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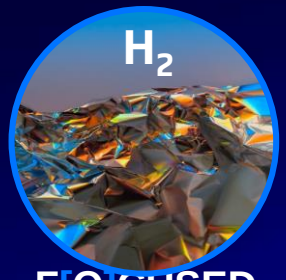
Hydrogen Development Landscape of Key Asian Nations

Image courtesy Mckinsey

Augmenting Value!

Hydrogen Development Landscape of Key Asian Nations – Brief View

Nations in focus – Japan, South Korea, China and India



FOCUSED RESEARCH

The deck is a snippet of the full report "Hydrogen Market and Opportunity in India" by Eninrac Consulting. To procure the full report, write to us at connect@eninrac.com

Asia

Japan will develop commercial scale supply chains by around 2030 to procure 300,000 tonnes of hydrogen annually and ensure that the cost of hydrogen reaches 30 yen/Nm3

JAPAN

In July 2021, Japan released the first draft of new 6th Strategic Energy Plan. To achieve 46 percent GHG reduction target by JFY (Japan Fiscal Year) 2030, ANRE (Agency of Natural Resources and Energy) proposes to reduce the total primary energy generation to approximately 430 billion litres crude oil equivalent (COE) by JFY 2030 from the JFY 2030 target of 489 billion litres COE in the 5th Strategic Energy Plan. ANRE expects this reduction to occur through decreased demand due to improved energy efficiency and energy conservation. Several other key changes in JFY 2030 targets from the 5th SEP to the draft 6 th SEP include -

(i) increase in the use of renewables; (ii) reduction in reliance on petroleum and coal; and (iii) addition of hydrogen and ammonia to the list of energy sources.

BASIC STRATEGY FOR REALIZING A HYDROGEN BASED SOCEITY

A. Realizing low-cost hydrogen use – Japan will develop commercial scale supply chains by around 2030 to procure 300,000 tons of hydrogen annually & ensure that the cost reaches 0.26 USD /NM3. In the later future , Japan will try to lower the hydrogen cost to 0.17 USD/NM3 to allow hydrogen to have the same cost competitiveness as traditional energy sources

> Japan's target is to cut GHG emissions by 26% by 2030 from 2013 level. In accordance with the Paris Agreement , Japan will attempt to cut GHG emissions by 80% by 2050
>
> _ APERC Annual Conference 2021

Japan will develop energy carrier technologies to enable efficient hydrogen transportation and storage

B. Developing international hydrogen supply chains. Japan will demonstrate a liquefied hydrogen supply chain by the mid - 2020s for commercialization around 2030.

C. Renewable energy expansion in Japan and regional revitalization. Japan will attempt to develop and commercialize power to gas systems by around 2032 and reduce the cost of hydrogen from renewable energy to as low as that of imported hydrogen in the later future.

The utilization of unused regional resources (including renewable energy , waste plastics , sewage sludge and by product hydrogen) will contribute not only to expanding the use of low carbon hydrogen but also to improving regional energy self sufficiency rates.

D. Hydrogen use in power generation
In the future , Japan will attempt to make hydrogen power generation including environmental values as cost competitive as LNG power generation. To this end, Japan's annual hydrogen procurement may have to be 5-10 million tons (amounting to 15-30 GW in power generation capacity).

Japan seeks to commercialize hydrogen power generation as well as international hydrogen supply chains and cut the unit hydrogen power generation cost to 17 yen/kWh around 2030. Japan's annual hydrogen procurement may have to reach around 300,000 tons (amounting to 1 GW in power generation capacity)

E. Hydrogen use in mobility
Japan aims to increase the number of FCVs in Japan to 40,000 units by 2020, to 200,000 units by 2025 and to 800,000 units by 2030. Japan also aims to increase the number of hydrogen stations in Japan to 160 by FY2020 and to 320 by FY2025 and make hydrogen stations independent by the second half of the 2020s. Japan aims to increase the number of FC buses in Japan to around 100 by FY2020 and to around 1,200 by FY2030. Japan aims to increase the number of FC forklifts in Japan to around 500 by FY2020 and to around 10,000 by FY2030

”

Japan will aim to achieve net zero greenhouse gas emissions by 2050. To decarbonize its economy Japan is increasingly looking to future fuels such as hydrogen and innovative technology

_ Mr. Yoshihide Suga, Prime Minister, Japan

Japan will develop energy carrier technologies to enable efficient hydrogen transportation and storage

F. Potential hydrogen use in industrial processes and heat utilisation

CO2-free hydrogen can (a) be used as fuel for energy areas where electrification is difficult, and (b) replace industrial-use hydrogen from fossil fuels, contributing to cutting carbon emissions

G. Utilizing innovative technologies

With an eye on 2050, it is necessary to develop innovative technologies for highly efficient water electrolysis for hydrogen production as well as low-cost, highly efficient energy carriers and highly reliable, low-cost fuel cells

H. Utilizing fuel cell technologies

As for Ene-Farms, Japan will seek to lower the price to 800,000 yen for a standard polymer electrolyte fuel cell (PEFC) and to 1 million yen for a standard solid-oxide fuel cell (SOFC) by FY2020 to secure their later autonomous diffusion

I. Innovative expansion

Japan will lead international standardization through international frameworks. Japan will promote technological development and cooperation with relevant organizations.

J. Promoting regional cooperation

It is necessary that the understanding of the safety of hydrogen and the significance of hydrogen use is shared among citizens. To this end, the central government will adequately provide information in cooperation with local governments and business sectors

”

. Government of Japan and New Zealand has signed a Memorandum of Cooperation on green hydrogen in 2018. The Memorandum seeks to encourage industry and research institutes to collaborate in the field of hydrogen

_ Japan Strategic Roadmap

Hydrogen strategy roadmap and targets for Japan – A landscape view till 2030

Hydrogen Utilization Objective

A. Mobility

Objective

- Fuel Cell Vehicle – 200,000 units by 2025 - 800,000 units by 2030
- Refuelling Stations – 320 locations by 2025 - 900 locations by 2030
- Buses - 1200 by 2030

B. Power

Objective

- Commercialization by 2030
- Grid parity early realization by 2025

Hydrogen Supply Objective

A. Fossil + CCS

Objective

- Reduction in hydrogen production cost – 30 yen /NM3 by 2030, 20 yen /NM3 by 2050
- Please note – 1 Yen = 0.0087 USD (As on Jan 2022), 1 NM3/hr= 1.295 kg/hr

B. Reenergised hydrogen

Objective

- Cost of water electrolysis system - 50,000 yen /KW by 2030
- Water electrolysis efficiency- 4.3 kWh/NM3

Landscape of Hydrogen in Japan as on 2021

¥77 Billion
Public funds allocated in year 2021 for development of hydrogen & fuel cells

¥2 Trillion
Investment anticipated by the government of Japan by 2030 for developing hydrogen & fuel cells

Currently Japan Has

- 3800 FCVs
- 135 Hydrogen Refueling STs
- 91 Fuel cell buses
- 250 Fuel cell forklifts

Key Demand Centers

Key industry archetypes focused in Japan for hydrogen usage

Maritime, Transpor, Buildings, Industry, Refinery, Power

Source: Eninrac research & analysis, Hydrogen Roadmap -Japan, Channel Checks

South Korea is betting big on hydrogen. The market size of Korea is anticipated to reach Korean Won (KRW) 26.8 Trillion by 2030

S.KOREA

The hydrogen economy is of key strategic importance to Korea, a country lacking in both conventional and easily exploitable renewable energy resources. Its industrial gases industry has long been influenced by Japanese, American and German technologies and standards, but as hydrogen begins to play a more transformative role in the broader economy, Korea is keen to ensure it has greater control over the technologies and standards that will underpin that transition. Building on this, the Korean government announced its Hydrogen Economy Roadmap in 2019. The roadmap aims to deploy 15GW of utility-scale and 2.1GW of commercial and residential fuel cells by 2040. In terms of mobility, the goal is to have 5.9 million fuel cell cars and 60,000 fuel cell buses on the road by 2040 all supported by 1,200 hydrogen refuelling stations.

The announcement of Korea's Green New Deal in July 2020 - a coronavirus stimulus plan outlining KRW 74 trillion (£47bn) in 'green' public-private capital investment by 2025 - should help the country on its way to achieving these aggressive long-term goals. Korea's hydrogen industry is forecast to almost double in size from KRW 14.1 trillion (£9.1bn) in 2020 to KRW 26.8 trillion (£17.3bn) by 2030. This growth will be driven by investments from large local players such as Hyundai and Doosan who increasingly see hydrogen as a key growth engine. Hyundai Motors intends to spend KRW 7.6 trillion (£4.9bn) under its 'Fuel Cell Vision 2030' programme and looks well placed to capitalise on its early-mover advantage in fuel cells, both by selling its own vehicles and by licensing its fuel cell systems to OEMs around the world.

> Korea Gas Corporation (KOGAS) laid out its 2030 H2 business development targets in May 2019, construction of 25 H2 production plants , more than 700 km of H2 pipelines and operation of 110 HRS and 500 H2 tube trailers by 2030
>
> _ KOGAS

Hydrogen strategy roadmap and targets for S.Korea – A landscape view till 2030

Hydrogen Utilization Objective

A. Mobility

Objective

- Taxis – 120,000 units by 2040 to expand across country
- Refuelling Stations – 1,200 by 2040 with localisation upto 100%
- Buses - 60,000 units by 2040 that can run for 800,000 kms
- Trucks - 120,000 units by 2040 with localisation upto 100%

B. Energy

Objective

- FC Power Plants - 15 GW by 2040
- Residential FC- 2.1 GW by 2040

$20 Billion Anticipated government investment in South Korea for hydrogen development till 2030

Hydrogen Supply Objective

A. Hydrogen Supply

Objective

- Hydrogen Supply – 5.26 Million Tones/ Year
  Note-
  Installation cost down to KRW 7.1m (£4,600)/kW
- Hydrogen Cost – KRW 3000 for large scale electrolyser (£1.9)/kg

B. National Core Technology Plan

		Current Status	Target
Technology	SMR	System Design small scale demonstration	System Efficiency 78% (HHV) by 2030
	Water Electrolysis	Design stage of the development of 1MW original technology and stack technology	100MW system; System Efficiency 50kWh/kg-H2; Dozens of MWs of P2H technology development connected to RE by 2030

Source: Eninrac research & analysis, Hydrogen Roadmap –S. Korea, Channel Checks

Hydrogen strategy roadmap and targets for S.Korea – A landscape view till 2030 (Contd.)

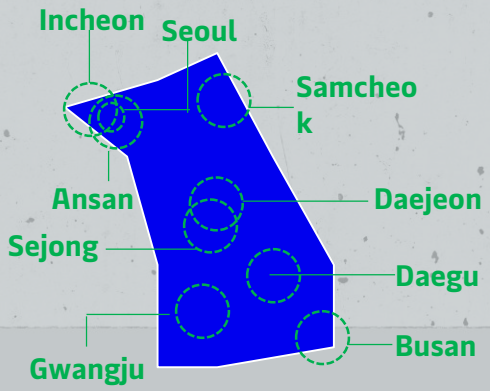
Landscape of Hydrogen in S.Korea as on 2021

Currently S.Korea Has

- Expected to run in large cities
- ~ 310 hydrogen fueling
- ~2000 buses
- ~ 10 – ton trucks

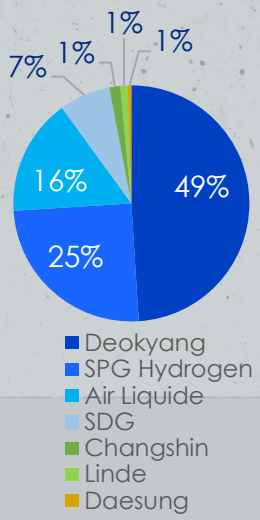
Key industry archetypes focused in Korea for hydrogen usage

Key Demand Centers



Key hydrogen suppliers in S. Korea and their market share

Company Name	Capacity (NM3/hr)
Deokyang	150,000
SPG Hydrogen	65,000
Air Liquide	53,000
SDG	21,300
Changshin	5,200
Linde	3,200
Daesung	2,000



> Hyundai is indeed well – positioned to become a fuel cell system supplier to the bus OEMs in Korea. However, we cannot deny the fact that this might put us at risk of becoming dependent on our competitor when it comes to the critical technology. Therefore, we are also considering the option of a foreign supplier for the development of our own fuel cell bus
>
> _ Mr. Chihwan KIM, Director of Purchasing Divison (Edison Motors)

Source: Eninrac research & analysis, Hydrogen Roadmap- S. Korea, Channel Checks

The Chinese government at various levels is actively promoting hydrogen energy development

CHINA

Hydrogen is gaining increasing attention from industries and policymakers in China. However, most of the current demonstration projects in the country have relied on conventional sources, including industrial by-product hydrogen and grey hydrogen produced from fossil fuels. The Chinese government at various levels has actively promoted hydrogen energy development. As of 2019, out of 34 Chinese provincial administrative regions, 17 (plus at least 22 municipal administrations) have published policies to develop hydrogen energy-related industries and infrastructure; this is complemented by more than 10 policy documents issued by the central government of China.

China launched a new FCEV pilot cities programme in 2020 to enlarge FCEV industry supply chains. In contrast with

vehicle purchase subsidies, the scheme rewards clusters of cities based on a series of parameters. To be eligible for financial rewards, city clusters must deploy more than 1 000 FCEVs that meet certain technical standards; achieve a delivered hydrogen price at a maximum of (Chinese Yuan) CNY 35.00/kg (~USD 5.00/kg); and provide at least 15 operational hydrogen refuelling stations (HRSs). Based on the plan and how well objectives are met, a maximum of CNY 1.5 billion (~USD 220 million) will be transferred to each selected city cluster between 2020 and 2023.

The Asia-Pacific region currently accounts for half of global industrial hydrogen demand, with China alone taking a major portion (17 Mt H2) for ammonia and methanol production. With growth across all sectors, China accounts for almost two-thirds of Announced Pledges Scenario hydrogen

> The Asia Pacific region currently accounts for half of global industrial hydrogen demand , with China alone taking a major portion
> 17 Mt H2 for ammonia and methanol production
>
> - IEA

Hydrogen strategy roadmap and targets for China – A landscape view till 2030

Hydrogen Utilization Objective

A. Mobility

Objective

- Passenger Cars –
  40,000 FCVs in service by 2025
  800,000 in service by 2030
- Buses/Trucks –
  10,000 buses/trucks by 2025
  200,000 buses/trucks by 2030
- Refuelling Stations –
  >300 stations by 2025
  >1000 stations (>50% of H2 production from renewable sources)

B. Commercials

Objective

- Cost of commercial vehicle –
  ≥ RMB 1.0 Million
  ≥ RMB 600,000
- Cost of passenger car –
  ≥ RMB 200,000
  ≥ RMB 180,000

$220 Million Anticipated government investment in China for hydrogen development till 2023 to each selected city cluster

Hydrogen Infrastructure

A. Hydrogen Supply

Objective

- Decentralized hydrogen production from renewable sources , industrial by-products such as coke-oven gas till 2025
- Decentralised H2 production from renewable sources till 2030

B. Hydrogen Delivery

Objective

- Cryogenic liquid hydrogen delivery by 2025
- High density organic liquid hydrogen storage and delivery at normal pressure by 2030

Landscape of Hydrogen in China as on 2021

Currently China has

- ~2000 Cars
- ~3000 Buses/trucks
- ~100 Refuelling hydrogen STs

Key Demand Centers

Source: Eninrac research & analysis, Hydrogen Roadmap -China, Channel Checks

Most hydrogen trade projects under development are in Asia –Pacific

Few Hydrogen Trade Projects in Australia to Japan

Project	Volume
Hydrogen Energy Supply Chain	225,540 tpa
Stanwell – Jwatani Gladstone Project	280,000 tpa
Asian Renewable Energy Hub	TBD
Origin Energy – Kawasaki Heavy Industries Townsville Project	36,000 tpa
Eyre Gateway	7,000 tpa

Source: Eninrac research & analysis, Hydrogen Council, IEA, Channel Checks

India and Italy have agreed to explore development of green hydrogen , setting up renewable energy corridors and joint projects in the natural gas sector

INDIA

On 15th August 2021 Honourable Prime Minister of India – Mr. Narendra Modi flagged the launch of National Hydrogen Mission and announced to transform India into a global hub for green hydrogen production and export. Further, the country is also focusing upon having international tie-ups for developing green hydrogen. The mission envisages commercial production of green hydrogen production in India from financial year 2025-26 onwards. The draft proposes to undertake hydrogen production projects through a competitive bidding mode which would be open to participation from both public and private entities. Further, the mission includes frameworks for indigenous manufacturing and research & development aimed at improving the efficiency of electrolysers – systems that use electricity to break water into hydrogen and oxygen in a process called electrolysis.

Among other provisions, the mission includes a framework for demand creation of green hydrogen through mandates in identified sectors. As for current capacity in the nation, a green hydrogen project with a production capacity of one tonne per day has been established at Bikaner, Rajasthan, under the private sector. Further, under a Research and Development project supported by the Ministry of New and Renewable Energy, a 5 Nm3/h (normal cubic meter per hour) green hydrogen production plant based on solar energy-powered electrolysis has been established at the National Institute of Solar Energy.

> Hydrogen demand in India was close to 6 million tonne per annum in 2020 with most of the demand coming from ammonia production and refineries.
>
> _ TERI

Hydrogen Development in the India – Market Landscape till 2021

Under development hydrogen projects for mobility in India supported by government of India

06 Fuel cell buses by Tata Motors Ltd.

50 Hydrogen enriched CNG buses in Delhi, (By Indian Oil in collaboration with Govt of NCT of Delhi)

02 Hydrogen fuelled internal combustion engine buses (by IIT Delhi, in collaboration with Mahindra & Mahindra)

15 Hydrogen fuelled three wheelers in Delhi, (by IIT Delhi, in collaboration with Mahindra & Mahindra)

02 Hydrogen diesel dual fuel cars (by Mahindra & Mahindra)

01 CSIR – Central Electrochemical laboratory and CSIR – National Physical Laboratory

₹ 21 Crores **Cumulative fund released from 2019-20 to 2020-21 for developing hydrogen and fuel cells**

Source: Eninrac research & analysis, Government Media Releases, Company reports, Channel Checks

Key Industry partnerships with global players

Partnership		Country of Origin	Area of Development
Indian Player	International Player		
JSW	Fortescue Future Industries	Australia	For hydrogen usage in steel making and mobility
BGR ENERGY	FUSION-FUEL™	Ireland	To develop a demonstrator plant for cost competitiveness
AYANA RENEWABLE POWER PRIVATE LIMITED	GREENSTAT	Norway	To accelerate hydrogen technology development
Reliance Industries Limited	Stiesdal	Denmark	To manufacture & set up electrolysers unit of capacity 2.5 GW
adani	Maire Tecnimont	Italy	Will explore development of industrial projects producing chemicals , ammonia& hydrogen

Hydrogen Development in the India – Market Landscape till 2021 (Contd.)

Key Industry partnerships with global players

Partnership		Country of Origin	Area of Development
Indian Player	International Player		
Greenko	John Cockerill	Belgium	To jointly develop market initiatives for green hydrogen electrolysers in India
HERO FUTURE ENERGIES planet positive power	ohmium	USA	To set up 1 GW green hydrogen facilities

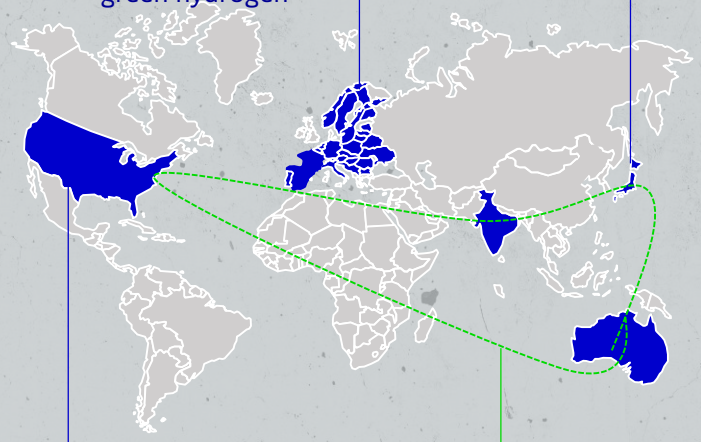
Key Industry partnerships of domestic players

Partnership		Area of Development
LARSEN & TOUBRO	ReNew POWER	To develop, own and operate green hydrogen projects in India
IISc	Indian Oil Corporation Limited	To develop and demonstrate biomass gasification based hydrogen generation technology for producing fuel cell grade hydrogen at an affordable price

Key partnerships of India with other countries for developing hydrogen

India-Japan
India to seek collaborations with Japan for innovations on hydrogen based technologies

India-EU
EU to partner with India through investments in green hydrogen



India-US Hydrogen Task Force

It aims to serve as a forum to achieve affordable hydrogen solutions. The key vision is to enhance energy security and resilience by scaling up low or zero-carbon hydrogen technologies and deployment

India- US-Japan-Australia

Establish a clean hydrogen partnership

It aims to strengthen and reduce costs across all elements of the clean hydrogen value chain , leveraging existing bilateral and multilateral hydrogen initiatives in other fora

Source: Eninrac research & analysis, Government Media Releases, Company reports, Channel Checks

The life of a man consists not in seeing visions and in dreaming dreams, but in active charity and in willing service

- Henry Wadsworth Longfellow

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