Hydrogen Compression Market Landscape

Speakers:

Zeeshan Sami Khan

Senior Market Research Analyst – Hydrogen

zeeshan.khan@prt.inc

Jannat Wasif

Market Research Analyst – Hydrogen

jannat.wasif@ptr.inc

Moderator:

Hassan Zaheer

Chief Commercial Officer

hassan@prt.inc

PTR Inc.

The three pillars of PTR: Transparency, Diligence, and Digestibility

Founded in 2016

Owned and operated by researchers, analysts, and power engineers

Objective:

To understand the recent and upcoming changes to our electric infrastructure while identifying and communicating the best technologies and associated business models applied by industry leaders.

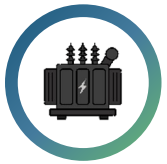
COVERAGE

Power Grid

New Energy

Specialized Power Grid & New Energy Market Research

Covering all aspects of transmission & distribution grid and emerging new energy topics



Transformers
(Dist., Power)

Substation Automation
(Dist. vs Cent.)

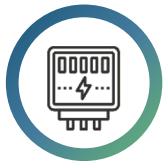
EV Charging Infrastructure
(Public, Private, Passenger/Comm.)

Switchgear
(HV, MV)

Port Electrification
(Shore-to-Ship, Microgrid)

Energy Storage Value Chain
(Utility Scale, C&I)

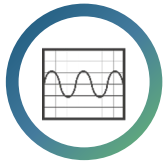
Flexible AC Trans. Systems
(SVCs, STATCOMs)



Smart Meters
(Power Quality, AMI)

Hydrogen in Power Sector
(Tech., Demand, Value Chain)

HVDC Market Analysis
(VSC, LCC, Cables)



Power Factor Correction
(Active, Passive)

AI in Power Grid
(Projects, Corp. Strategy, Policy)

Synchronous Condensers
(4-Pole, 6-Pole,...)

Grid Communication
(Private LTE, 5G)

Impact of EVs on Power Grid
(Quantitative, Trafo., Switchgear)

Industrial Motors & Drives
(MV/LV - Custom)

Comm. & Off-Highway Vehicles
(BEVs, PHEVs, ICEs)

Agenda

1. **Introduction (10 min)**

2. **Role of Hydrogen in Future Energy Systems (5 min)**

3. **Hydrogen Compression: Overview (5 min)**
   - Importance of hydrogen compression
   - Challenges associated with hydrogen compression
   - Hydrogen compression value chain

4. **Hydrogen Compression Applications and Technologies (10 min)**
   - Established and emerging hydrogen compression applications
   - Established and emerging hydrogen compression technologies

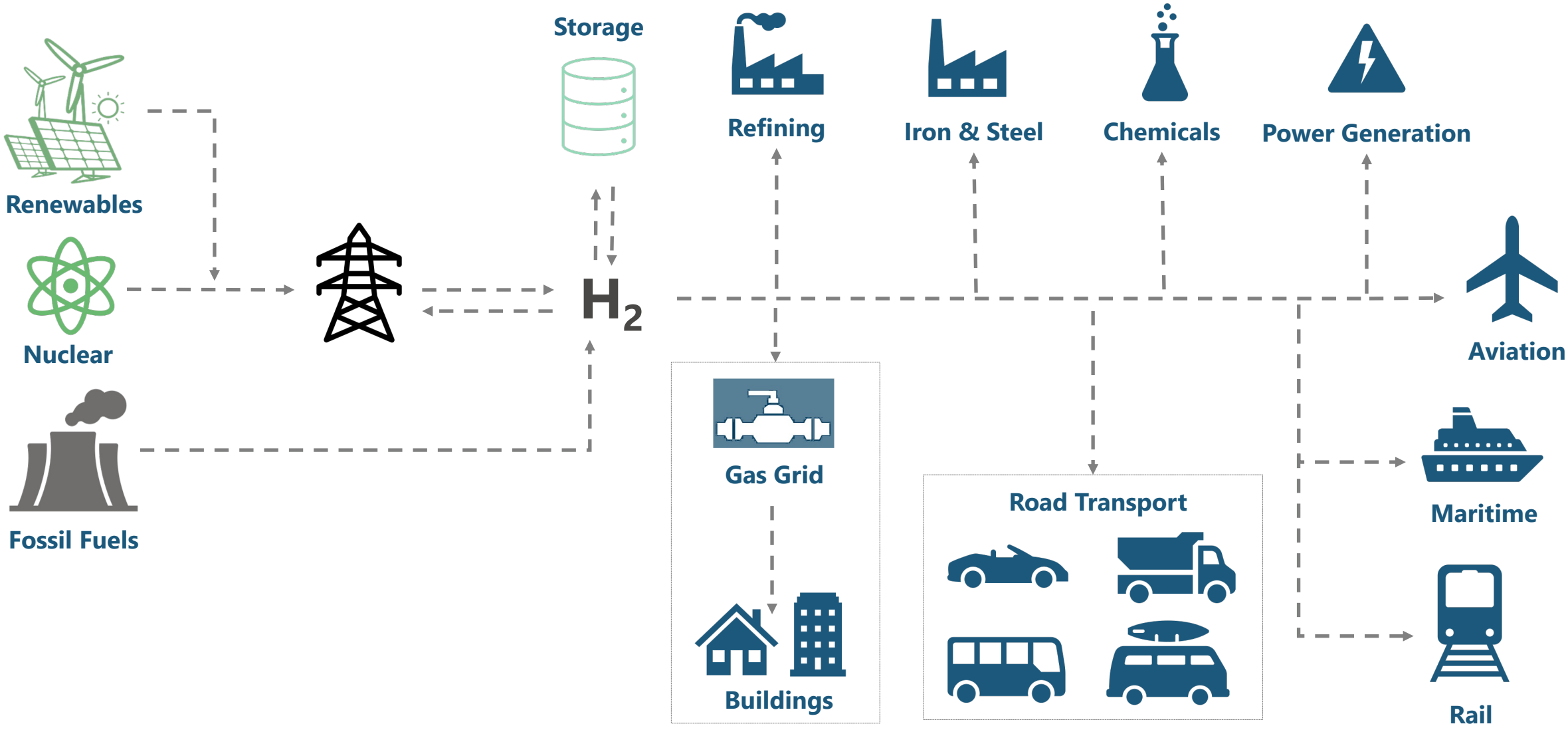
5. **Global Hydrogen Compression Market Analysis (20 min)**
   - Hydrogen Compression Demand Centers
   - Factors Impacting the Global Hydrogen Compression Market
   - Hydrogen Compression Market By Application
   - Asia-Pacific: The Epicenter of Hydrogen Compression
   - Leading Hydrogen Compression Market Companies

6. **Q/A Session (10 Mins)**

Role of Hydrogen in Future Energy Systems

Role of Hydrogen in Future Energy Systems

Hydrogen is rapidly emerging as a low-carbon alternative fuel that has widespread applications in several industries.



Hydrogen Compression: Overview

Harnessing the Power of Hydrogen: Unlocking the benefits through Effective Compression

Overcoming challenges and maximizing potential for pure and hydrogen-rich applications

Hydrogen Compression and its Importance

- Hydrogen has a molecular weight of *2.02 g/mole*
  - The *lightest* of all gases
- Very *high* energy content per unit of weight: *~33 kWh/kg*
  - An *ideal* energy carrier
- However, density of hydrogen at atmospheric conditions is very *low* as compared to other gases: *90 g/m3*

Hence, compression of hydrogen is *frequently* required to meet various process conditions of different applications

Challenges to Hydrogen Compression

Highly energy-intensive process

Requirement of a large number of compression stages

Very high impeller operating speeds required

Risk of hydrogen embrittlement

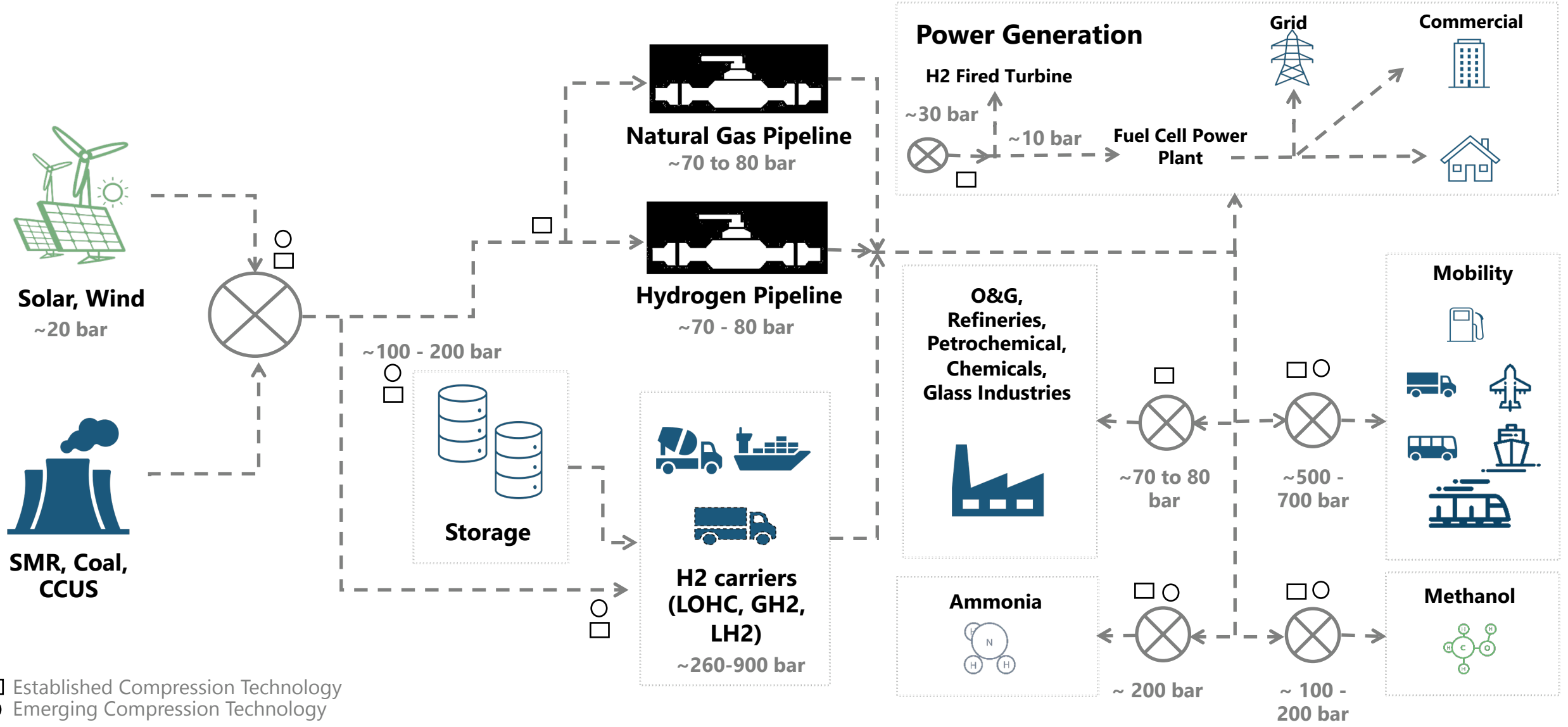
Escape and leakage of hydrogen molecules through gaps

Hydrogen Compression applications can be separated into two categories

- *Pure* or *100%* hydrogen applications
  - For example: A *hydrogen production facility*, where hydrogen is produced – ideally from an electrolyzer powered by renewables – and then compressed and stored for various different applications
- Hydrogen-rich applications
  - For example: In *refineries* and *chemical plants* where recycle or make-up compressors are used to handle process gas containing high hydrogen content and other constituents

Hydrogen Compression Value Chain

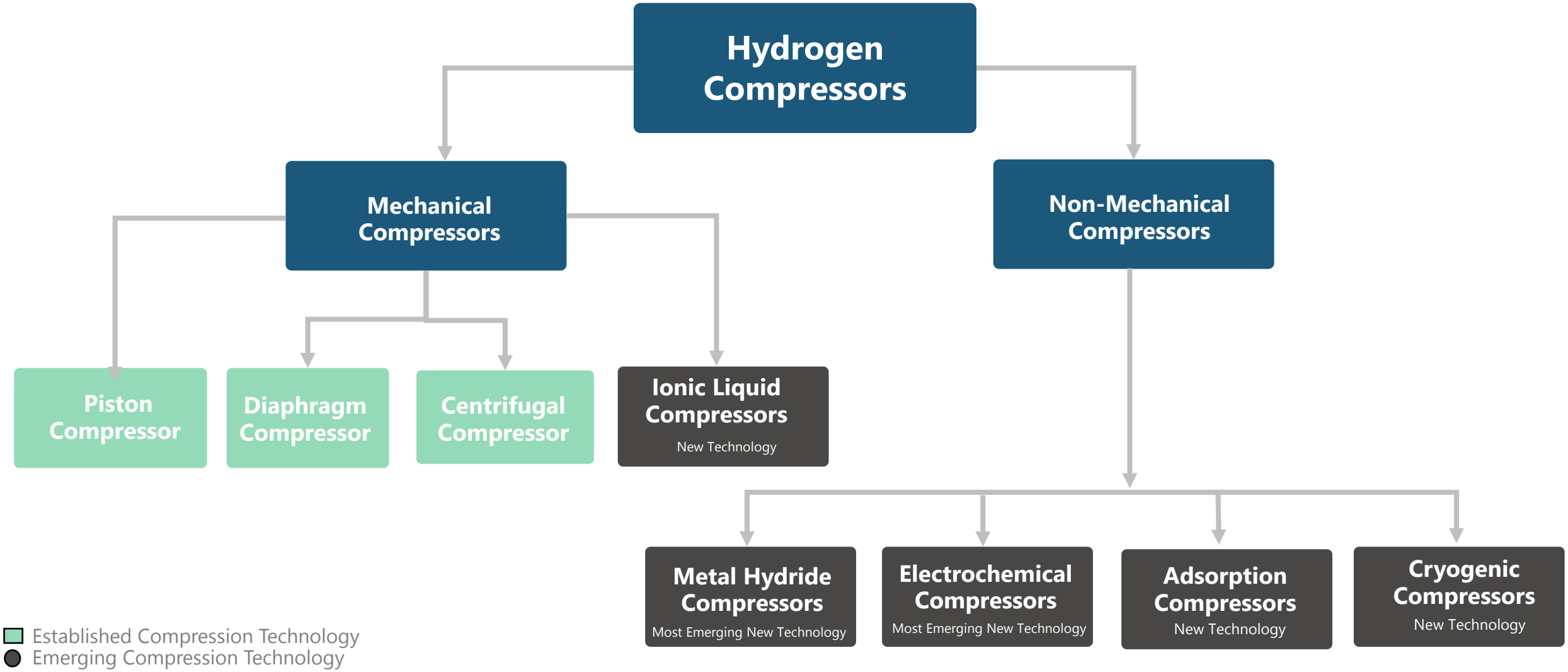
Hydrogen is a versatile fuel that presents untapped potential as a clean energy source.



Hydrogen Compression Technologies

Hydrogen Compression Technologies

Existing and emerging hydrogen compression technologies.



Existing Hydrogen Compression Technologies

Piston and Diaphragm Compressors currently lead the hydrogen compression technologies

TECHNOLOGY	ADVANTAGES	DISADVANTAGES	KEY MARKETS
Piston Compressors	• Mature technology • High discharge pressures • Adaptable to a large range of flow rates	• Vibrations and noise • Complex design • Risk of embrittlement and contamination by lube oils	• Chemical plants • Petrochemical plants • Refineries
Diaphragm Compressors	• High throughput • Low power consumption • Less cooling requirements	• Complex design • Risk of diaphragm failure	• Hydrogen refueling stations • Chemical plants
Centrifugal Compressors	• Mature technology • High discharge pressures • Adaptable to a large range of flow rates	• High RPM of the turbine • Moderate compression ratio • Risk of hydrogen-induced cracking	• Chemical • Petrochemical plants • Refineries • Pipelines

Emerging Hydrogen Compression Technologies

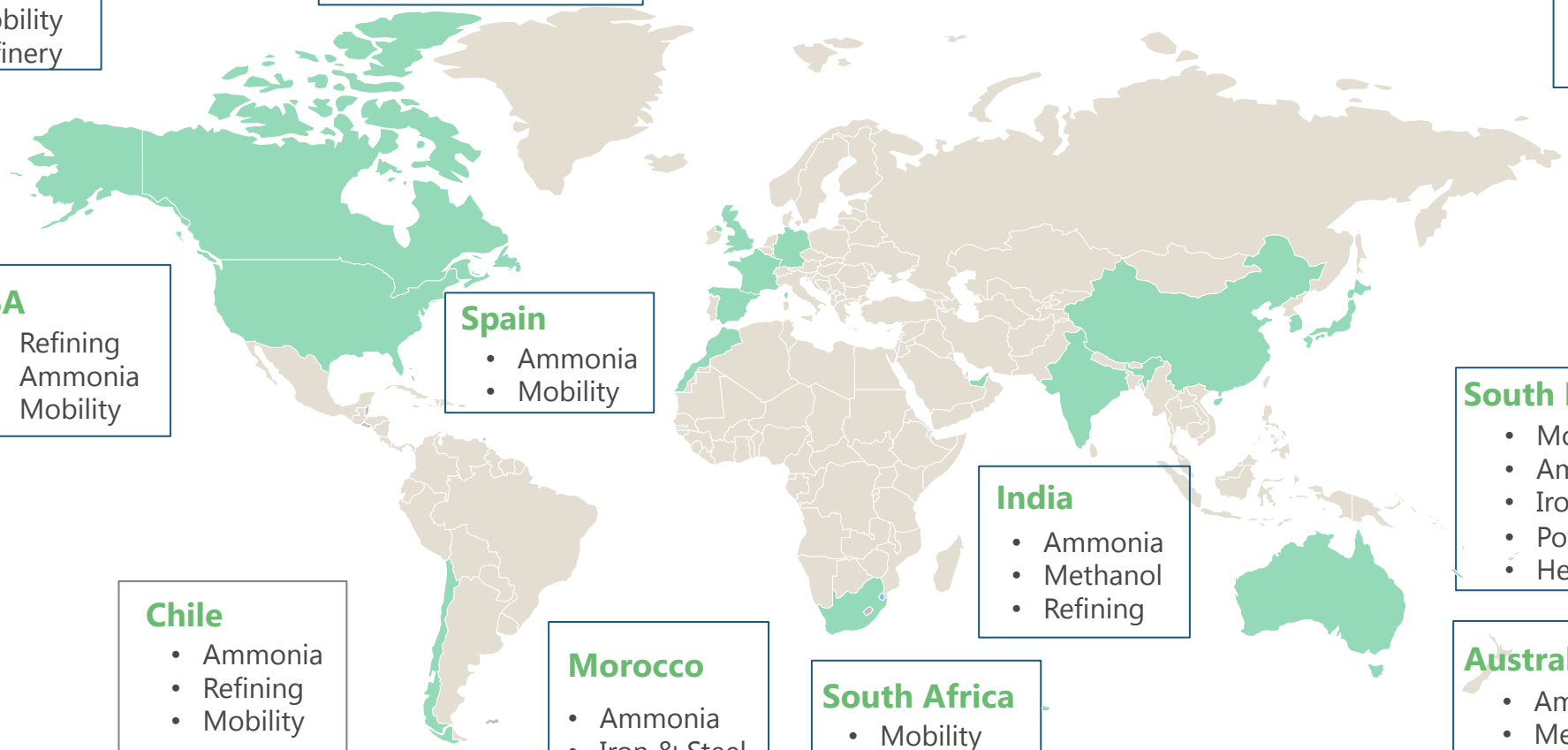
Driving Efficiency and Cost Reduction: Pioneering Non-Mechanical Technologies that are poised to Transform Hydrogen Sector

TECHNOLOGY	ADVANTAGES	DISADVANTAGES	KEY MARKETS
Ionic Liquid	• High efficiency and compression factor • Less energy consumption	• Risk of liquid leakage, cavitation, and corrosion	• Hydrogen refueling stations
Metal Hydride	• Thermally-driven compression • Compact and safe design • High-purity hydrogen at the output	• Limited heat transfer • Low efficiency • Weight and cost of compression elements	• Chemical plants • Power generation
Electrochemical	• Low-cost operation and high efficiency with no moving parts • High-purity hydrogen at the output • Used as a hydrogen purifier	• High cell resistance • Hydrogen back diffusion • Difficult to manufacture cell assembly and realize a perfect sealing	• Hydrogen refueling stations • Power generation
Cryogenic	• High hydrogen density • High volumetric efficiency • High gravimetric and volumetric capacities	• Low temperatures required for liquefaction • Added energy cost due to liquefaction • Difficult to manage thermal insulation	• Chemical plants • Refineries
Adsorption	• Thermally-driven compression • No vibration and noise • No sealing required • Low cost of adsorbent	• Low thermal conductivity of adsorbents • Low-temperature operation • Difficulty in thermal management	• Hydrogen refueling stations • Chemical and Petrochemical plants

Global Hydrogen Compression Market Analysis

Hydrogen Compression Demand Centres

Major hydrogen compressors demand centers across the globe by region and application.



Canada
- Mobility
- Refinery

UK
- Mobility
- Refining
- Blending
- Power Generation

France
- Mobility
- Ammonia
- Refining
- Iron & Steel

Germany
- Mobility
- Ammonia
- Refining
- Iron & Steel

China
- Mobility
- Ammonia
- Methanol
- Refining
- Iron & Steel

Japan
- Mobility
- Ammonia
- Refining
- Power Generation
- Heating

USA
- Refining
- Ammonia
- Mobility

Spain
- Ammonia
- Mobility

South Korea
- Mobility
- Ammonia
- Iron & Steel
- Power Generation
- Heating

India
- Ammonia
- Methanol
- Refining

Chile
- Ammonia
- Refining
- Mobility

Morocco
- Ammonia
- Iron & Steel

South Africa
- Mobility
- Refinery
- Iron & Steel

Australia
- Ammonia
- Methanol
- Power Generation
- Blending

Factors Impacting the Global Hydrogen Compression Market

Several large-scale hydrogen projects are driving the growth of the global hydrogen compression market. However, there are also a few factors that have the ability to hamper the growth of this market.

Major Projects Driving the Global Hydrogen Compression Market

- **European Hydrogen Backbone Initiative**
  - *5* Pan-European hydrogen supply and import corridors by 2040
  - *28,000 km* pipeline by 2030 and a *53,000 km* pipeline by 2040
  - *69%* repurposed and *31%* entirely new hydrogen pipelines
- **H2 Med Pipeline**
  - *1st* major hydrogen corridor connecting the Iberian Peninsula with RoE
  - Transport *~2 Mt* of green h2/year through a *703 km-long* pipeline
- **HyNet NorthWest**
  - Hydrogen Production Volume: *2160 t/day* by 2030
  - Storage and transportation of compressed H2
  - *Refinery, Power Generation* and *Blending*
- **Europe's Hydrogen Hub**
  - Hydrogen Production Volume: *3180 t/day* by 2026
  - Storage and transportation of *compressed H2*
  - *Mobility, Refinery, Chemicals, Power Generation* and *Blending*
- **Wyoming Clean Power Center**
  - Hydrogen Production Volume: *160 t/day* by 2026
  - Storage and transportation of *compressed H2*
  - *Refinery, Power Generation* and *Blending*

Potential Disruptions in the Value Chain

- Price Volatility

Uncertainties in crude oil prices negatively affect investments in oil and gas industry

- Unforeseen Disasters and Lockdowns

During the covid-19 lockdown, manufacturers in the hydrogen compressor market had to halt their business production

- Hazards and Accidents

Oil contamination may result in spoiled or unsafe products, production downtime, and legal issues

- Risk and Reliability Issues

Threat of premature wear, presence of moving parts and H2 embrittlement

- High purchasing and maintenance costs

High purchasing and maintenance costs of hydrogen compressor

Hydrogen Compression Market By Application

According to PTR, the hydrogen mobility sector is expected to lead the hydrogen compression market due to increasing demand of hydrogen compressors from hydrogen refueling stations.

Conventionally, the oil and gas sector has held the largest market share of the hydrogen compression market

- *Surge* in demand for cleaner fuels
- *Rise* in government regulations for the desulfurization of petroleum products
- *Increasing* demand for hydrogen in oil refineries to remove impurities or contaminants and process crude oil into a refined fuel

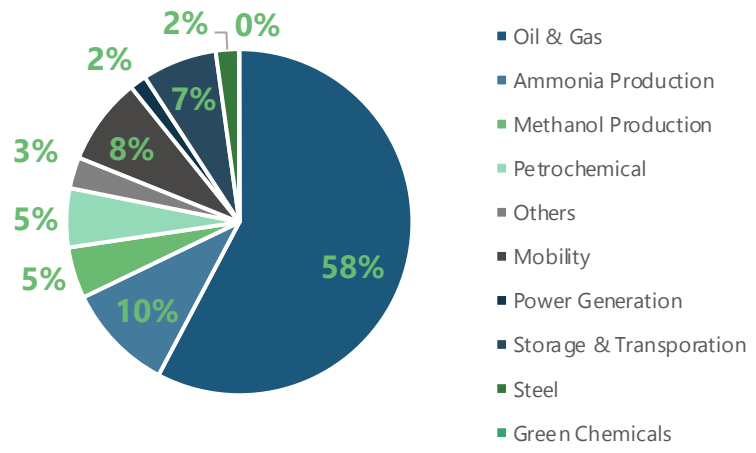
Moving forward, the hydrogen mobility sector, especially the road transport segment, will emerge with a significant market share of the global hydrogen compression market

- *Increase* in demand for construction of hydrogen refueling stations (HRS) due to *rapid* deployment of hydrogen FCEVs
- Targets for construction of HRS announced in *national hydrogen strategies*
- Government regulations *mandating* the construction of HRS

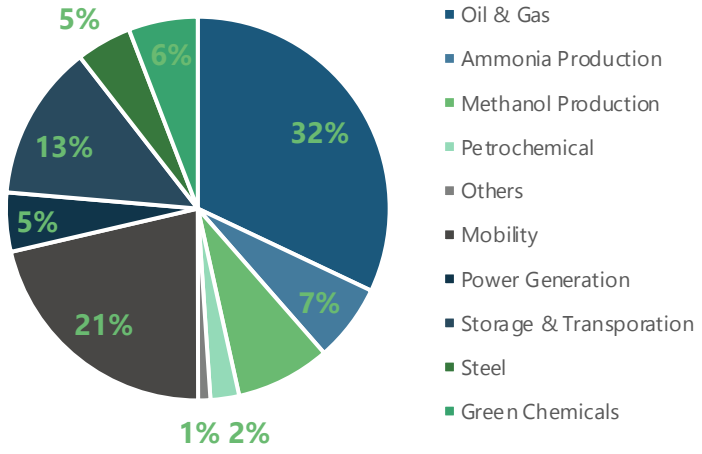
Hydrogen storage and transportation infrastructure will emerge as a significant driver of the global hydrogen compression market

- Hydrogen transportation through tube trailers in *compressed gaseous* form
- Construction of hydrogen *pipeline* infrastructure to transport hydrogen
- *Import* and *export* terminals

Annual Sales by Application - 2021



Annual Sales by Application - 2030



Asia-Pacific: The Epicenter of Hydrogen Compression

According to PTR, APAC is expected to lead the hydrogen compression market due to rapid development in the hydrogen mobility sector, great number of projects under development, and a huge investment plan.

The race to establish low-carbon hydrogen production bases in the Asia-Pacific region is heating up, with Western and regional companies cooperating on massive projects to produce the next-generation clean-fuel

- BP - *largest* shareholder in *Asian Renewable Energy Hub*, a huge Australian project
- Chevron, Pertamina and Keppel Corporation - green hydrogen production using *geothermal energy*
- Orsted and POSCO - feasibility study for green hydrogen production and supply of *hydrogen steel*

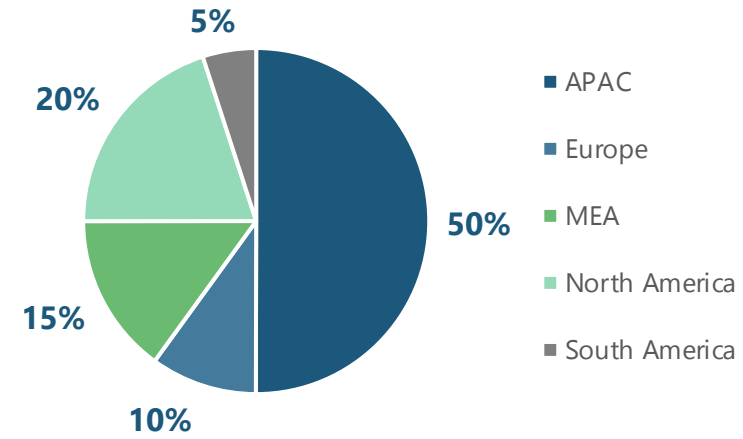
Growing demand for hydrogen refueling stations in Asia-Pacific region will drive the hydrogen compressor market

- South Korea, China, and Japan are among the *top 4 largest* markets for FCEVs globally
- *Highest* number of FCEVs deployed on the roads – 67.4%
- *Largest* share of hydrogen refueling stations globally - 59.5%
- Home to *leading* FCEV manufacturers
  - Hyundai Nexo - South Korea
  - Toyota Mirai - Japan

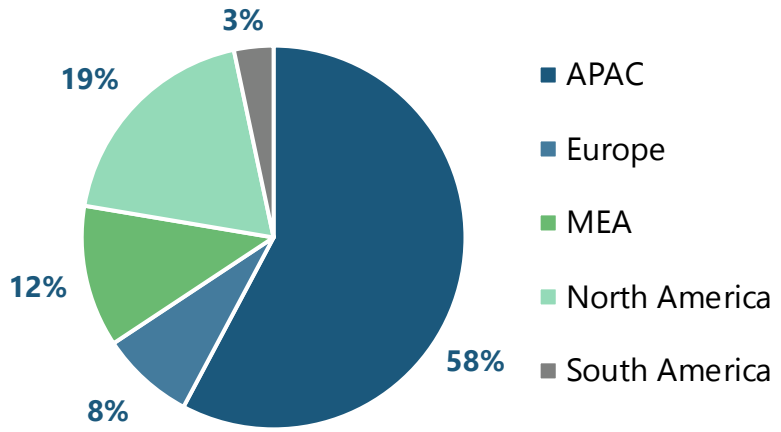
According to Hydrogen Council, the combined hydrogen demand of China, India, Japan and South Korea will reach 285 Mt in 2050 - 43% of the global total

- China – world's *largest* producer and consumer of hydrogen
- Presence of technologically *advanced* industries in China and Japan
- *Increase* in renewable energy projects owing to government investments
- Focus on developing regional and global *hydrogen supply chains*
- Targeted use of hydrogen in *multiple* sectors

Market Shares by Region- 2021



Market Shares by Region- 2030



Leading Hydrogen Compression Market Companies

According to PTR, following are the top companies in the hydrogen compression market.

Key Hydrogen Compression Market Players Across the Globe

Company	Compressor Technology	Targeted Markets
Siemens Energy	Reciprocating, Centrifugal	Energy
Atlas Copco Group	Centrifugal, Piston	Storage, transportation, refinery, power generation
Baker Hughes	Reciprocating, Centrifugal	Energy
Neuman & Esser (NEA) Group	Diaphragm, Piston	Mobility, heat, storage, transportation
Burckhardt Compression	Diaphragm	Energy, transport, refinery, chemical, petrochemical
Sundyne	Centrifugal, Diaphragm	Transportation, refinery, chemical, power generation
PDC Machines	Diaphragm	Mobility
Ariel Corporation	Reciprocating	Transportation, refinery, chemical
Howden	Centrifugal, Diaphragm	Transportation, power generation , chemical, petrochemical
Ingersoll Rand	Piston	Transportation, power generation

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 this month, this market sizing database depicts 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.

Q&A