HYDROGEN PRODUCTION BY ELECTROLYSIS

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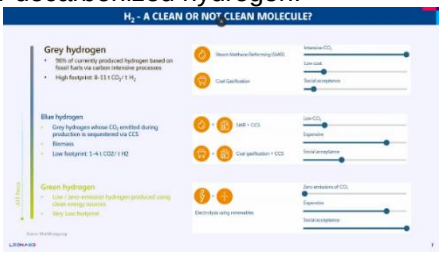
Hydrogen is a well-known element in Space Industry. Hydrogen is used since the 80s in the space activities, but its production is derived from natural gas and produced from fossil fuels.
The main vector of decarbonation will be the use of renewable or decarbonized hydrogen.

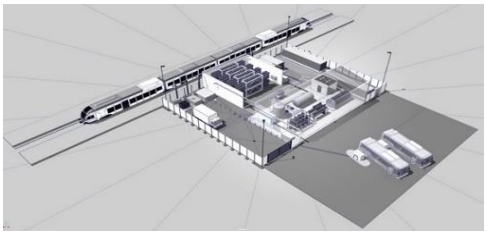


Different types of decarbonized Hydrogen Production
Hydrogen can be produced by different ways:

- Reforming
- Gasification
- Electrolyze

Production unit by electrolysis
Currently the cost of renewable or decarbonized hydrogen issued from electrolysis production is much higher than that the one used from fossils energy. Even if we're heading in the right direction, it is still important to optimized as much as possible the station.
In order to reduce the costs, it is necessary to perform a feasibility study to properly define the needs (actuals & futures) to optimize the transportation of hydrogen and electricity consumption by specifying:

- Location
- Electrolyser technology
- Compressor technology
- Storage sizing



Location:
Set up of the location shall be defined to minimize transportation costs:
-H2 production close to off-takers
-H2 production close to renewable production sources

Electrolysis technology:
The choice of the right electrolyser technology for the needs is one of the factors to set.
The most developed and matured technologies are alkaline and PEM (Proton Exchange Membrane).
Two new technologies have been developed more recently: AEM technology & High Temperature electrolysis.

	Current | 2030 [A]	Alkaline	Pressurized Alkaline	PEM	SOE	AEM
Efficiency	kWh/Nm³	4.7 | 4.3	4.7 | 4.3	4.8 | 4.5	3.6 | 3.3 [B]	4.8 (stack only)
Stack lifetime	hours	80,000 | 100,000	80,000 | 100,000	50,000 | >80,000	20,000 | >20,000	5,000
Flexibility	Time to reach nominal capacity	Minutes	<10s	<1s	<1s [C]	<1s
Pressure	bar	Atm.	<40 | <70	<40 | <70	atm. | <20	<35
Commercial status		Available	Available	Available	Available 2022 2024	Under development

[A] Predictions based on manufacturer indications, literature or FCH JU targets.
[B] Efficiency of SOE assumes external heat is provided.
[C] Hot system in laboratory, unknown for commercial systems. Cold systems require start up times of hours if not more.

The choice of electrolysis technology in mainly related to the need and the H2 consumption profile.

Compressor technology:
We can identify 3 main types of compressors:
- Ionic technology: fast and continuous compression, simplified maintenance and better efficiency
- Membrane technology: energy-efficient and optimized maintenance
- Piston technology: proven technology

Storage Sizing:
Some specific tools have been developed to define the quantity of hydrogen that need to be stored, at which pressure, depending on the consumption profiles.
The difficulty is to find the optimum ratio between Seveso regulation, fatigue of the storages and efficiency of the filling (cascade filling).

References: 1. *DNV_Hydrogen Forecast To 2050.* **2022**