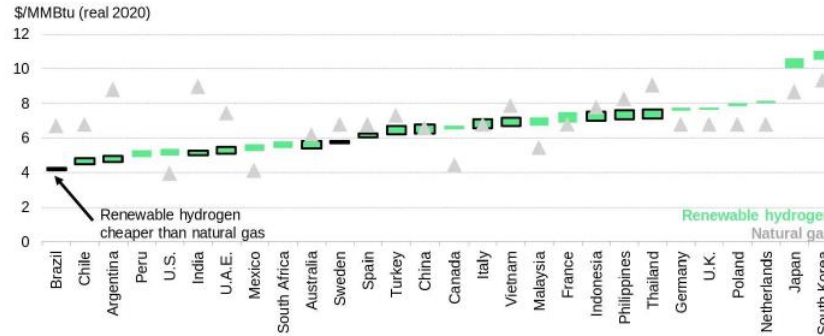
Market	Coal dependency in Power Mix	Established targets and/or long-term hydrogen policy			
		Official H ₂ Policy	H ₂ Target	E.g. of Targeted H ₂ Incentives/Mandates	Positioning of H ₂
Australia 	53%	 Exists (National Hydrogen Strategy 2019)	Scale-up green H ₂ production by generating H ₂ at <A\$ 2/kilo	<ul style="list-style-type: none"> NSW's A\$3billion government subsidy for green H₂ 	Net exporter
China 	61%	 Exists (Hydrogen Industry Development Plan, 2021-2035)	100-200k tonnes of annual green H ₂ production by 2025	<ul style="list-style-type: none"> Subsidy of up to \$741,000 for each new eligible H₂ power charging station 	Neutral
India 	74%	 Exists (National Green Hydrogen Mission)	Produce 5 million tonnes of green H ₂ by 2030	<ul style="list-style-type: none"> Production-linked incentive (PLI) scheme for electrolysers Compulsory H₂ consumption targets for industries e.g. refineries, fertilisers 	Net exporter
Indonesia 	62%	 In progress - no fixed release date	Produce Green H ₂ by 2031, 52 GW generation capacity in 2060	-	-
Malaysia 	46%	 In progress – no fixed release date	-	<ul style="list-style-type: none"> Broad umbrella policy – Green Investment Tax Allowance on assets & projects 	Net exporter
New Zealand 	7%	 In progress – to be released by end 2024	-	-	Net exporter
Philippines 	60%	 Not available	-	-	-
Singapore 	<1%	 Exists (National Hydrogen Strategy)	Target 50% of power needs by 2050 from H ₂	-	Net importer
South Korea 	33%	 Exists (Hydrogen Economy Roadmap 2040)	-	<ul style="list-style-type: none"> Clean H₂ Energy Portfolio Standards mandate 	Net importer
Thailand 	22%	 In progress – no fixed release date	Alternative Energy Development Plan (AEDP): H ₂ included in 10 Kilotons of oil equivalent of alternative fuel in total goal by 2036	<ul style="list-style-type: none"> BOI 5-year strategy (2022): Incentives for production of H₂ vehicles 	-
Vietnam 	47%	 Not available	-	-	-

Trends: Cost of Hydrogen & Natural Gas, Cost of Electricity from Renewables, and CAPEX from Electrolysers

2021: Levelized cost comparisons of green, blue & grey hydrogen:

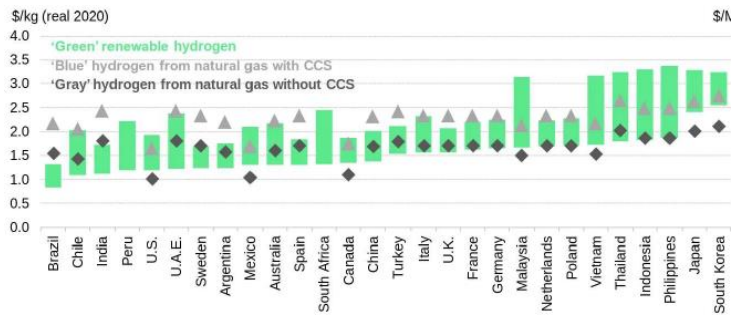


Levelized cost comparison of green hydrogen & natural gas:

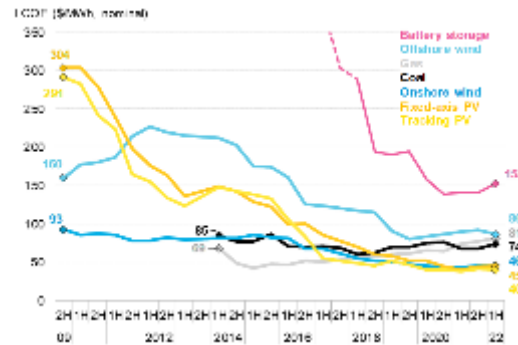


Source: BNEF, Green Hydrogen Set to Cost Less Than \$1/kg (2021)

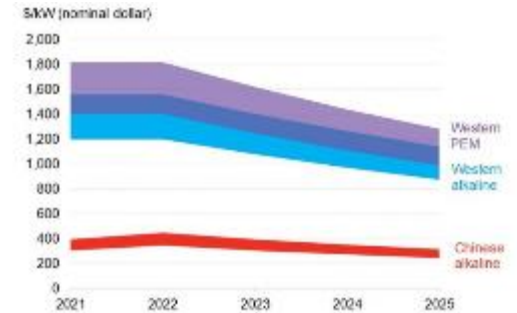
2030:



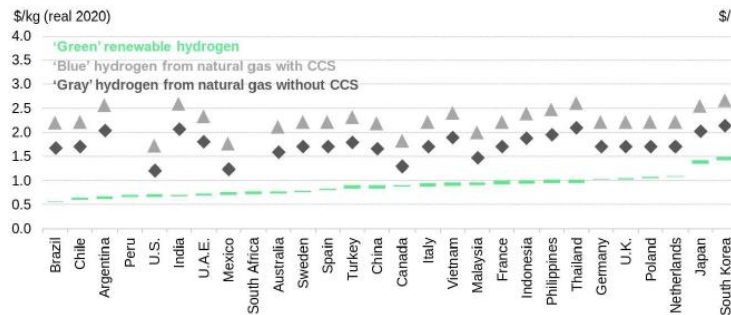
Global levelized cost of electricity from renewables:



Benchmark system CAPEX from electrolysers:



2050:



Source: BNEF, Cost of New Renewables Temporarily Rises as Inflation Starts to Bite (2022)

Source: BNEF, Electrolysis System Capex Could Drop 30% by 2025 (2022)

Source: BNEF, Green Hydrogen Set to Cost Less Than \$1/kg (2021)

Source: MUFG compiled from BNEF and various public sources

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