LANDIRENZO GROUP

Hydrogen as an energy transaction: opportunities & challenges for the mobility value chain

Movet
Realtà e prospettive per la generazione e l'utilizzo dell'Idrogeno

November 27th 2020

Our Mission is to bring the clean energy of the future

Landi Renzo is a forward-thinking group that provides innovative solutions for ***alternative fuel mobility and transportation***

By designing gas-mobility systems and components, we partner with our customers in developing highly innovative and reliable solutions for **gas and hydrogen mobility**, focusing on a broad range of applications, from **Heavy Duty to passenger cars**

Founded in 1954

Listed in the STAR stock exchange since 2007

11 Plants & Offices in 9 Countries

~ 500 Employees worldwide of which 100 in R&D

Gas solutions for CNG, RNG, LNG, LPG and H_2

191,9M€ Revenues in 2019

Export share of 80%

~ 9 M€ Investments

Main business segments served

- OEM Heavy Duty and Off Road
- OEM Passenger cars and LCV
- AM passenger cars, LCV, M&HD Dual Fuel
- Equipment for gas distribution and RNG production through SAFE&CEC

- Landi Renzo owns 51% of **SAFE&CEC**, an international leading player in the design and manufacturing of advanced equipment for CNG and RNG distribution, with plans to expand into H_2 applications
- SAFE&CEC in 2019 had a **production value of 73,4M€**

Hydrogen

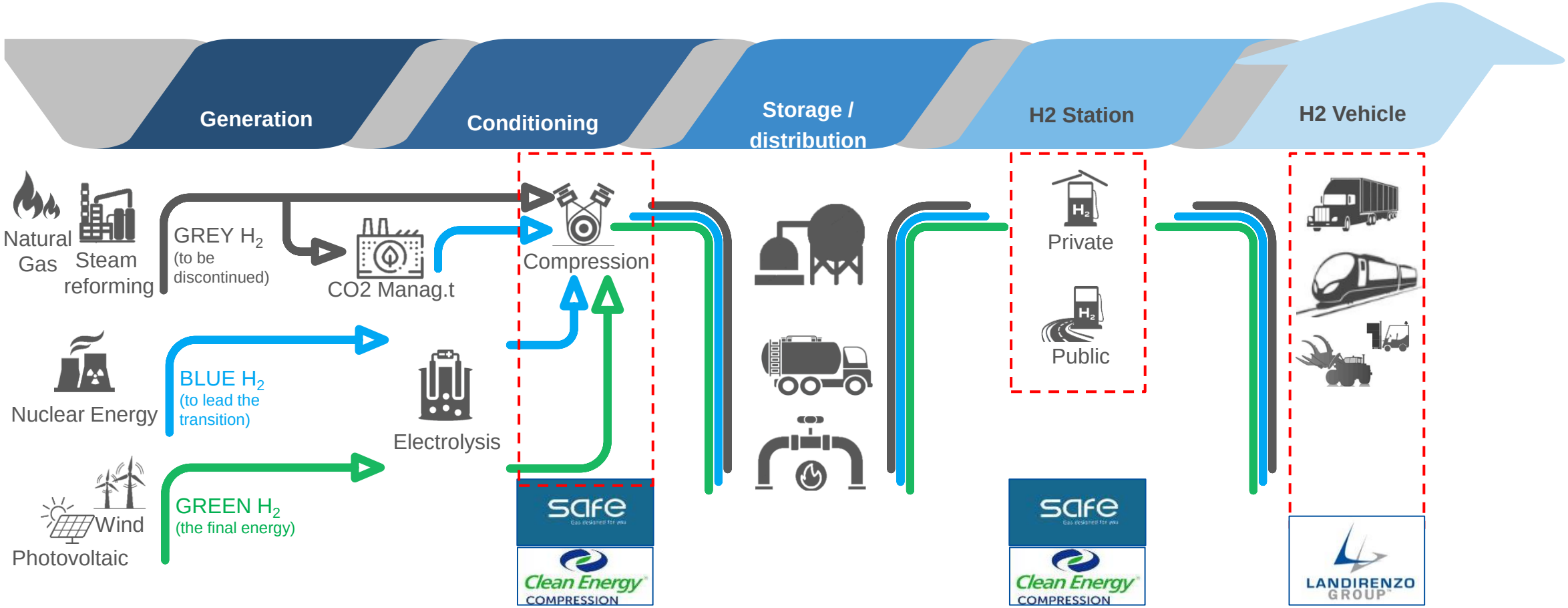
In 2017 LRG made the strategic decision to invest in hydrogen believing in its potential to become the “real” zero-emissions technology of the future.

Landi Renzo Group is developing a **complete & flexible range of products** for Hydrogen Internal Combustion Engine or Fuel Cell propulsion covering **on road, off road and railway applications**

Safe&CEC is developing dirrent application for **Hydrogen compression,** from 350 up to 800Bar

- Component supplier
- Engineering support for component installation
- Engineering support to customize functionalities of Control Unit, injection system, pressure regulation, metering system and integrated manifold
- Validation support according to OEM standards
- Homologation support according to international regulations

… and are now ready to play a leading role in the Hydrogen evolution, increasing the range of application, both in distribution as well as in automotive



Landi Renzo Group Role

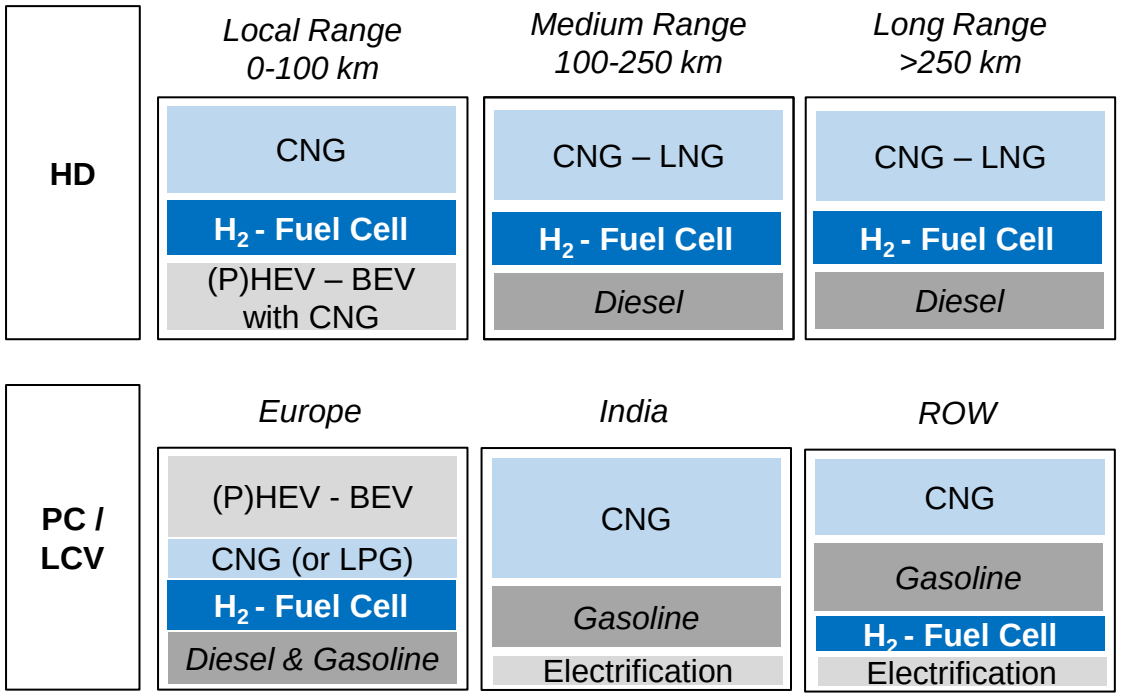
New reciprocating-diaphragm compressors up to 800/850 Bar to be lauched within end of 2021

Update of current Hydraulic Compressor up to 350 Bar. Already started project to reach 700Bar

New products already on the market, new launch within end of 2020 and during 2021

In a world that demand sustainable solutions, Hydrogen, Gas-Mobility and Electrification will play a key role in future transportation, enabling a cleaner mobility worldwide

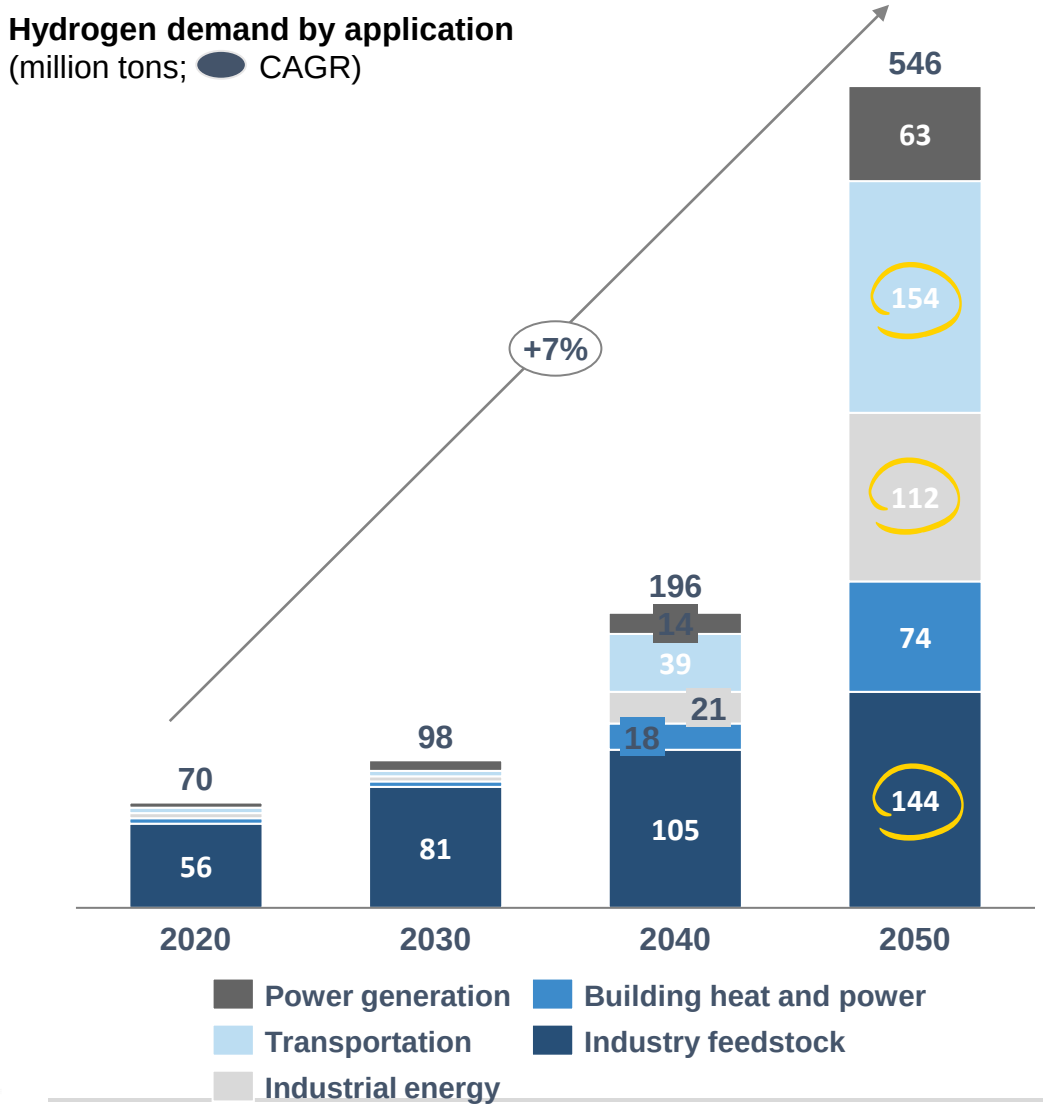
Mobility evolution toward 2025



- **Gas-mobility** represents, for both Passenger Cars (LPG, RNG, CNG) and Heavy Duty (CNG, RNG, LNG) segments, a viable and ready-to-use solution, which will coexist in the future with other alternative fuel technologies (Hybrids, BEVs, FCEVs, …)
- **Hydrogen, both Fuel cell vehicles and H2 Combustion Engine** represent the next evolution step, joining the benefits from gas-mobility and electric powertrains
  - In the last few years scenario, Fuel Cell powertrain has been recognized to be the **only zero-emission solution** both for trucks and long haul commercial (passengers and goods) in general
  - In Passenger Cars hydrogen has **significant potential** for mid-sized/large cars (SUV and mid duty)
  - We strongly believe also H2 propulsion will play a very important role

- **Different Technologies will coexist**
- **Gas-mobility and Hydrogen will play an increasing role in the clean energy transportation of the future**

Annual demand for hydrogen is expected to increase tenfold by 2050: transportation, industrial energy and feedstock will be the largest applications



+13%

+13%

- **2030:** Globally **10** to **15 million cars** and ~**500,000 trucks** powered by hydrogen. Deployment of hydrogen-powered trains and passenger ships
- **2050**: Up to **400 million passenger vehicles** (~25%), **5 million trucks** (~30%), and more than **15 million buses** (~25%) running on hydrogen. **20 million barrels of oil** replaced per day

+12%

+11%

- **2030:** Approximately **1 out of 10** steel and chemical **plants** in Europe, North America, and Japan uses hydrogen for **low-carbon production**. **4 million tons** (0.6 EJ) extra hydrogen used
- **2050**: **12%** of global industry **energy demand** (16 EJ) met with hydrogen

+3%

- **2030:** Steel plants pioneering **zero-carbon iron making** using hydrogen reduction. **10 to 15 million tons** of **methanol** and **derivatives**, such as olefins and aromatics, produced from clean hydrogen and carbon
- **2050**: **10%** of **crude steel** production, about **200 million tons**, based on hydrogen. **30%** of **methanol** and **ethanol** derivatives produced through hydrogen and carbon

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There are many clear motivations to adopt Hydrogen as alternative fuel

- High energy density
- Intrinsically clean energy carrier
- ✓ Improver of efficiency
- Low/No carbon content
- Renewable
- ✓ Available and cheap

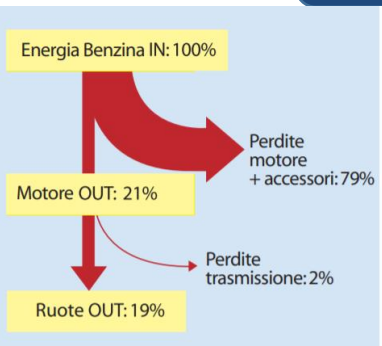
Improver of efficiency

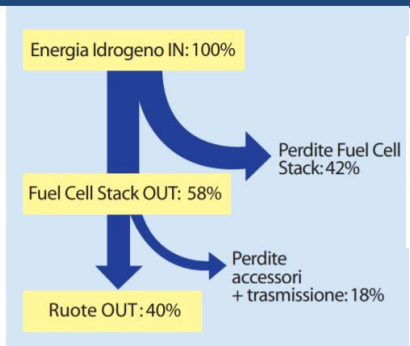
In well-to wheel scenario FCEV could have the best efficiency

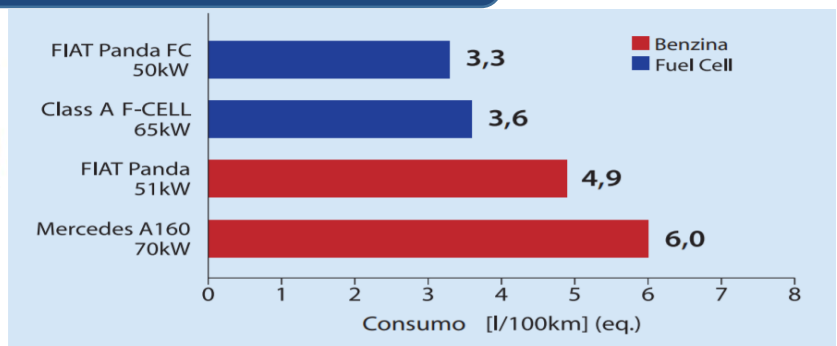
	Well to Tank							Tank to wheels							
BEV	**Natural Gas [kWh]**	**NG Combined Cycle Turbine generator**		**Transmission & distribution**		**DC Rectifier**		**Battery Charge 94% Battery discharge 90%**		**Inverter 86.7% Gear box 91.5%**		**Energy to Motor [kWh/km]**	**MILEAGE [Km]**	**Efficiency [Km/kWh]**
Weight 2269 kg	270.5	Eff. ≈ 48.0%	129.8	Eff. ≈ 92.0%	119.5	Eff. ≈ 96.0%	114.7	Eff. ≈ 84.6%	97.0	Eff. ≈ 79.3%	77.0	0.2565	300.0	1.11
								0.172 kWh/km ratio						
FCV 350	**Natural Gas [kWh]**	**Steam methane reformer**		**Compression**		**Distribution**		**Fuel Cell**		**Inverter 86.7% Gear box 91.5%**		**Energy to Motor [kWh/km]**	**MILEAGE [Km]**	**Efficiency [Km/kWh]**
Weight 1280 kg	187.9	Eff. ≈ 75.0%	140.9	Eff. ≈ 93.0%	131.1	Eff. ≈ 99.0%	129.7	Eff. ≈ 51.8%	67.2	Eff. ≈ 79.3%	53.3	0.1777	300.0	1.60
								0.073 kWh/km ratio						
NG 250 ICE	**Natural Gas [kWh]**			**Compression**		**Distribution**		**ICE Engine**		**Gear box**		**Energy to Motor [kWh/km]**	**MILEAGE [Km]**	**Efficiency [Km/kWh]**
Weight 1150 kg	196.5			Eff. ≈ 94.0%	184.7	Eff. ≈ 99.0%	182.9	Eff. ≈ 33.0%	60.3	Eff. ≈ 87.0%	52.5	0.1750	300.0	1.53
								0.05 kWh/km ratio						

www.energy.gov/sites/prod/files/2014/03/f9/thomas_fcev_vs_battery_evs & al.

"In Vehicle" point of view





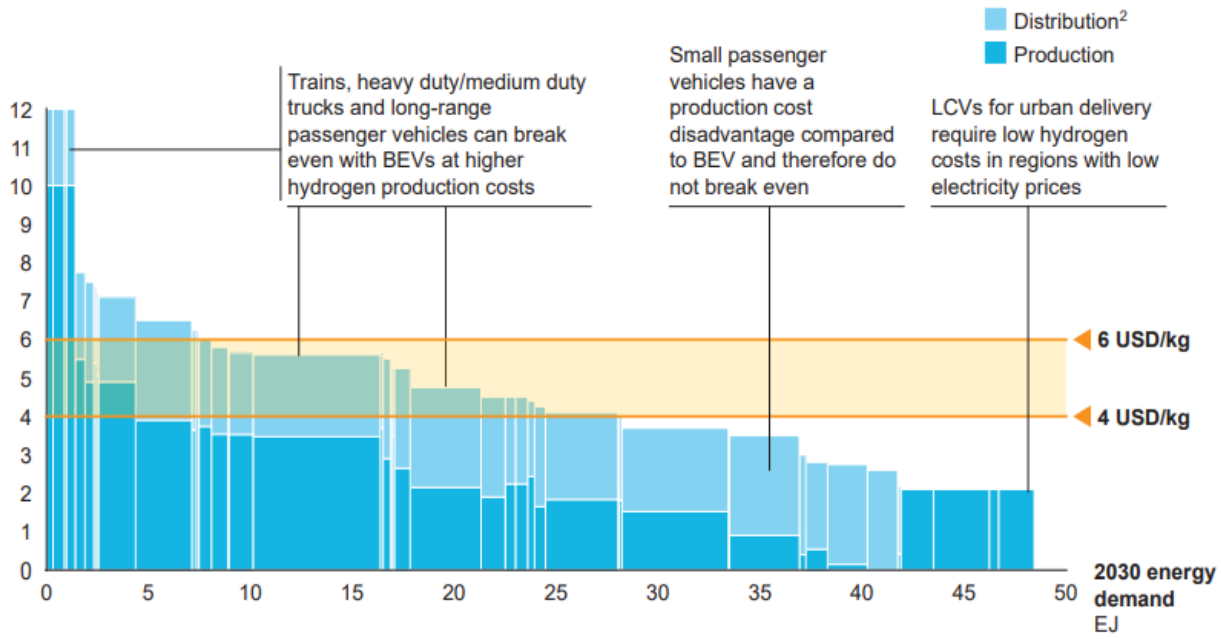


Test cycle: NEDC
1 kg H2 converted in 3.74 l gasoline

Available and cheap

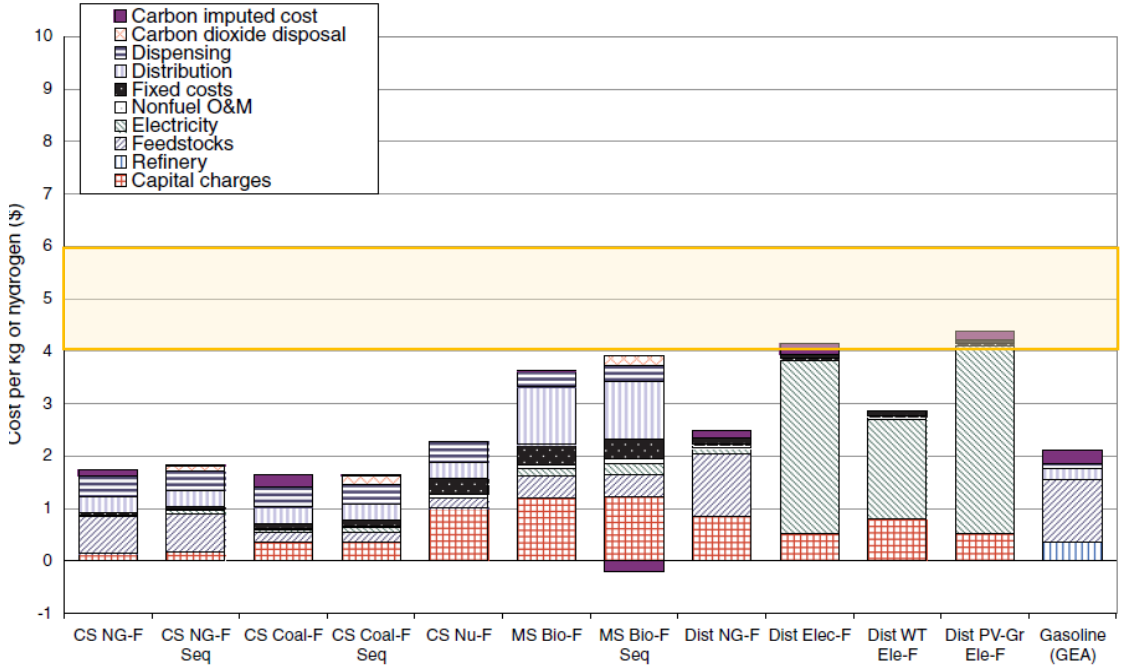
Hydrogen is all around us. It makes up two thirds of the composition of water, exists in all living things and is even given off as a gas from volcanoes whether they are erupting or dormant.

Breakeven hydrogen costs at which hydrogen mobility applications becomes competitive against low-carbon alternative in a given segment in focus regions[1]
USD/kg at nozzle



1. Regions assessed are the US, China, Japan/Korea, and Europe
2. No distribution costs for aviation as it can be distributed as liquid fuel

SOURCE: McKinsey; IHS; expert interviews; DoE



SOURCE: The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs – www.nap.edu

In this context there are many levers that will sustain Hydrogen evolution in the next years

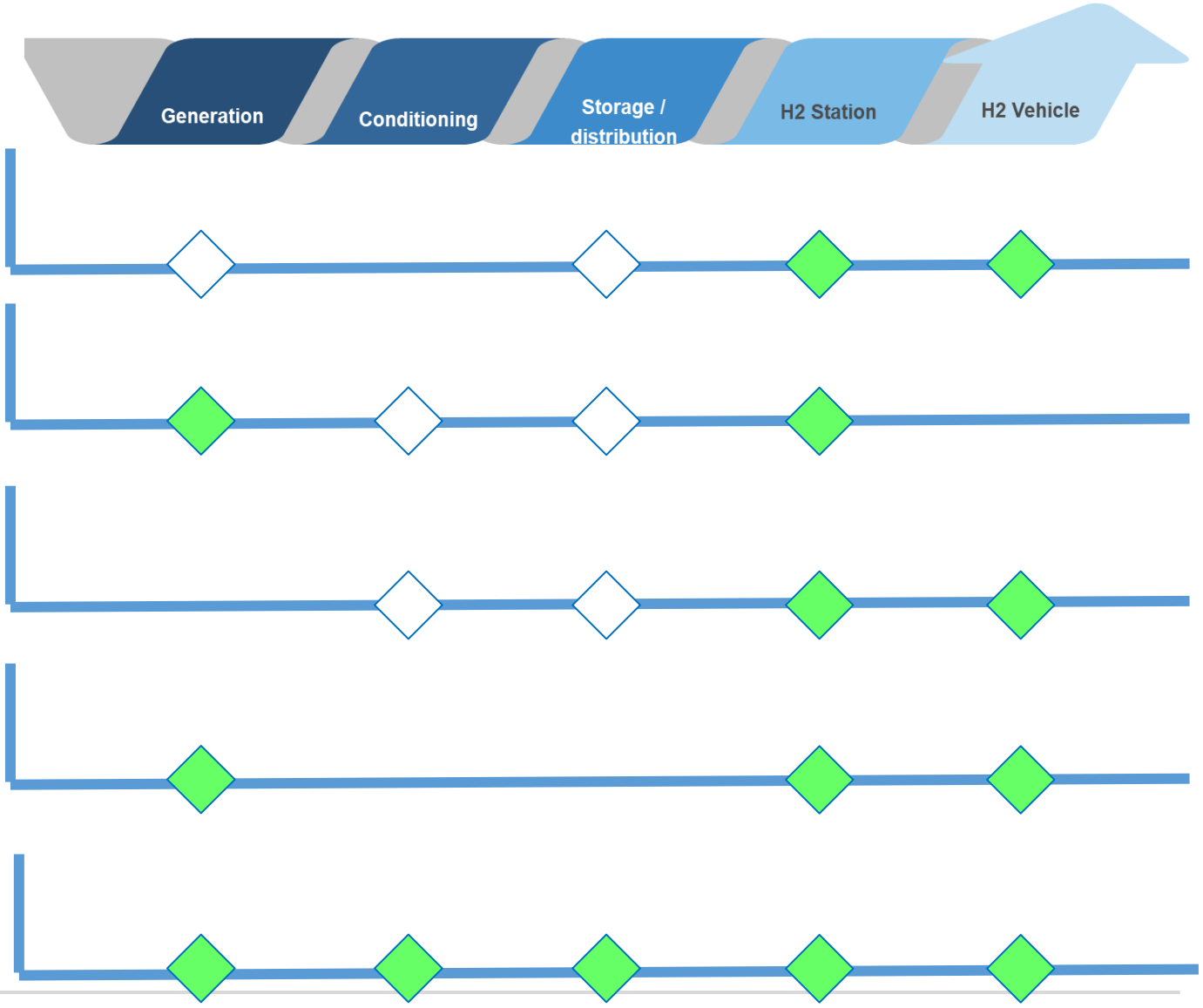
- Distribution and vehicle evolution:
  - **2500 – 2800** stations planned globally by 2025 (25% - 35 % CAGR)
  - Projected **at least 1 Million FCEVs by 2025**

- **Availability leveler for renewables**:
  - Frees use of photovoltaics and wind power generation

- **Unique alternative for zero-emission and M&HD & long haul transportation**:
  - Refueling time
  - Mileage

- **Fleets develpoment** virtually independent to supply network:
  - Already proven in trains, urban bus, courier delivery.
  - Significant CapEx reduction expected

- **Hydrogen production and distribution price** @ 2030 :
  - SMR+CCS could drop to 1.8 $/kg in USA.
  - Renewables H2 prod. price 2.5 $/kg in EU and WW



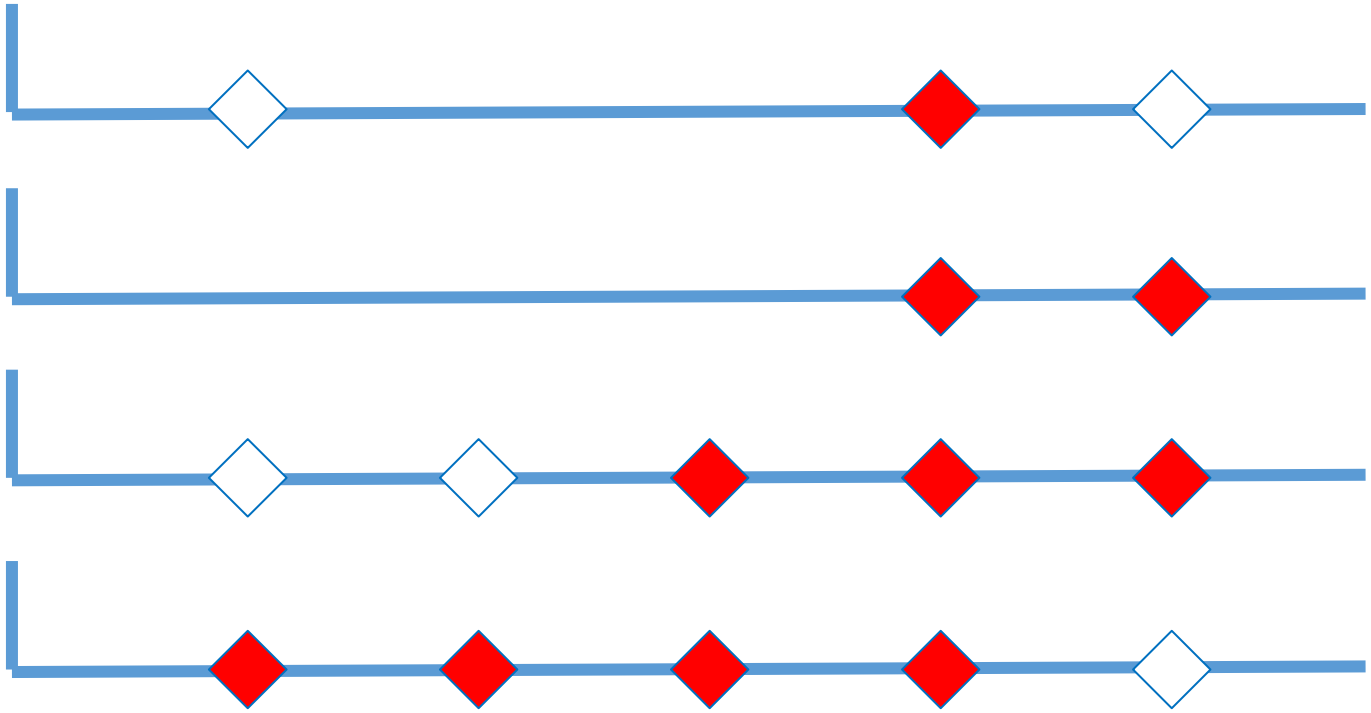
Of course there also challenges to be faced, but the many activities are ongoing to find solutions

- **Improved avaialbity and reliability of components** to support higher demand perfromance.

- Identification and commitment of a partner/s available for system and station testing
- Lack of H2 components test labs

- **Chicken and Egg loop unbroken yet**
  - HRS network vs FCV spread

- **WW common regulations**
  - Lack of regulations in the first part of value chain
  - National regulations on vehicles



By the way we strongly believe the high level of attention, studies, innovative projects and investment ongoing on Hydrogen Economy will help solving these issues in the very short terms