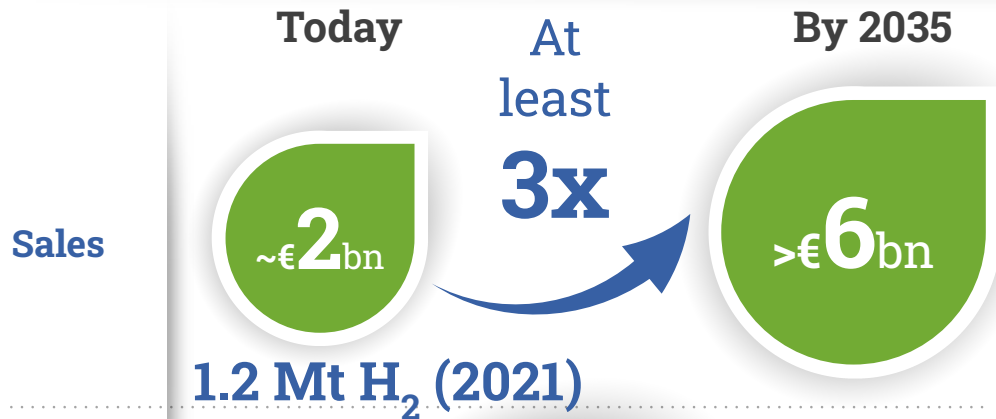




Hydrogen release: A supply chain overview

The 2023 Hydrogen & Fuel Cell Seminar (February 7th, 2023)
Pavol Pranda and Guy de Reals

We think BIG for hydrogen



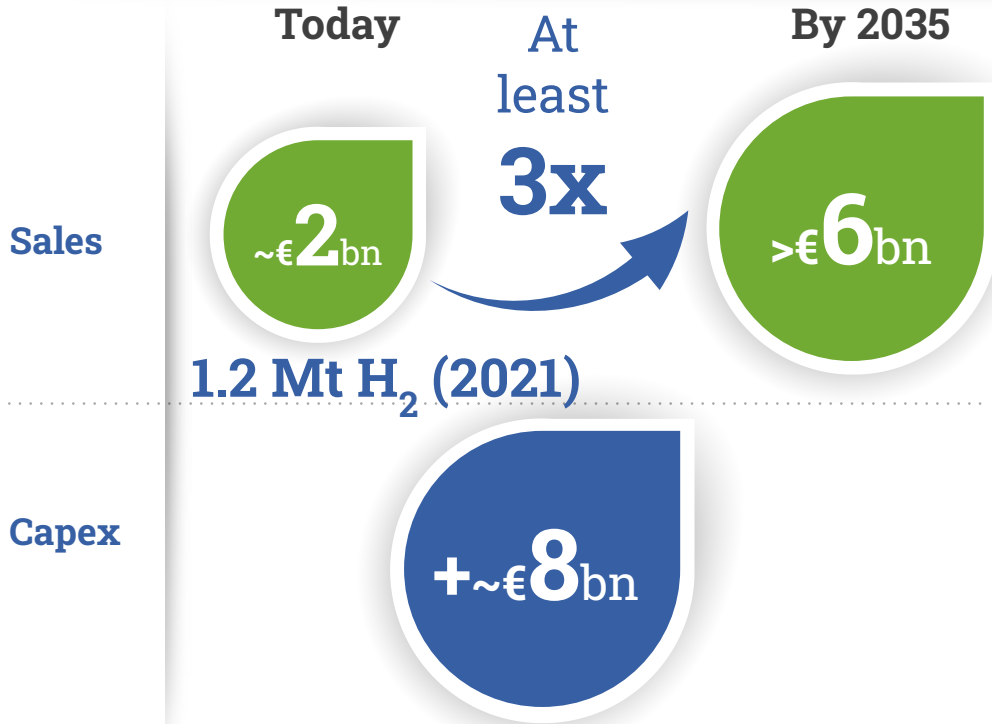
Capturing demand:

- Low Carbon + Renewable H₂ offer
- New H₂ industrial applications
- Carbon Capture as a service
- H₂ mobility

Capturing additional value by decreasing customers CO₂ footprint

(a) Including a confirmed capacity of 1 GW still under construction

We think BIG for hydrogen



Capturing demand:

- Low Carbon + Renewable H₂ offer
- New H₂ industrial applications
- Carbon Capture as a service
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Capturing additional value by decreasing customers CO₂ footprint

Investment in:

- CO₂ Capture plants
- Electrolyzers
- Supply chain for mobility
- Takeovers

3 GW^(a)



(a) Including a confirmed capacity of 1 GW still under construction

Why hydrogen release?

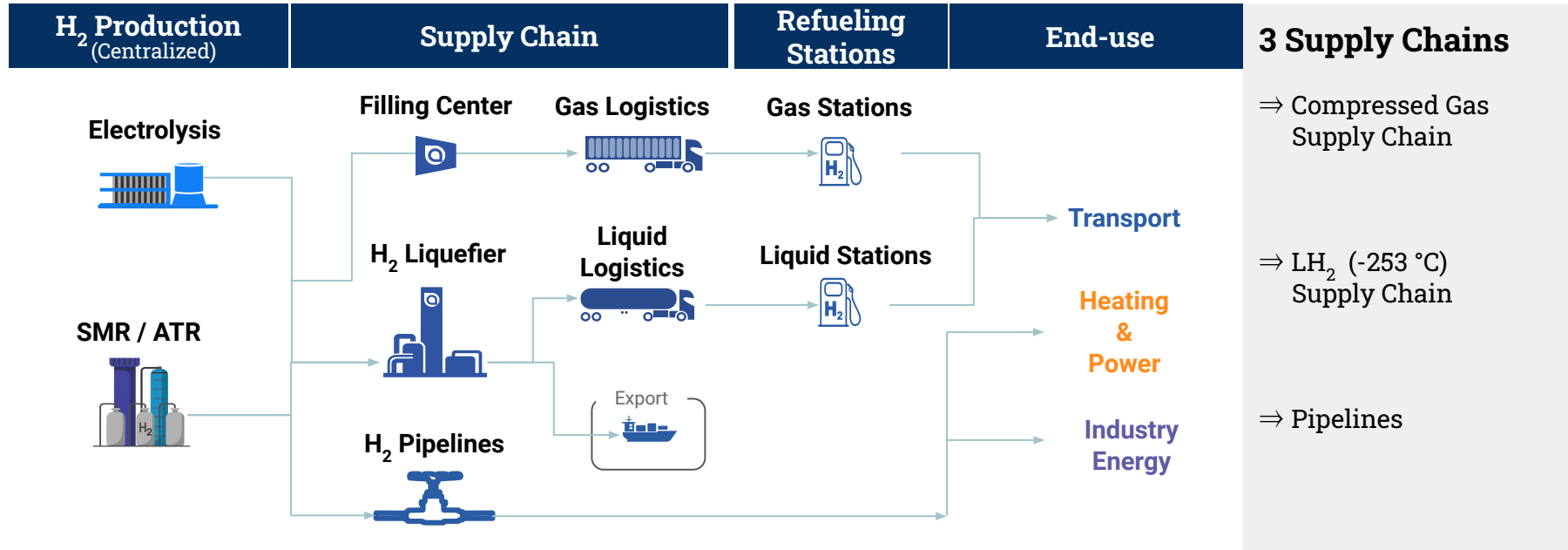
Disclaimer

Within the context a plausible scenario informed by current knowledge, the following is meant to provide **rough orders of magnitude** of what ***could be*** the **potential impact** of hydrogen released into the atmosphere following the deployment of the hydrogen economy.

It aims at giving **conservative figures** to evaluate whether **hydrogen released** as a result of **the hydrogen economy deployment** actually represents a **significant *potential* contribution** to climate change or not.

Context

Supply Chain Organization



Production

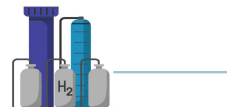
H₂ release into the atmosphere

H₂ Production (Centralized)

Electrolysis



SMR / ATR



Today

Under Development/Mature

⇒ ~**0.2%** of the production:

- Venting, H₂ in O₂
- Dryers Regeneration
- Leakages etc

Mature

⇒ Well optimised
⇒ Very low losses of **10⁻⁴ %** of the production

Target 2030

Mature

⇒ Very low losses: ~**0.03%** of the production:

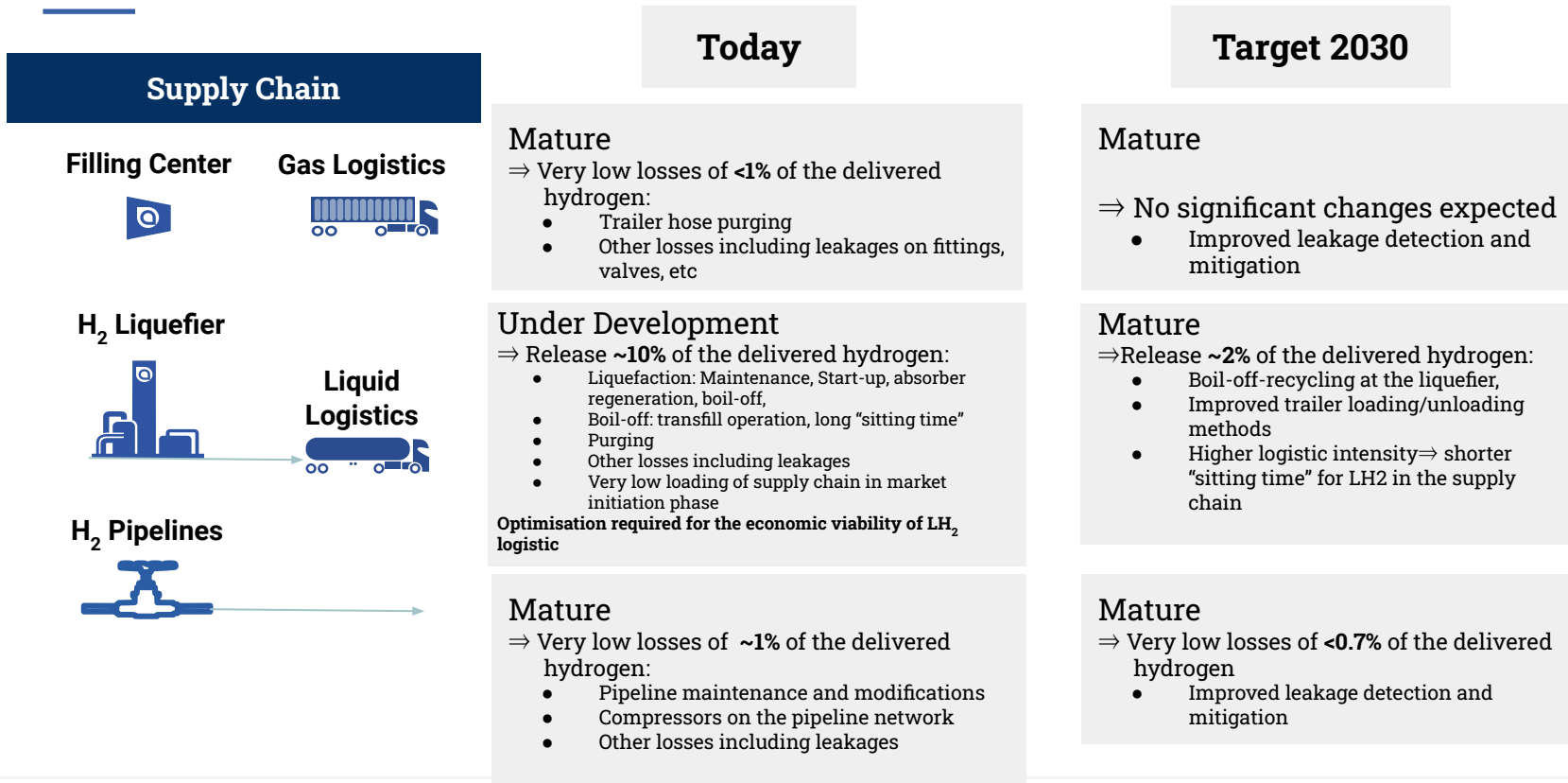
- Venting H₂ in O₂ (reduced crossover)
- Improved Dryers Regeneration
- New techno for leakage detection

Mature

⇒ No significant changes expected

Supply Chains: Gas, Liquid & Pipeline

H₂ release into the atmosphere



Refueling Stations

H₂ release into the atmosphere

Refueling Stations

Gas Stations



Today

Under Development/Mature

- ⇒ ~3% of the delivered H₂:
- Purging : Heat exchanger, hoses (dispenser, trailer)
 - Compressor membrane loss
 - Commissioning, buffer inspection, leakages etc.

Target 2030

Mature

- ⇒ ~2% of the delivered hydrogen
- New optimized standards for the inspection (eg acoustic)

Liquid Stations



Under Development

- ⇒ ~8.5% of the delivered hydrogen:
- Purging : dispenser hose
 - Boil-off stationary (pump & storage) & dynamic (pump)
 - Commissioning, buffer inspection, leakages etc.

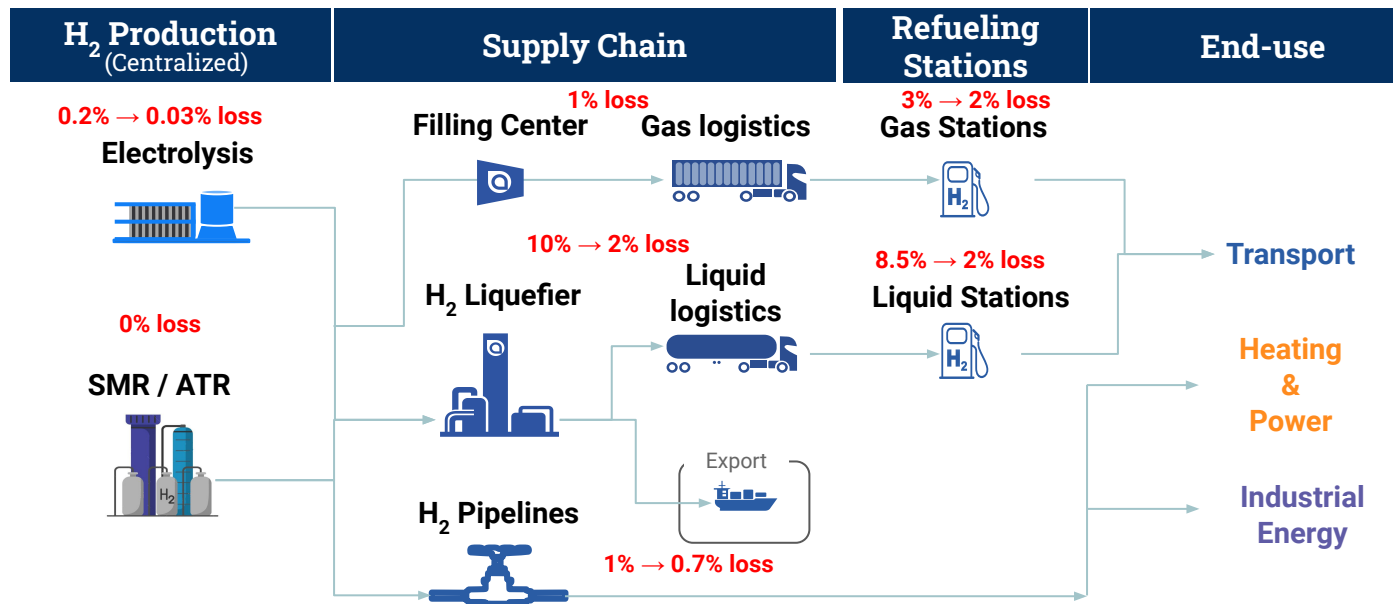
Optimisation required for the economic viability of LH₂ logistic

Mature

- ⇒ ~2% of the delivered hydrogen:
- Technology improvement
 - Procedures optimisation
 - Higher logistic intensity ⇒ Shorter "sitting time" for LH₂ at HRS

Summary on releases:

H₂ release into the atmosphere



3 Supply Chains

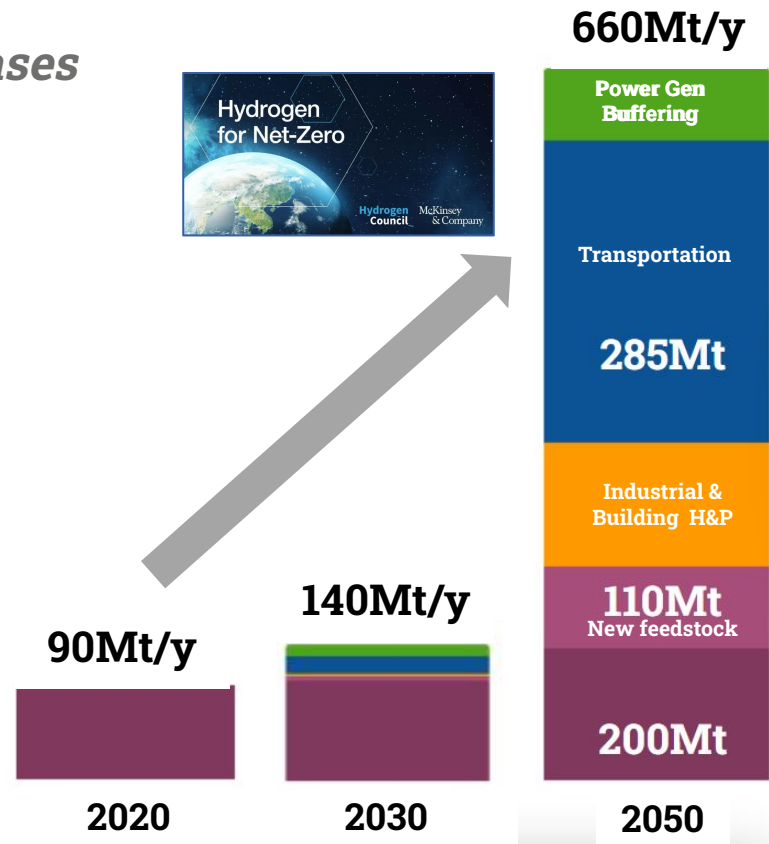
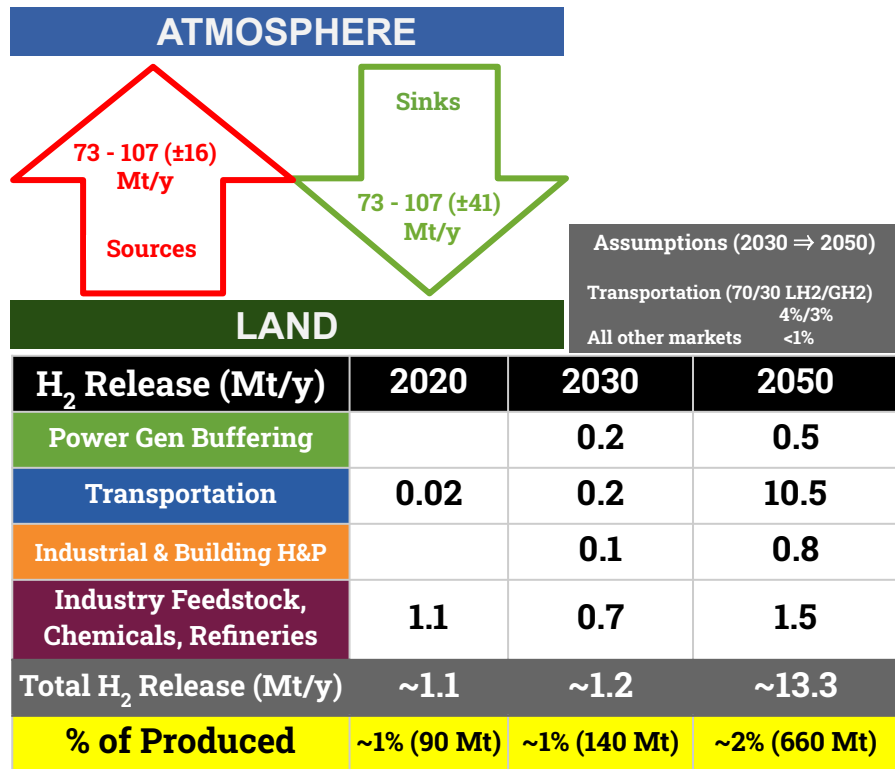
⇒ Compressed Gas:
Today ~4.2% ⇒ 3% (2030)

⇒ LH₂:
Today ~10-20% ⇒ 4-5% (2030)

⇒ Pipelines:
Today ~1% ⇒ <1% (2030)

Summary: Global View

Global H₂ Budget vs H₂ Production & Releases



1. Atmospheric Impacts of Hydrogen as an Energy Carrier, Center for International Climate and Environmental Research (CICERO), Oslo, 2020
2. Global Hydrogen Budget 2008-2017, Global Carbon Project, Yang et al., 2022

Summary: Takeaway Points

H₂ release values

- represent **rough orders of magnitude** aiming at giving **conservative values**.
- release values due to the deployment of hydrogen economy would be around **13 Mt/y in 2050**.
- **of ~13 Mt/y** represent a **limited quantity** compared to the **2020** sources of **73 to 107 Mt/y**.
- **should decline with time**
 - due to **methane and NMVOCs decrease** ⇒ **Less H₂ from the photochemical production**.
 - due to **decline of the fossil fuel use**.

Funding Opportunity Announcements (EU and US) published recently to further investigate H₂ release topic



Thank you