Green Hydrogen Production & Utilization

EPSC WG on Energy transition hazards

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AGENDA

- Hydrogen Process
- Hydrogen Value Chain
- Hydrogen Utilization
- HSE Relevancy
- Nebula – MOL Refinery Green Hydrogen Project

HYDROGEN PRODUCTION PROCESS

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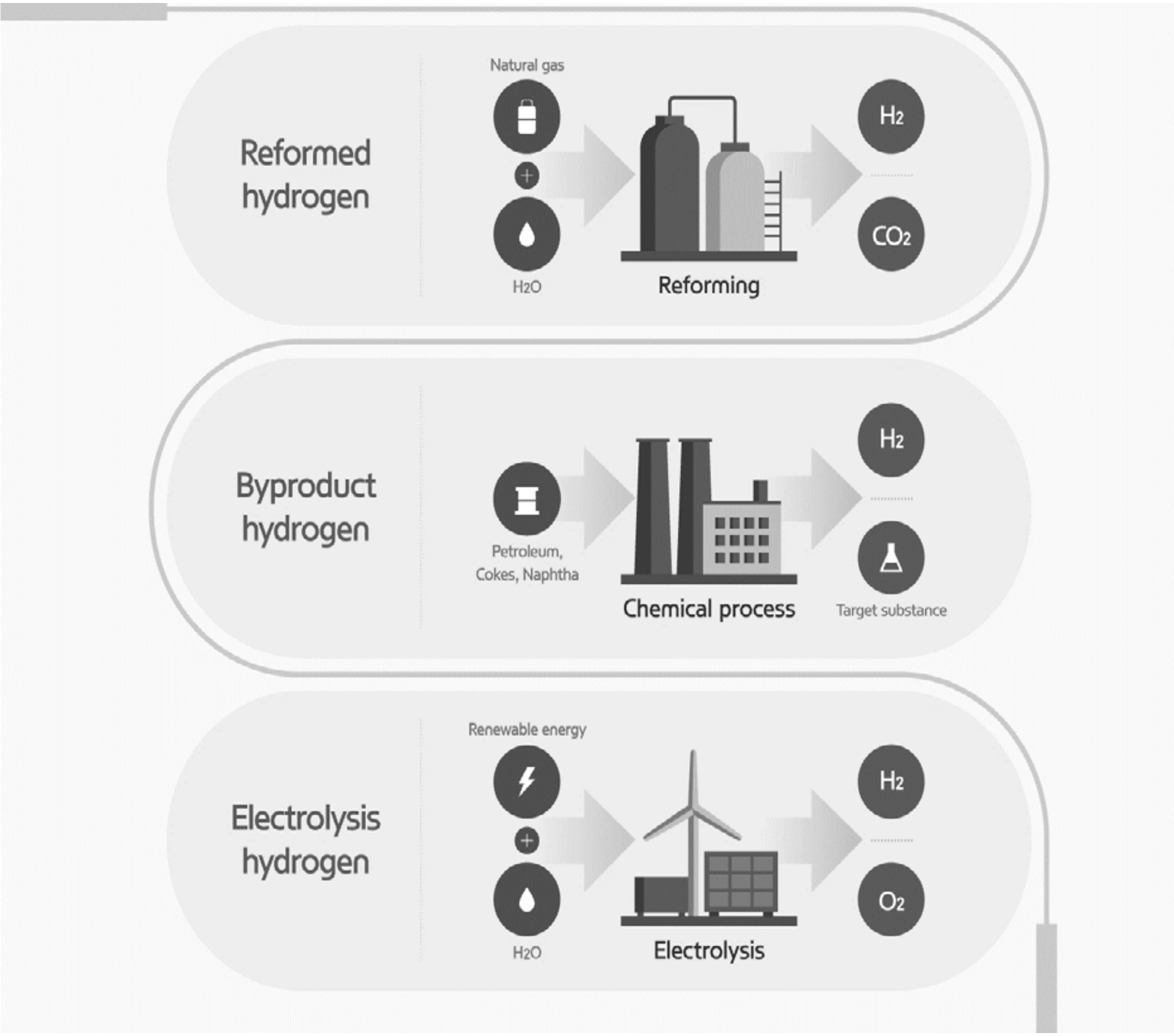
HYDROGEN PRODUCTION AND UTILISATION OPTIONS



The primary energy sources from which hydrogen can be generated include:

- Fossil fuels
  - Steam Methane Reforming of Natural Gas
  - Reforming of Naphtha
- Electrolysis with:
  - Photovoltaic (light)
  - On & off shore wind and wave power,
  - Nuclear
- Biomass
  - Biogas based
  - Gasification

In the **short to medium term** it is expected that the bulk of the hydrogen produced will continue to be **derived from the reformation of fossil fuels**, with the associated expansion of the need for CO_2 capture and sequestration .

SHAPE TOMORROW

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HYDROGEN VALUE CHAIN

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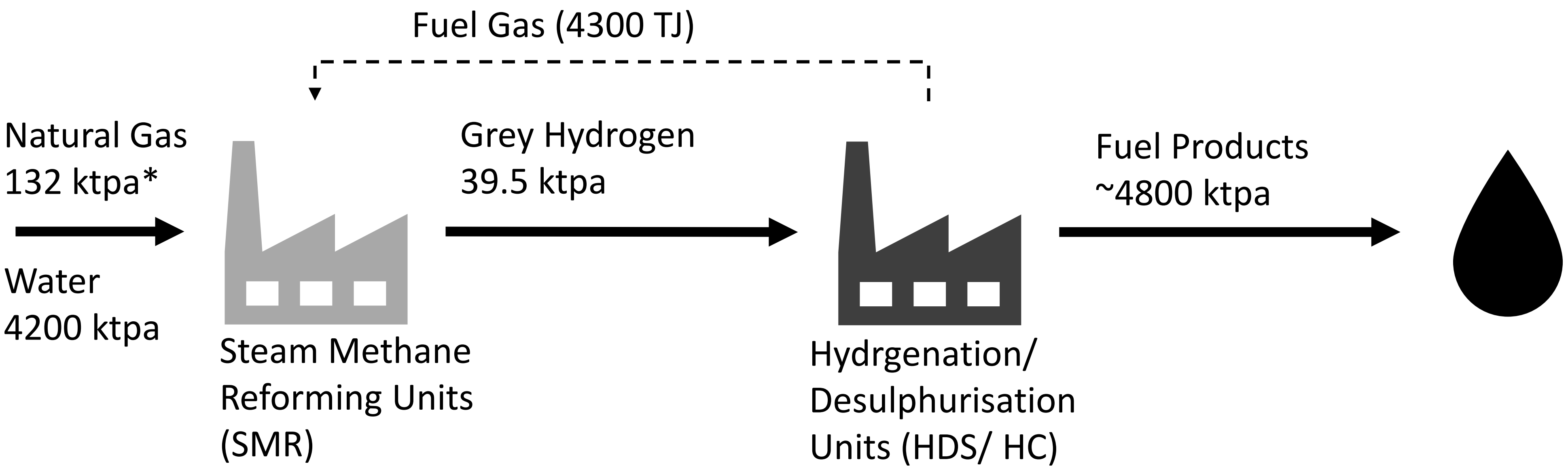
HYDROGEN PRODUCTION AND UTILISATION IN MOL REFINERY



Side Products:

- CO_2 (emission):
  588 – 635 ktpa**
- Steam Production:
  1700 TJ

- Hydrogen only ~1% of the volume of the final product, it is 3.5-4 % of the energy content
- Not all the utilized hydrogen is built in the final product (depending on the technology)
- Additional investment required for both the renewable compliance and ETS targets

SHAPE TOMORROW

*Sum Natural Gas utilisation of DR: ~280 ktpa
** Full emission of site: ~1530 ktpa CO2

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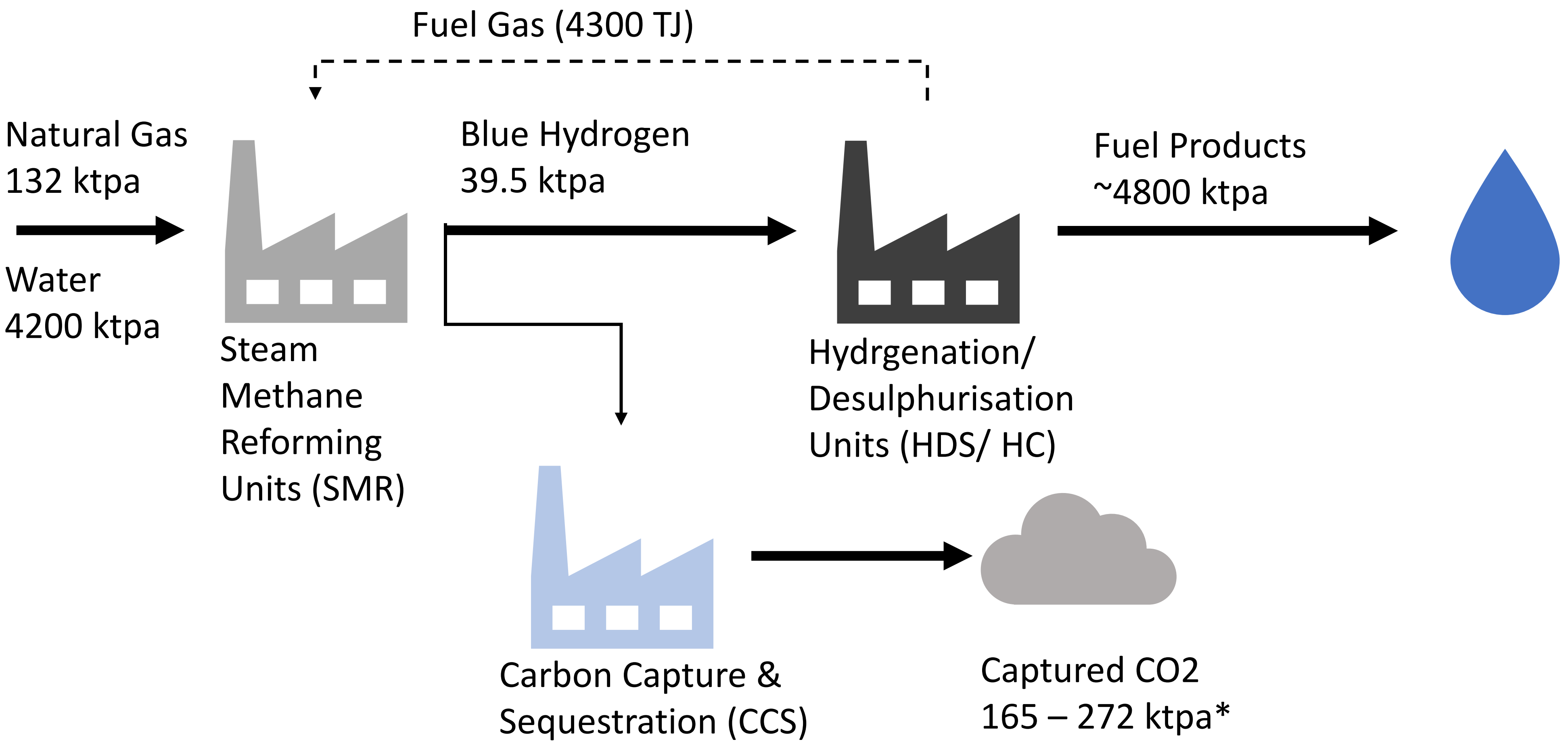
HYDROGEN PRODUCTION ALTERNATIVES: BLUE HYDROGEN



- Additional investment and OPEX cost for sequestration required
- Blue hydrogen do not have additional value regarding the value chain
- ETS target could be reasonably achieved with high level CCS utilization

SHAPE TOMORROW

*CCS capacity of the current scope, additional capture is possible on the site

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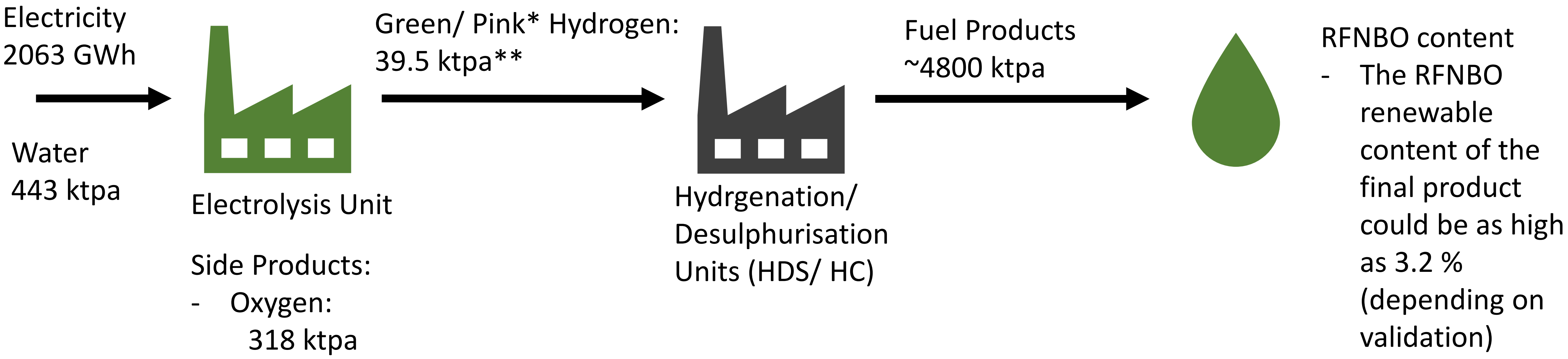
HYDROGEN PRODUCTION ALTERNATIVES: GREEN HYDROGEN



- Green hydrogen has the added benefit to count as renewable energy component if used for fuel production – in accordance with RED III regulations
- Green hydrogen (or derivatives) will be required from 2030 as part of the fossil fuel pool (RFNBO – renewable fuels of non biological origin)
- Non refining industries (for example the polyol unit) will be required to source at least 50% of its hydrogen consumption from renewable source

*Green Hydrogen based on renewable electricity. Pink hydrogen based on low carbon/ nuclear electricity.
**Hydrogen from reforming unit is not the scope of the shift

GREEN HYDROGEN IN MOL'S VALUE CHAIN

Relevant sources of green hydrogen:

Breakdown of water to hydrogen and oxygen with renewable electricity

Water Electrolysis

Steam reforming (SMR) of renewable sourced methane

Biogas Utilisation in SMR units

Potential utilisation of green hydrogen

Added to the refinery portfolio

Hydrogenation

Nitrogen and Sulphur removal

Desulphursation

Petrochemical feedstock

Pethem production

Heat/ electricity recovery

Energy storage

Market potential of green hydrogen products

Hydrogen drivetrain vehicles

Fuel (direct)

Traditional fules from green hydrogen

Fuel (indirect)

Natural gas substitution for energy

Sale (energy)

Sale as feedstock (fertilizers, chemicals)

Sale (chemicals)

HYDROGEN UTILIZATION

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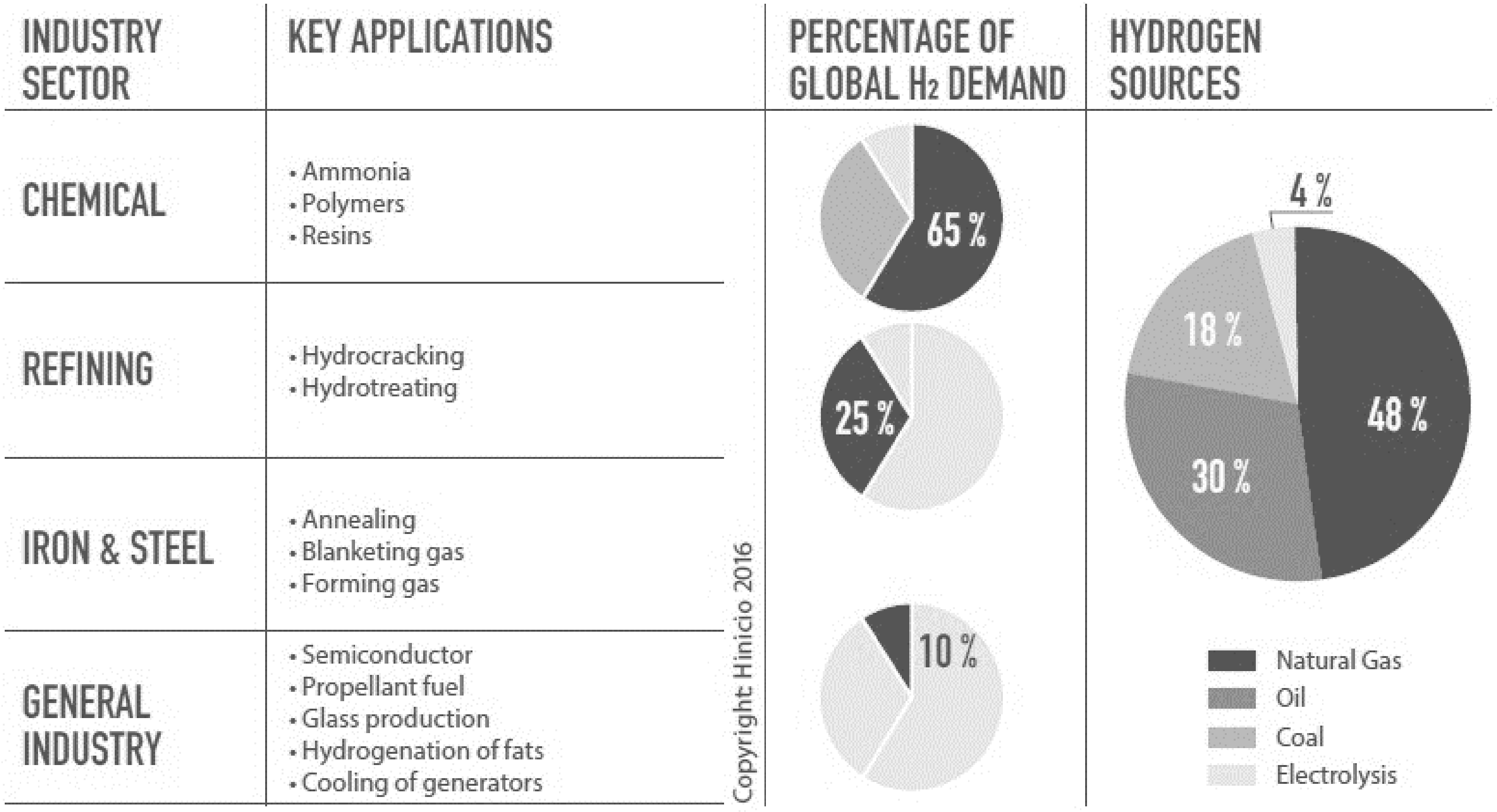
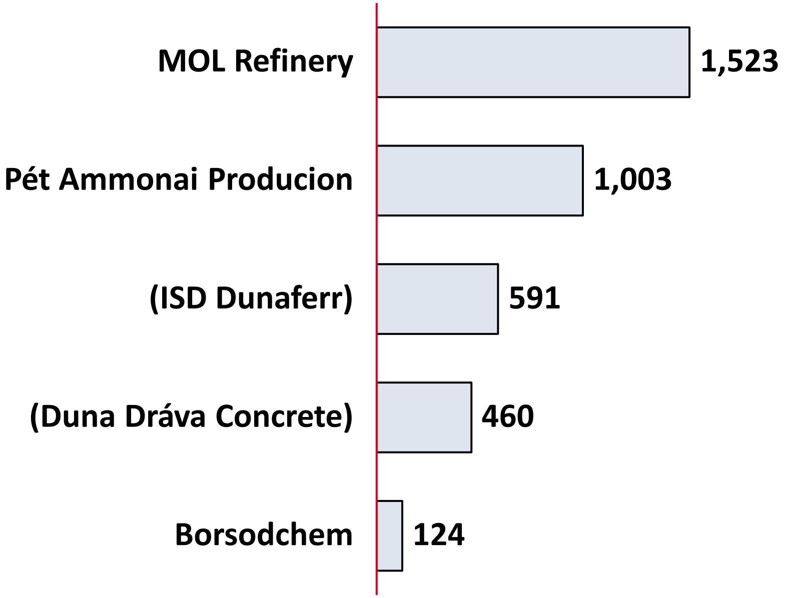
INDUSTRIAL HYDROGEN APPLICATIONS



Top-5 Hungarian CO_2 emission from (potential) hydrogen consuers (th. Tonnes of CO_2]

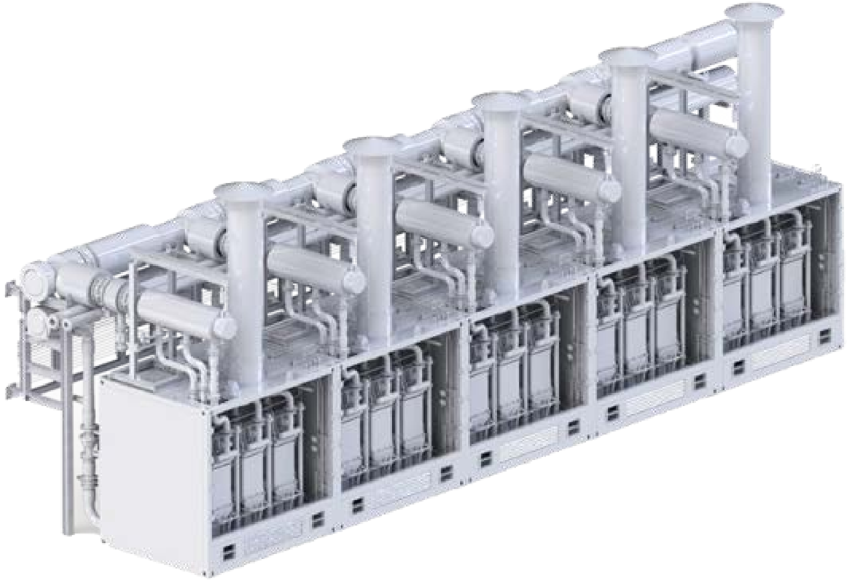


HSE RELEVANCY: PROCESS, LOGISTICS

HSE RELEVANCY: ELECTROLYSIS PROCESS

Alkaline Electrolyzer:

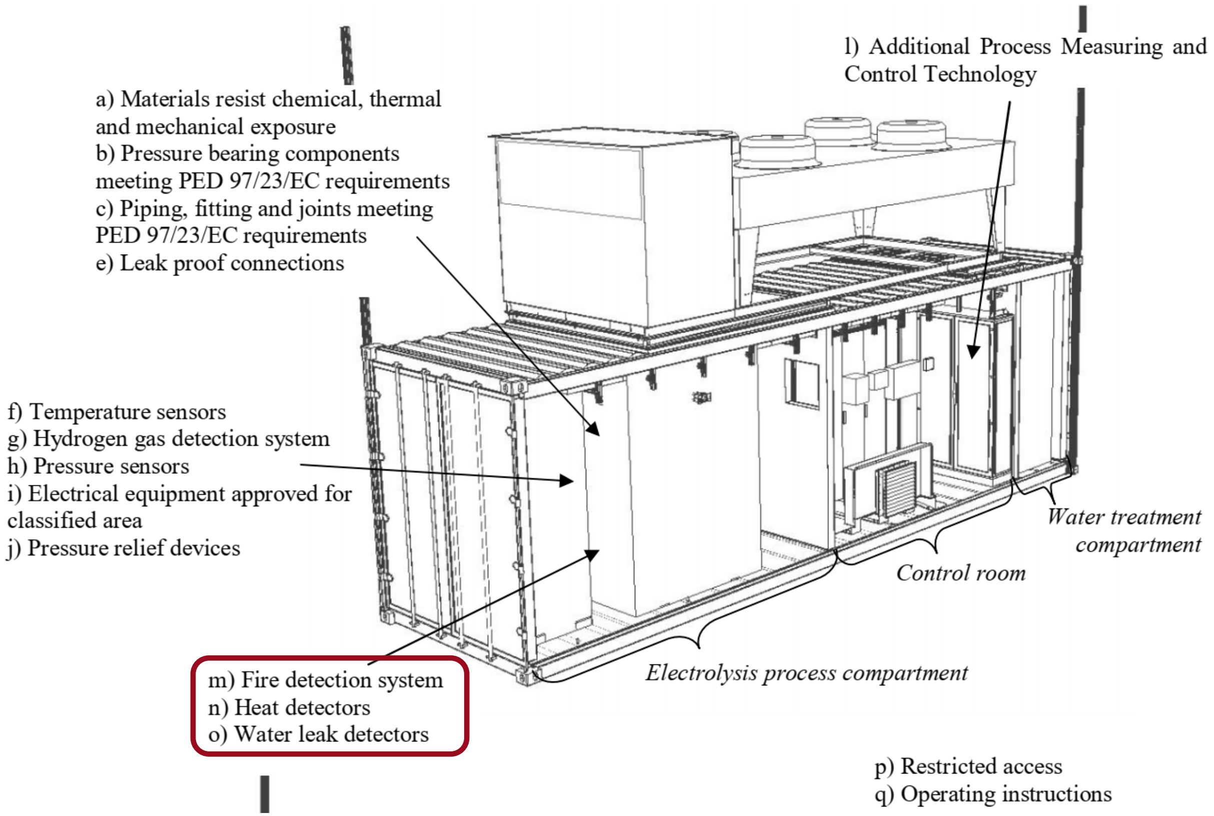
- Well established, multiple large-scale operation since 1920s
- Suitable for large scale operations, with relatively constant energy intake
- Somewhat lower efficiency than PEM
- H_2 **pressure and quality requires further investment** in gas purification and compression
- Slower system response time and low flexibility for lower utilization makes it less attractive for renewable energy balancing

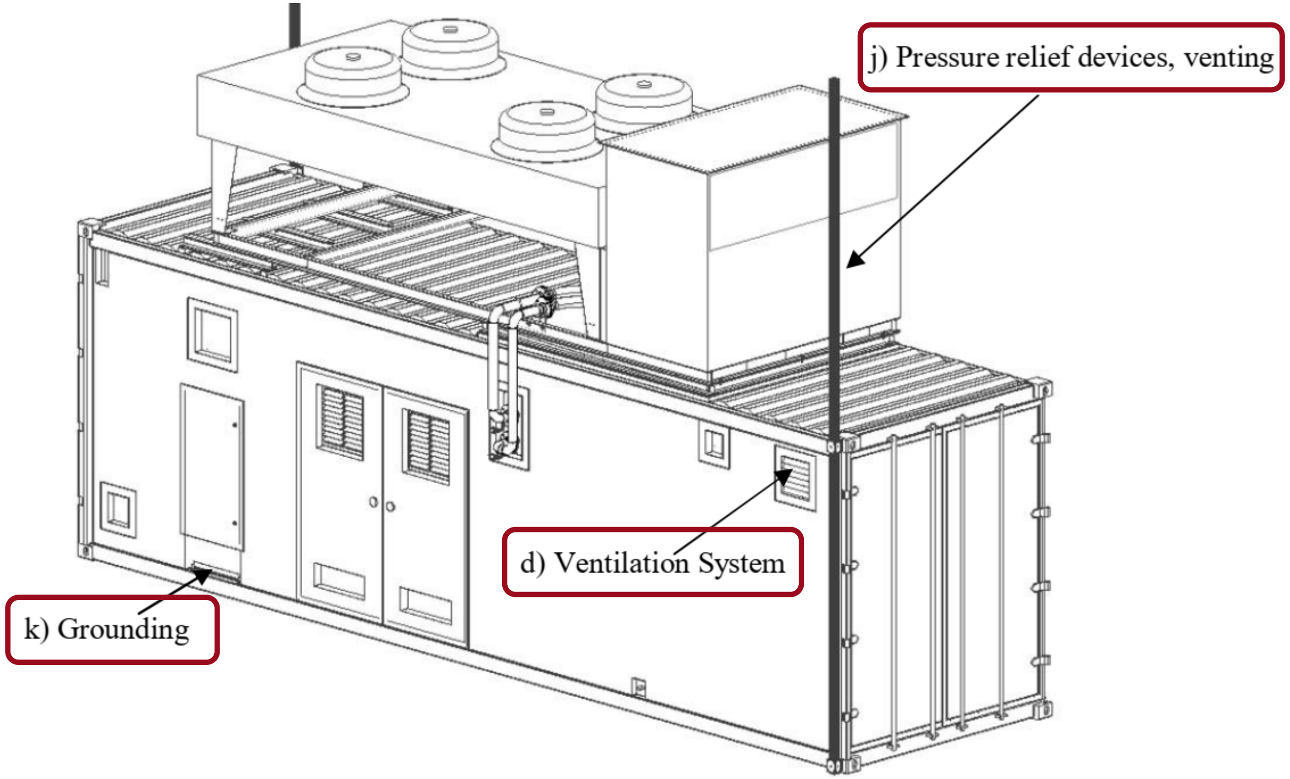


PEM Electrolyzer:

- Small scale operation since 1970s, commercial projects started recently
- Suitable for smaller scale investments (based on NEL and IHS findings)
- Higher efficiency than Alkaline, with room for improvement (theoretical)
- H_2 purity and pressure is close to the required (by DR H2 system), might additional compression required
- Faster system respond time and flexible operation makes it more suited for non- grid RE utilization

HSE RELEVANCY: ELECTROLYSIS PROCESS

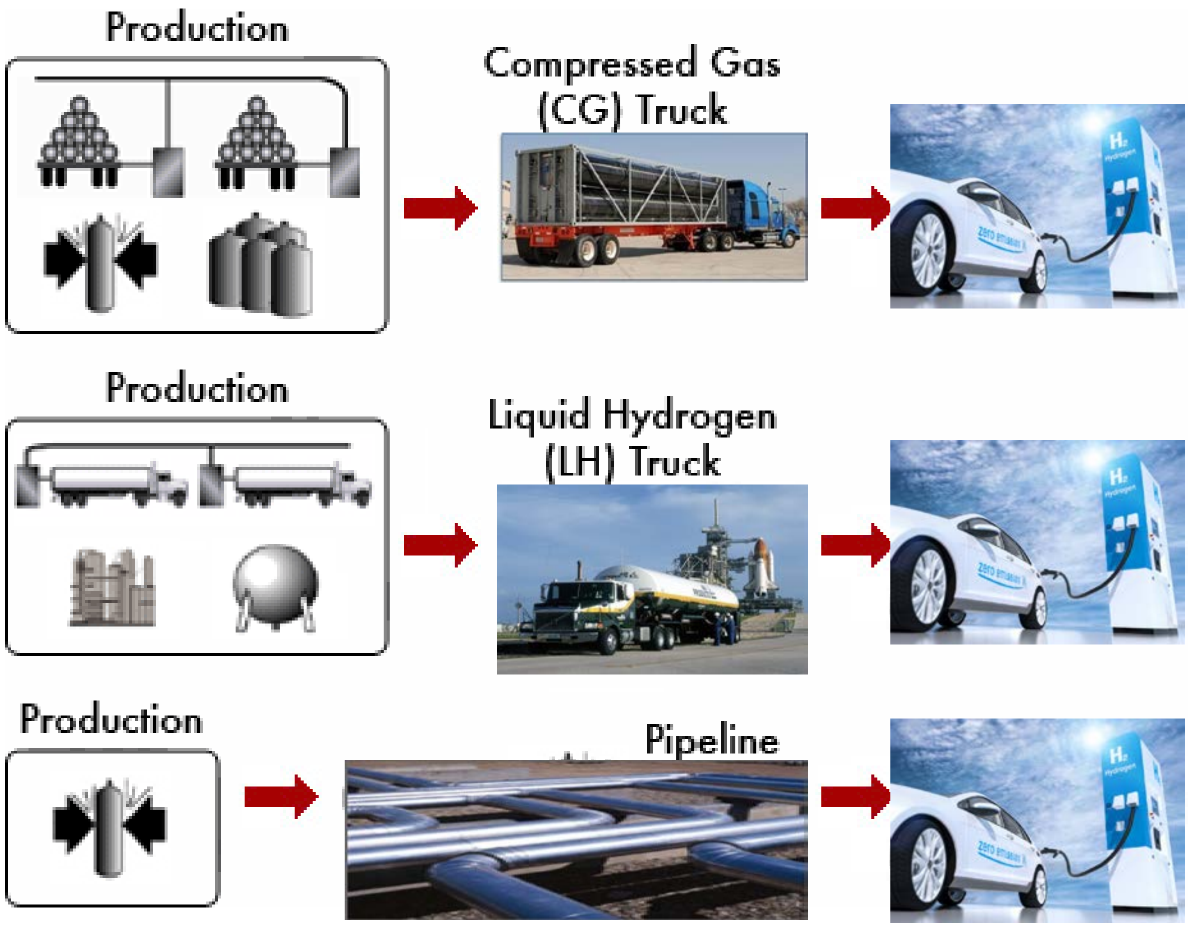




PEM Electrolyzer skid:

- The whole unit is grounded – the most exposed parts are made of/ covered with epoxy resins or other non conducting materials
- Hydrogen pressure and air quality is continuously monitored to prevent leakage/ LEL concentration of hydrogen in the equipment

HSE RELEVANCY: LOGISTICS



Tube trailers:

- Gaseous hydrogen is compressed to pressures of 180 bar or higher (up to 600 bar) into long cylinders that are stacked on a trailer.
- Steel tube trailers are most commonly employed and carry approximately 380 kg onboard; their carrying capacity is limited by the weight of the steel tubes.
- Composite storage vessels have been developed that have capacities of 560–900 kg of hydrogen per trailer.

Super-insulated, cryogenic tanker trucks:

- After liquefaction, the liquid hydrogen is dispensed to delivery trucks
- Over long distances, trucking liquid hydrogen is more economical
- Liquid tanker truck can hold a much larger mass of hydrogen
- Challenges with liquid transportation include the potential for boil-off during delivery.

Through pipelines:

- Approximately 1,600 km of hydrogen pipelines are currently in operation in the EU. Owned by merchant hydrogen producers, these pipelines are located where large hydrogen users concentrated
- Transporting gaseous hydrogen via existing pipelines is a low-cost option for delivering large volumes of hydrogen.

NEBULA - DANUBE REFINERY
GREEN HYDROGEN PROJECT

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PROJECT NEBULA - GREEN HYDROGEN PRODUCTION

- **Aim of the project**: to decrease the CO2 footprint of MOL Refinery by a new green-hydrogen producer electrolysis technology
- **Scope**: installation of 10 MW electrolyzer unit at MOL Refinery
- **Gate-2 Approval**: 04.02.2022, 18.5 mn
- **Historical outlook**: Licensor market scanning (ISBL), basic study (OSBL utility point)
- **FID proposal**: EUR 21.9 mn
- **Financial KPIs**: considering financial trends, by the early 2030s green hydrogen production will be a potential alternative to traditional one without regulatory obligations

Project KPIs

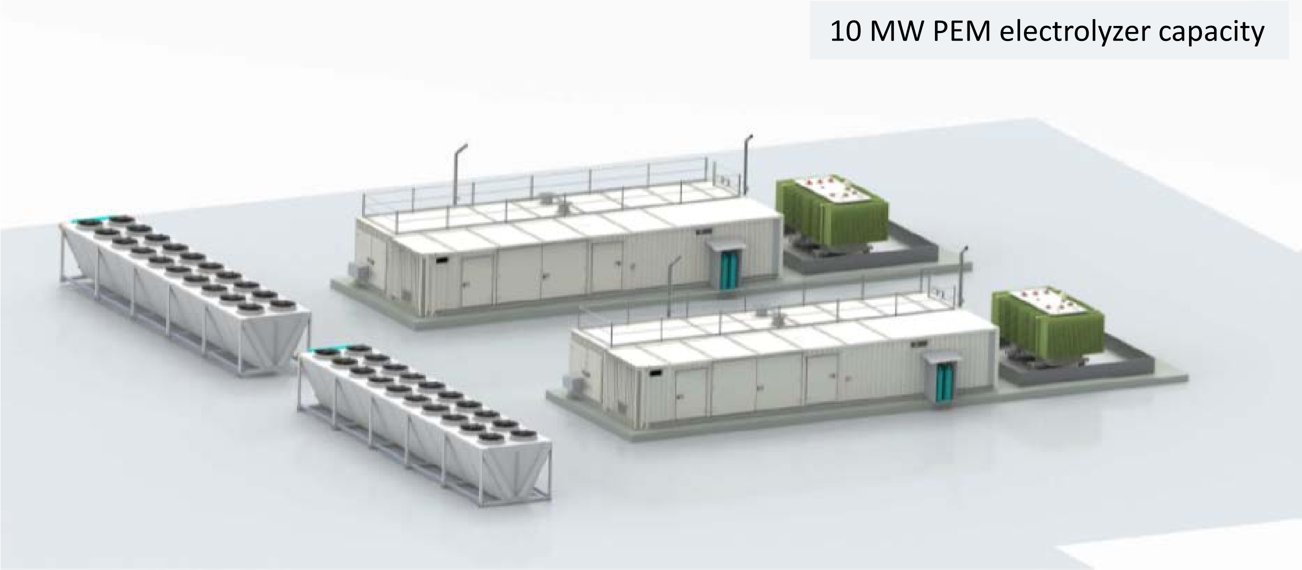
Capacity (MW)	10
Capacity (ktpa GH2)	1.6
Year of commission	2024
Years of operation	20
CO2 savings, ktpa	26
CAPEX, Mn EUR	21.9

Note: *w/o and w/ ren. Upside. According to the current understanding of the GH upside, subject to change due to the regulatory development

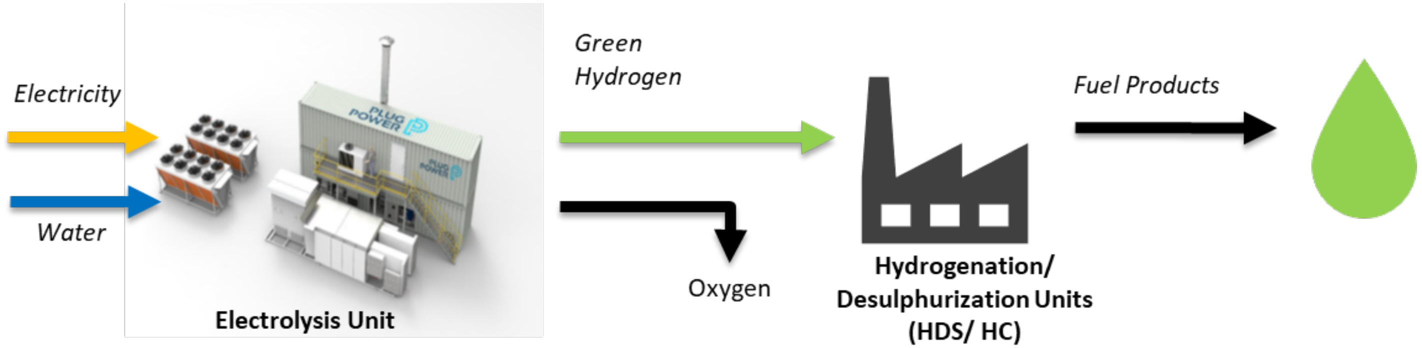
GREEN HYDROGEN – STRONG POTENTIAL SYNERGY WITH E-FUEL INVESTMENTS & FURTHER DEVELOPMENTS

- **In line with MOL group 2030 strategy and at EU level accepted Renewable Energy Directive 'RED2' regulation** , project aims to **substitute partially and gradually** the production of the **lower efficiency hydrogen production** unit (HGY-1) in the MOL Refinery with a beneficial, reasonable and most rational business case alternative.

ISBL Part	EUR 10.06 mn
OSBL Part	EUR 11.33 mn
Owner's Internal Resource cost	EUR 0.52 mn
TOTAL INVESTMENT COST	EUR 21.91 mn



The technology process



RFNBO content
The RFNBO renewable content of the final product could be as high as 3.2 % (depending on validation)

Remarks:
- **Full utilization of the existing electric grid of MOL Refinery.**
- **The green electricity** will be provided by renewable certificate trading therefore linking investments to produce green electricity **are not scope of the project.**

THANK YOU FOR YOUR ATTENTION!