

Clean Hydrogen as an Alternative Fuel for Sustainable Mobility

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Table of Contents

1

Scope of Hydrogen in the Mobility Sector

2

Hydrogen Powered Mobility - Market Outlook

3

APAC Leading the Hydrogen Mobility Market

4

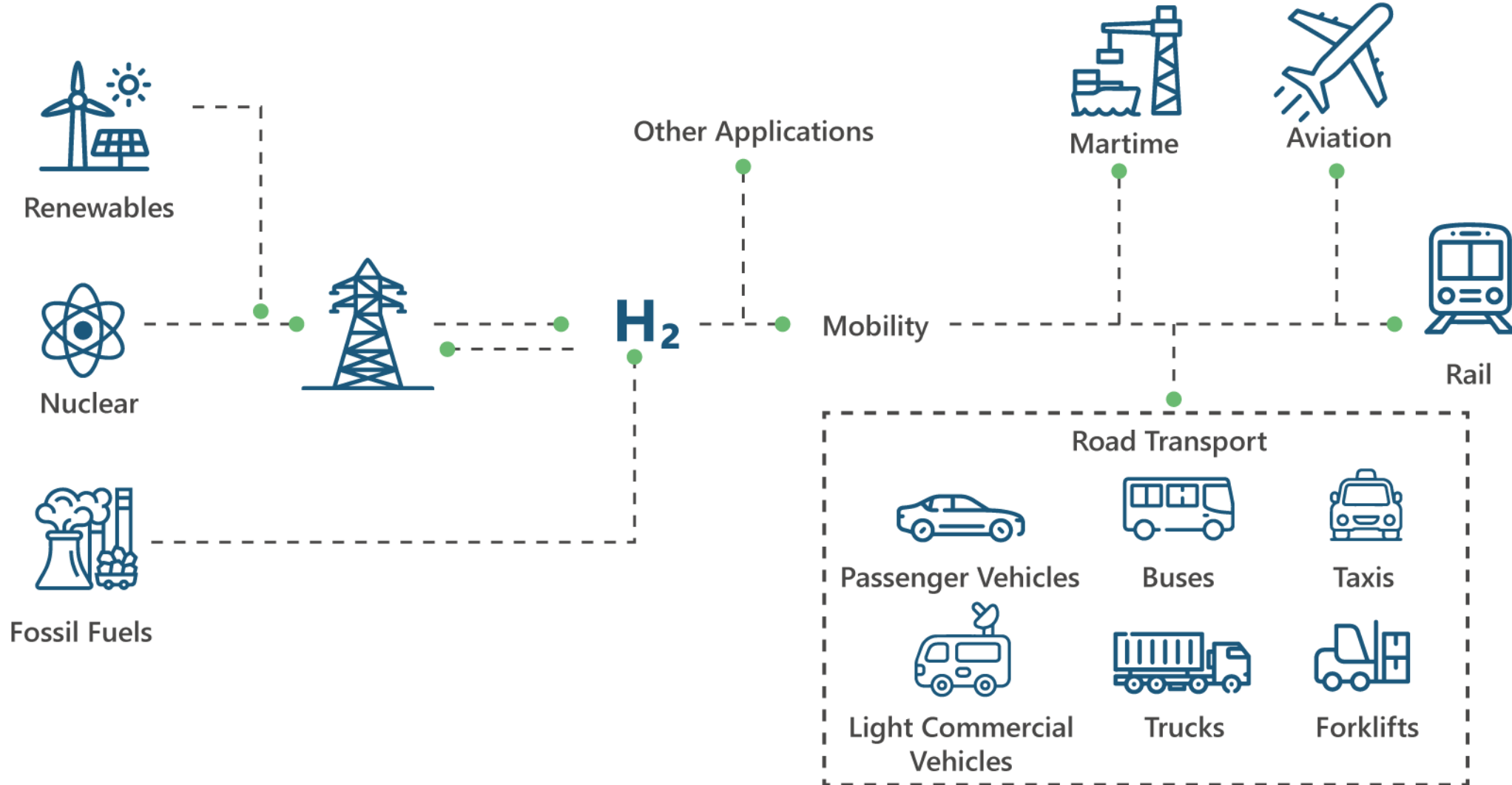
North America Stepping Up its Game

5

Europe Advancing Towards Hydrogen Mobility

Scope of Hydrogen in the Mobility Sector

Hydrogen is a versatile fuel that presents untapped potential as a clean energy source.



Hydrogen Powered Mobility - Market Outlook

Despite its challenges, hydrogen is emerging as a low-carbon alternate fuel option for the mobility sector primarily because of hard-to-find alternatives for long-haul transportation.

• Hydrogen in Road Transport

- Most **established** hydrogen mobility segment
- Hydrogen fuel cell passenger vehicles hold the **largest market share – 82%**
- As of 2021, **51407 FCEVs** were on the road worldwide with **729** hydrogen refueling stations in operation

Region	FCEVs	HRS
APAC	67.5%	60.2%
North America	24.5%	29.4%
Europe	7.7%	10%
RoW	0.1%	0.4%

• Next Stop, Hydrails!

- **3 times** more efficient than Internal Combustion Engines
- Refueling time of **20 minutes**
- **140 km/h** speed achievable
- Distance of **1000 km** covered without being refueled
- **Cost competitive** as compared to electrification

• Hydrogen in Maritime

- In 2020, IMO restricted sulfur content in fuel used by ships from **3.5%** to **0.5%**
- In 2021, a Global Maritime Forum study examined **106** zero-emission shipping pilot projects - **nearly half** of these utilized **hydrogen**
- Hydrogen can replace
 - **43%** of voyages between the U.S. and China without any changes
 - **99%** of voyages with minor changes to fuel capacity or operations

• Hydrogen Powered Skies

- International Energy Agency identifies **hydrogen-based synthetic fuels** as a potential solution for lowering emissions in aviation
- According to AIRBUS, hydrogen has the potential to reduce **50%** of aviation sector's CO2 emissions
- In 2020, a EU Clean Sky and FCHJU study found that **hydrogen** could power short-range aircrafts by **2035**
 - **70 to 80%** emission reduction, **20 to 30%** additional cost

APAC Leading the Hydrogen Mobility Market

South Korea, China, and Japan are among the top 4 largest markets for FCEVs globally with South Korea leading the global FCEV market.

Hydrogen Mobility Market Landscape: Regional Outlook

4

National Hydrogen Strategies published

Vision and Targeted Sectors:

- Strong focus on FCEV deployment
- China, Japan, and South Korea: FC passenger vehicles, buses, and taxis
 - South Korea's 'Hyundai Nexo' - World's best-selling hydrogen FC passenger car.
- Australia: FC heavy-duty transport
- China launched **Asia's 1st** and the **world's 2nd** hydrogen-powered train
- R&D initiatives seen in the maritime sector in China, Australia, and Japan
 - **Hydrobingo Project:** The world's 1st hydrogen-powered ferry in Japan
 - **Three Gorges Hydrogen Boat No. 1 Project:** China's 1st hydrogen fuel cell-powered boat

Supporting Policies, Regulations, and Incentives:

Subsidy Schemes and Incentives:

- South Korea provides a national subsidy for purchasing FCEVs
 - State-level subsidies also offered in Busan and Incheon
- China provided tax reductions and direct subsidies for FCEVs up till 2022
 - 2023 onwards, public financial support in the form of tax exemptions and incentives
- Japan provides subsidies, at national and local levels, for purchasing FCEVs
- In Australia,
 - Australian Capital Territory:
 - 2-year free registration for FCEVs until June 2024
 - South Australia
 - Subsidies and a 3-year registration exemption for FCEVs
 - New South Wales
 - Rebates on the purchase of FCEVs
 - Victoria
 - Subsidies for the 1st 20,000 FCEVs sold at a certain price
 - Western Australia
 - Largest rebate offer in Australia to 1st 10,000 Western Australians that buy an FCEV

North America Stepping Up its Game

Tremendous potential to utilize hydrogen in the road transport and maritime sectors.

Hydrogen Mobility Market Landscape: Regional Outlook

2

National Hydrogen Strategies published

Vision and Targeted Sectors:

- Strong focus on FCEV deployment
- California leads the h2 mobility sector in North America
 - Highest number of FC passenger car deployments and HRS
- At federal level, USA targets all types of FCEVs including material-handling vehicles
- Alberta and British Columbia: FC trucks and buses
 - Quebec and Ontario also emphasize hydrogen usage in mobility sector
- Hydrogen initiatives are also seen in the aviation, maritime, and rail sectors
 - **Sea Change Vessel Project:** 75-passenger hydrogen fuel cell ferry launched in San Francisco
 - **Lighting McClean Project, Washington:** Equipped with the largest hydrogen fuel cell ever to power an aircraft
 - **Coradia iLint Project:** North America's 1st hydrogen-powered train to debut in Canada

Supporting Policies, Regulations, and Incentives:

Inflation Reduction Act (IRA), USA:

- Up to 3 USD/kg for low-carbon hydrogen production
- Up to 100,000 USD for Hydrogen Refueling Stations (HRS)
- Up to 7,500 USD credits for new clean vehicle purchases
- Up to 4,000 USD for used clean vehicle purchases
- Up to 40,000 USD for FC trucks and buses being tested and deployed in the U.S.

Hydrogen for Trucks Act, USA:

- Incentives for hydrogen FC trucks and refueling infrastructure

Zero-Emission Vehicles Act, Canada:

- Automakers to meet an escalating annual percentage of new light-duty ZEV sales and leases
 - 10% of light-duty vehicle sales by 2025
 - 30% by 2030
 - 100% by 2040

Subsidy Schemes and Incentives:

- In USA, California and Connecticut offer rebates on purchase or lease of FCEVs
- In Canada, consumers receive a federal incentive for purchasing FCEVs
 - Regional incentives also offered in Quebec, British Columbia, and Yukon

Europe Advancing Towards Hydrogen Mobility

Despite having a huge investment plan, several published strategies, and highly ambitious targets, Europe is behind other regions in adopting hydrogen in the mobility sector.

Hydrogen Mobility Market Landscape: Regional Outlook

20

National Hydrogen Strategies published

Vision and Targeted Sectors:

- Spain, Norway, and the Netherlands: Light- and heavy-duty FCEVs
- Germany, Italy, and Switzerland: Heavy-duty vehicles e.g., trucks and military vehicles
- Poland: FC buses only
- France: Light-duty commercial vehicles and heavy-duty vehicles
- Hydrogen initiatives also seen in aviation, maritime, and rail sectors
 - **ZeroAvia**: World's largest aircraft powered by a hydrogen-electric engine
 - **Hy4 Project**: World record for highest-flying altitude of a hydrogen aircraft.
 - **Coradia iLint Project**: World's 1st passenger train powered by hydrogen fuel cells
 - **HydroFLEX Project**: UK's 1st hydrogen-powered train
 - **Topeka: base to base Project**: World's 1st hydrogen-powered zero-emission cruise ship concept

Supporting Policies, Regulations, and Incentives:

Hydrogen Roadmap Europe:

- By 2030
 - 3.7 million FC passenger cars
 - 500,000 FC LCVs
 - 45,000 FC heavy-duty vehicles
 - 3,700 H2 Refueling Stations
- By 2050
 - 45 million FC passenger cars
 - 6.5 million FC LCVs
 - 1.7 million FC trucks
 - 250,000 FC buses

Alternative Fuels Infrastructure Regulation (AFIR):

- 1 HRS after every 100 km
- At least one 700 bar dispenser at each HRS
- 1 liquid hydrogen dispenser after every 400 km
- At least one HRS per urban node by 2027
- Hydrogen and ammonia refueling points at TEN-T core maritime ports by 2025
- Rollout of infrastructure for hydrogen-powered planes at airports

Subsidy Schemes and Incentives:

- Denmark exempts hydrogen cars from initial registration taxes
- Germany provides environmental or innovation bonuses for purchasing FCEVs
- Switzerland exempts FCEVs from performance-related heavy vehicle charges and petroleum taxes
- Austria, Spain, Italy, France, Sweden

PTR's Hydrogen Market Intelligence

Research on the use of Hydrogen as an energy transition fuel around the world



Global Hydrogen Projects Database

- This is a database style service containing over 700 Hydrogen projects. It includes project specific information of hydrogen projects delivered around the globe. Additionally, announced projects are added into the database which gives an overview of the global hydrogen project pipeline.



Global Hydrogen Market Outlook Report

- This report provides a detailed analysis of the entire value chain of hydrogen. It provides a global outlook of the hydrogen market covering APAC, Europe, Middle-East and Africa, and the North and South American regions. Details of 29 National Hydrogen Strategies, 39 Hydrogen Valleys and 10 company profiles each of electrolyzer, compressor and fuel cell manufacturers have been highlighted in the report.



Global Hydrogen Compressor Market Sizing Database

- Launching soon, this market sizing database will depict the growth of the hydrogen compressors market from 2021-2030 with a regional/country level forecast of annual sales of hydrogen compressors segmented into categories and sub-categories that differ on the basis of technology and end-use applications.

