TotalEnergies' renewable and low-carbon hydrogen ambition

Fondation Tuck

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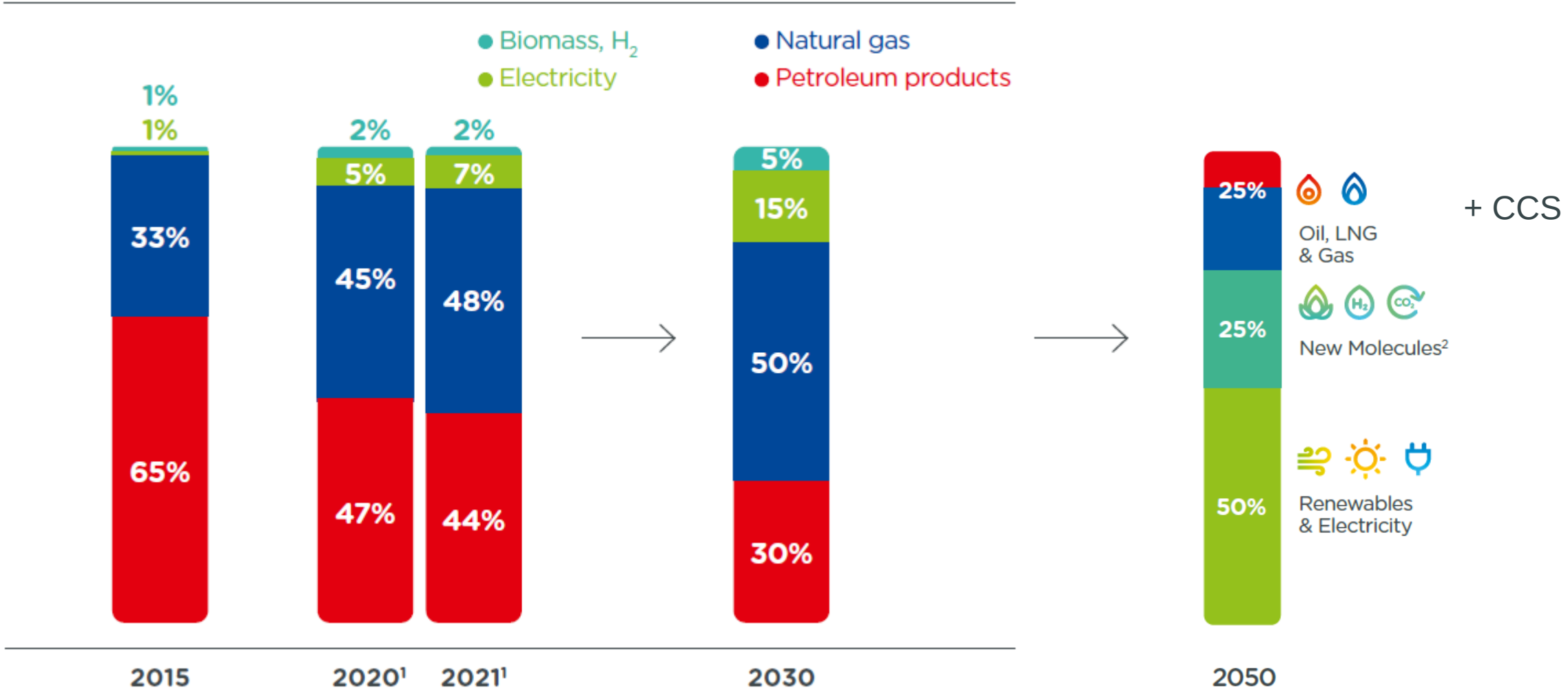
TotalEnergies' sales mix is evolving towards net zero emissions

New molecules, including hydrogen, to play a key role in the future



Markets for renewable and low-carbon hydrogen

H_2 as building block / reactant

INDUSTRY

Existing uses (mainly grey or black hydrogen demand of 90 MTPA in 2020)*

- Refining (desulfurization and hydrocracking) ~45%
- Ammonia synthesis (mainly for fertilizers) ~40%
- Methanol synthesis (mainly as a chemical building block) ~10%
- Steelmaking (Direct Reduction of Iron) ~ 5%

New uses

- High-temperature process heat (e.g., petrochemicals, cement, glass or paper manufacturing)

H_2 as energy carrier

MOBILITY

Road: compressed or liquid hydrogen consumed in fuel cells or H2 ICE
Sea: ammonia, methanol
Aviation: e-kerosene (a type of SAF)

POWER GENERATION

Coal-fired power plants: ammonia co-firing
Gas-fired power plants: co-firing of hydrogen, then pure hydrogen

HEATING (RESIDENTIAL & COMMERCIAL)

Hydrogen blended with gas or pure hydrogen
(could also entail small-scale local power generation)

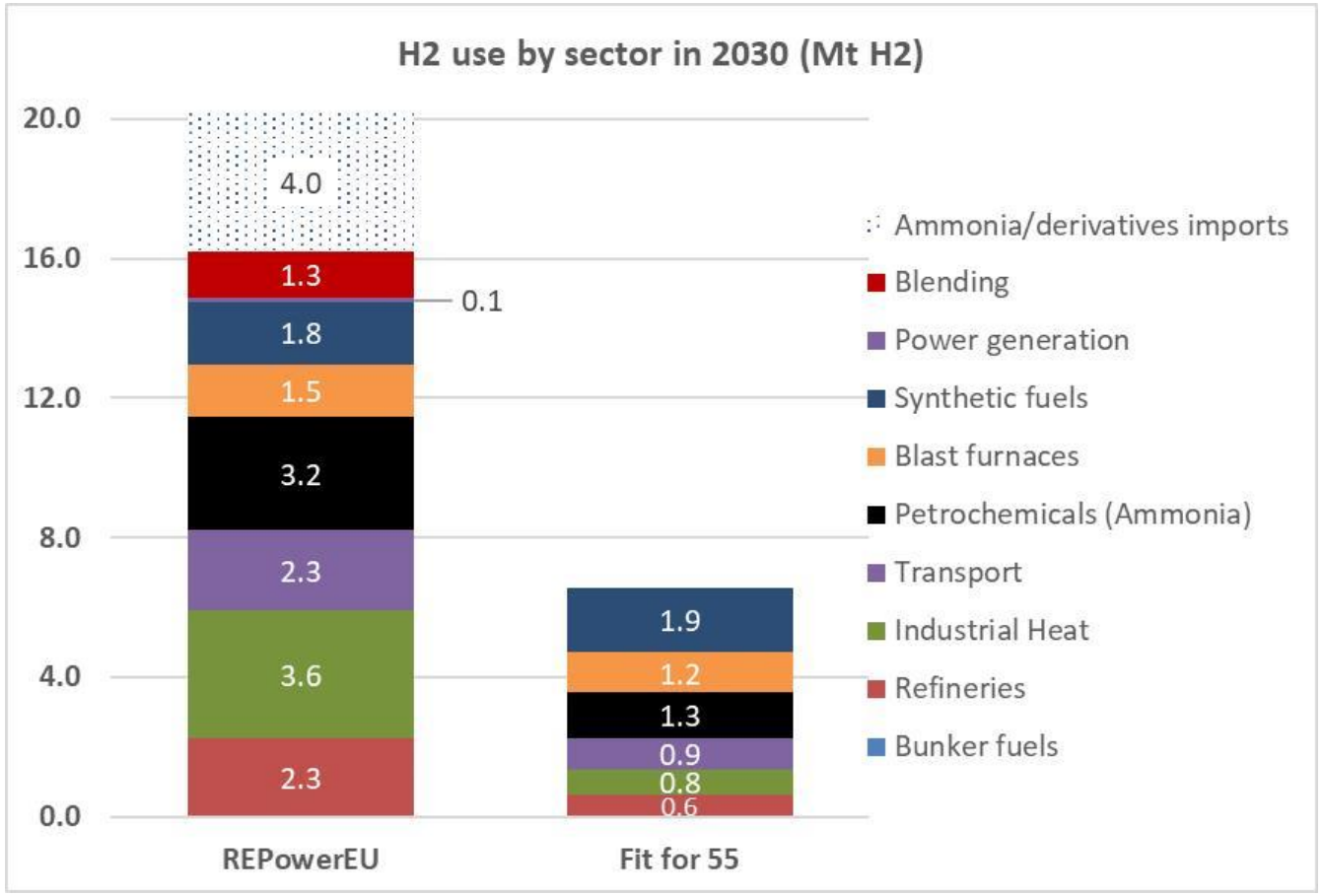
STORAGE

Seasonal or as a complement to intermittent renewables

* IEA's Global Hydrogen Review 2021.

European Commission targets 2030 demand for renewable hydrogen at 20 MTPA

(expected to be met with 10 MTPA produced in Europe, requiring ~100 GW of electrolysis capacity and ~200 GW of renewables, and 10 MTPA imported)



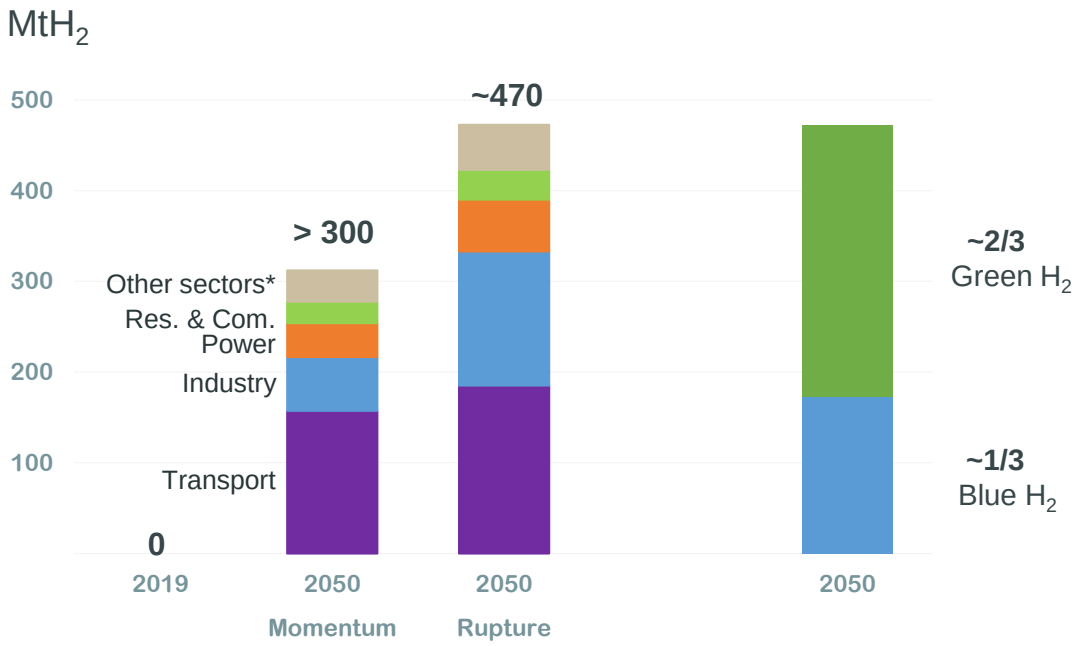
"The Commission will roll out carbon contracts for difference to support the uptake of green hydrogen by industry and specific financing for REPowerEU under the Innovation Fund, using emission trading revenues to further support the switch away from Russian fossil fuel dependencies."

- For the industrial applications, a CCfD incentive equivalent to 1 $/kgH2 (as an example) will require ~$10bn per year

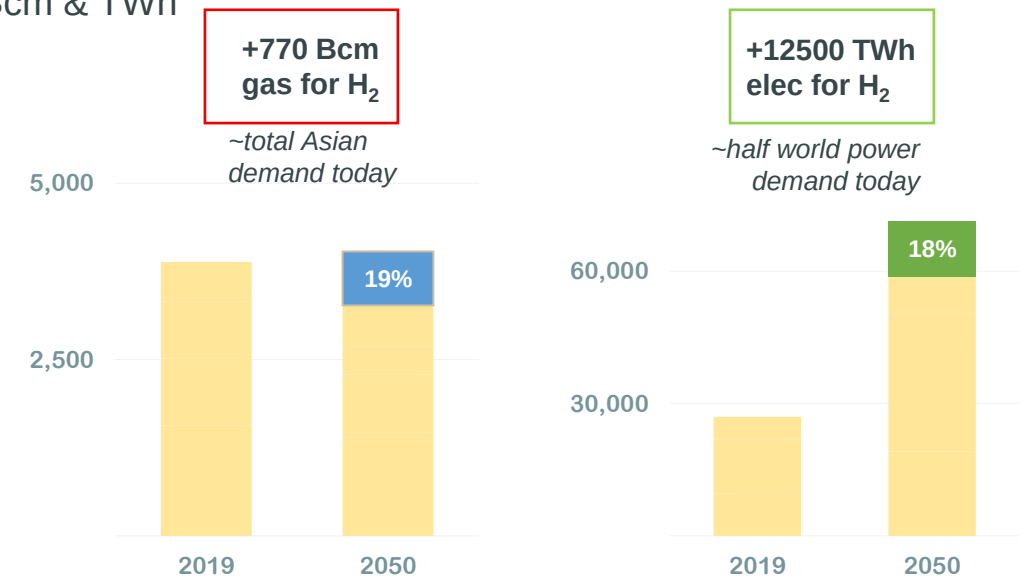
Source: EUROPEAN COMMISSION STAFF WORKING DOCUMENT "IMPLEMENTING THE REPOWER EU ACTION PLAN: INVESTMENT NEEDS, HYDROGEN ACCELERATOR AND ACHIEVING THE BIO-METHANE TARGETS"

Demand forecast (TotalEnergies Energy Outlook 2022)

Adding ~20% to natural gas and power demand in 2050



- **Nat Gas and Power demand by sector including H2 (Rupture)**
- Bcm & TWh



- H_2 production taking off after 2030 drives up electricity & gas demand with CCS & electrolysis development
- Transport & Industry are the main users of clean H_2
- Costs must come down and infrastructure must be built up in order to support H_2 adoption and industrial scale up

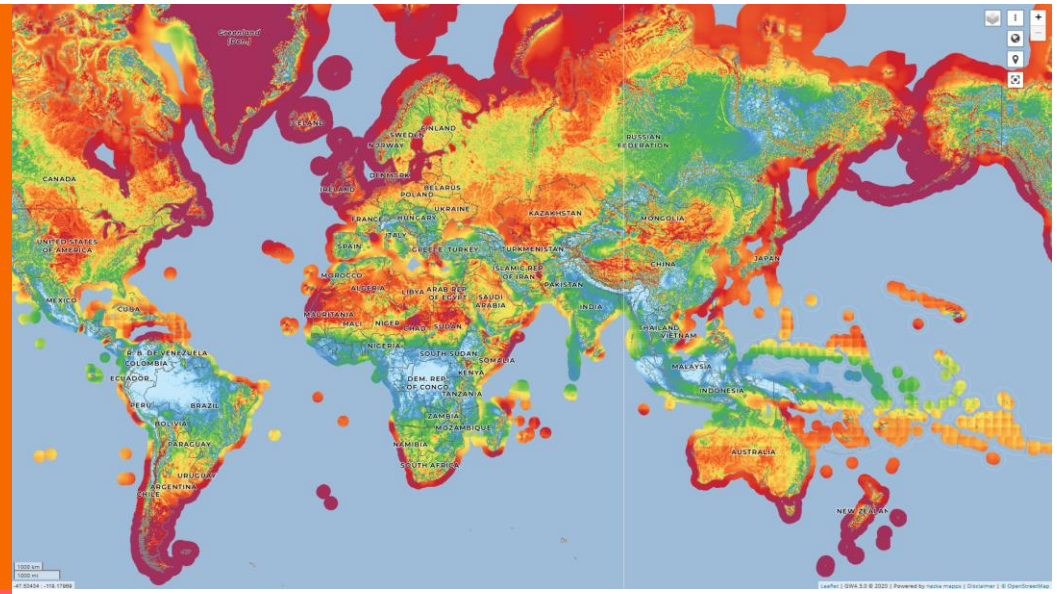
- H_2 becomes a significant growth driver for natural gas demand starting in the 2030's
- Power for Green H_2 pushes up power demand CAGR from 2.5%/y to 3.2%/y until 2050

* *Other energy use, non-energy use and agriculture*

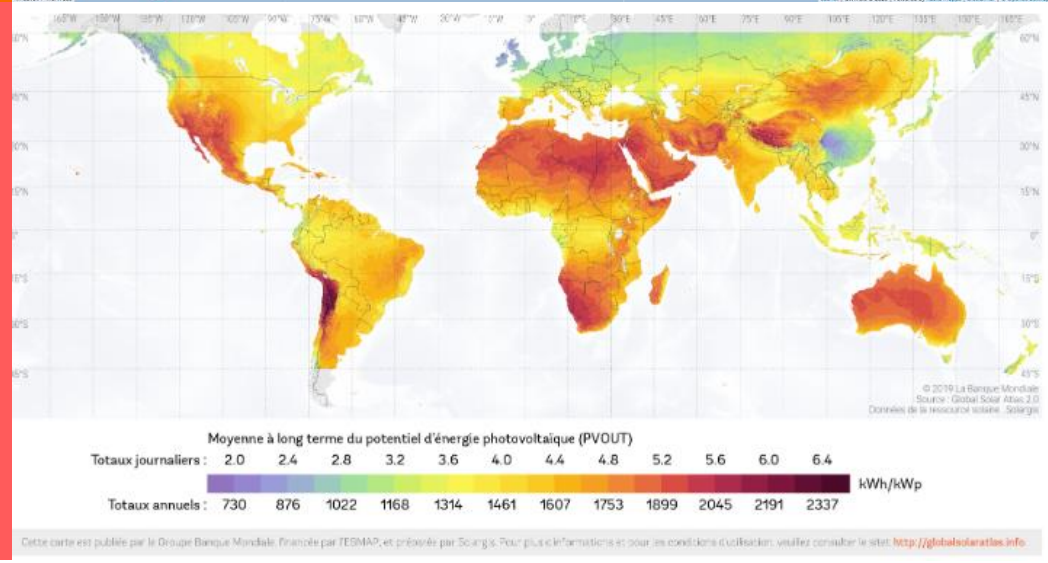
Rupture

Key demand centres vs. key production centres

Wind resources



Solar resources



- Demand centres:
  - Such key demand centres as **India, United States and China** can be self-sufficient in hydrogen in the first approximation at least in the short- and medium-term given their resources or will strive to be self-sufficient.
  - Such key demand centres as **Europe, Japan and Korea** will have to import

- Production centres:
  - Important criteria other than quality of renewables and distance to demand centres:
    - Ease of doing business, government stability, country risk to drive lower cost of debt
    - Infrastructure
    - Labor market and general cost environment

Transport if the client is interested in hydrogen (as opposed to a derivative)

Schematic from a EU think tank
(comparison between LH2, LOHC,
Ammonia is highly uncertain at this stage)

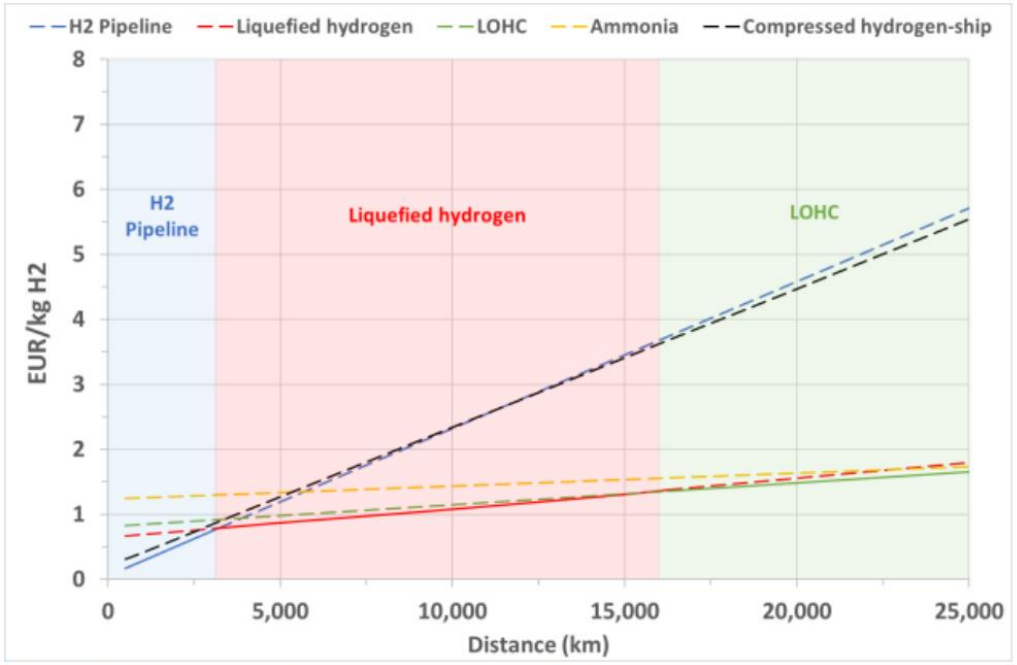
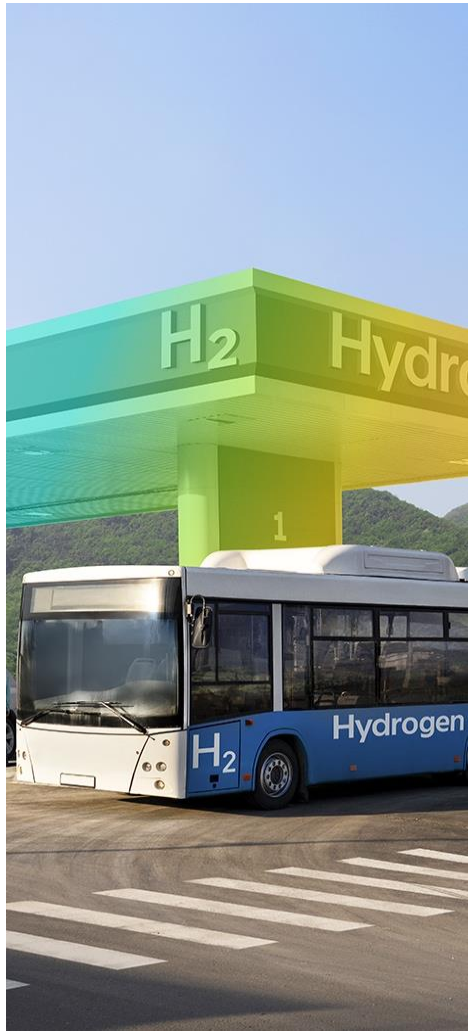


Figure 2 Hydrogen delivery costs for a simple (point to point) transport route, for 1 Mt H_2 and low electricity cost scenario.

- Hydrogen is a gas and as such follows the same transport logic as natural gas:
  - Cost of transport of a unit of hydrogen by pipeline (or compressed) starts at zero and increases linearly with distance
  - Cost of transport in a different state (e.g., liquefied or ammonia vector) has a high fixed component but then increases more slowly with distance
    - The result of the competition between such vectors of hydrogen transport as Liquefied H2, Liquid Organic Hydrogen Carrier or Ammonia (with cracking) is yet unclear
  - Up to a certain distance which is less than 5000 km, pipeline is the cheapest transport solution

→ Europe hydrogen imports will normally mimic Europe gas imports (with blue and green hydrogen flowing from neighboring countries + top-up by sea)

TotalEnergies' ambition in renewable and low-carbon hydrogen: to pioneer and then become a leader in its mass production



1 Kick-start by addressing our refining demand

- La Mède Bio-Refinery: Masshylia (125 MW electrolyser, FEED stage)
- Zeeland Refinery: EnergHys (250+ MW electrolyser)
- Electrolyser opportunities evaluated for Leuna, Antwerp and other refineries
- CCS projects on existing SMRs in some refineries

2 Develop mass production

- Renewable hydrogen from low-cost renewable electricity
  - Adani New Industries Limited, Flotta
- Low-carbon hydrogen from competitive gas and CO2 storage capacity
- Technological roadmap, including hydrogen transportation carriers / end-products
  - Masdar City: renewables-to-SAF demo plant project

3 Act on hydrogen infrastructure and demand

- Decarbonize heavy-duty transport
- Work with utilities and industrials to decarbonize other hard-to-electrify sectors
- Anchor investor in €2bn hydrogen infrastructure fund

Integrating along the entire hydrogen value chain:

From primary energy to end-uses across development, operations, trading, and marketing

TotalEnergies

Benefiting from

- Long-standing technical credibility, large-scale project management and customer relationships
- Asset base and global footprint
- Vast hydrogen experience in Refining-Chemicals segment, including experience of ammonia and urea production in Europe and UAE in the recent past
- CCS expertise and renewables track record and “100 GW by 2030” ambition

Dedicated **technical** (development planning, engineering, operations) and **commercial** (including demand origination) teams for clean hydrogen/derivatives

Material **pilots** and **R&D effort**

Emerging **portfolio of large-scale** clean hydrogen/derivatives projects in locations **with advantaged renewables or gas feedstock / CCS capacity**

TotalEnergies and Adani Join Forces to Create a World-Class Green Hydrogen Company: Adani New Industries Limited (ANIL)

- **Exclusive platform for the production and commercialization of green hydrogen in India.** Can and will export too
- In order to control green hydrogen production cost, ANIL will be **integrated along the value chain**
  - From manufacturing of PV modules (starting from MG silicon), wind turbines and electrolyzers at GW scale – in a country capable of low-cost manufacturing
  - To renewable power generation, production of green hydrogen and its transformation into derivatives
  - "*Our confidence in our ability to produce the world's least expensive electron is what will drive our ability to produce the world's least expensive green hydrogen.*"
- ANIL will target **1 MTPA of hydrogen by 2030,** underpinned by around 30 GW of new renewable power generation capacity, as its **first milestone**
- **TotalEnergies brings** expertise in renewable technologies and large-scale industrial projects, hydrogen R&D, financial strength, understanding of the end consumer and global market reach

ANIL's first project on the journey to 1 MTPA of hydrogen milestone: 1.3 MTPA of urea for the domestic market, as a substitution to imports