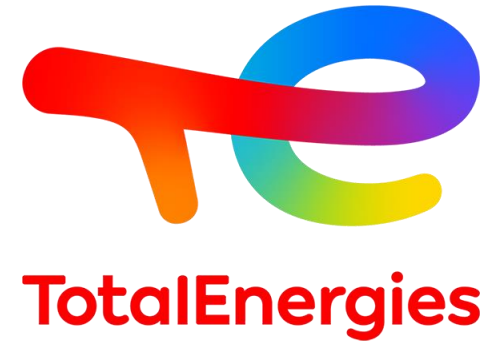


Comité National
CNC
Chimie

3^{èmes} Rencontres académie-industrie du CNC
L'Hydrogène vecteur énergétique et réactif chimique



Developments of low carbon hydrogen at TotalEnergies

David AYME-PERROT
R&D project manager
07/12/2023



In a nutshell

TotalEnergies

The company



OIL



GAS



ELECTRICITY



HYDROGEN



BIOMASS



WIND



SOLAR



TotalEnergies

Our organisation

**Exploration
&
Production**



**Gas
Renewables
& Power**



BU H2

**Refining
&
Chemicals**



**Marketing
&
Services**

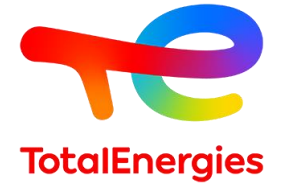


OneTech

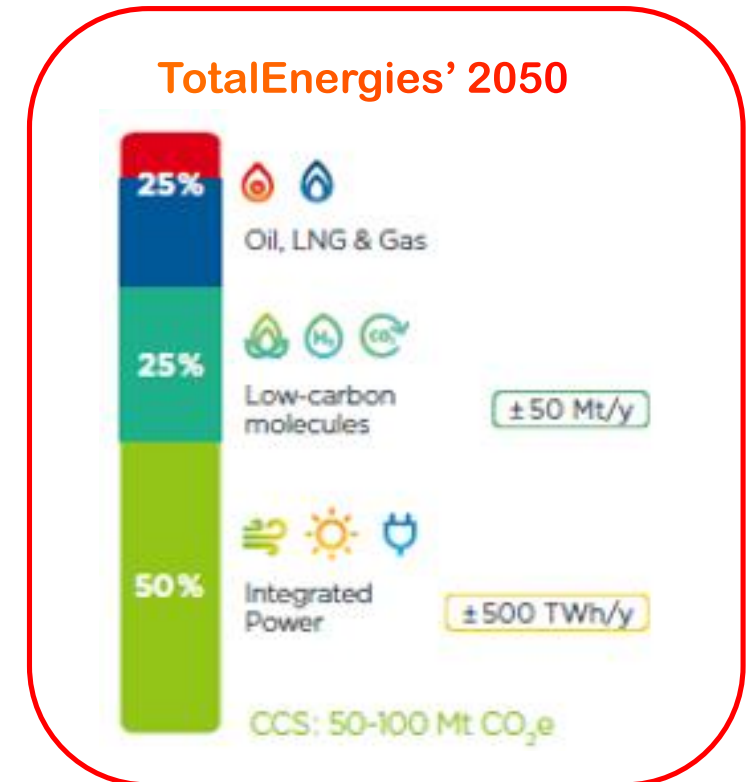
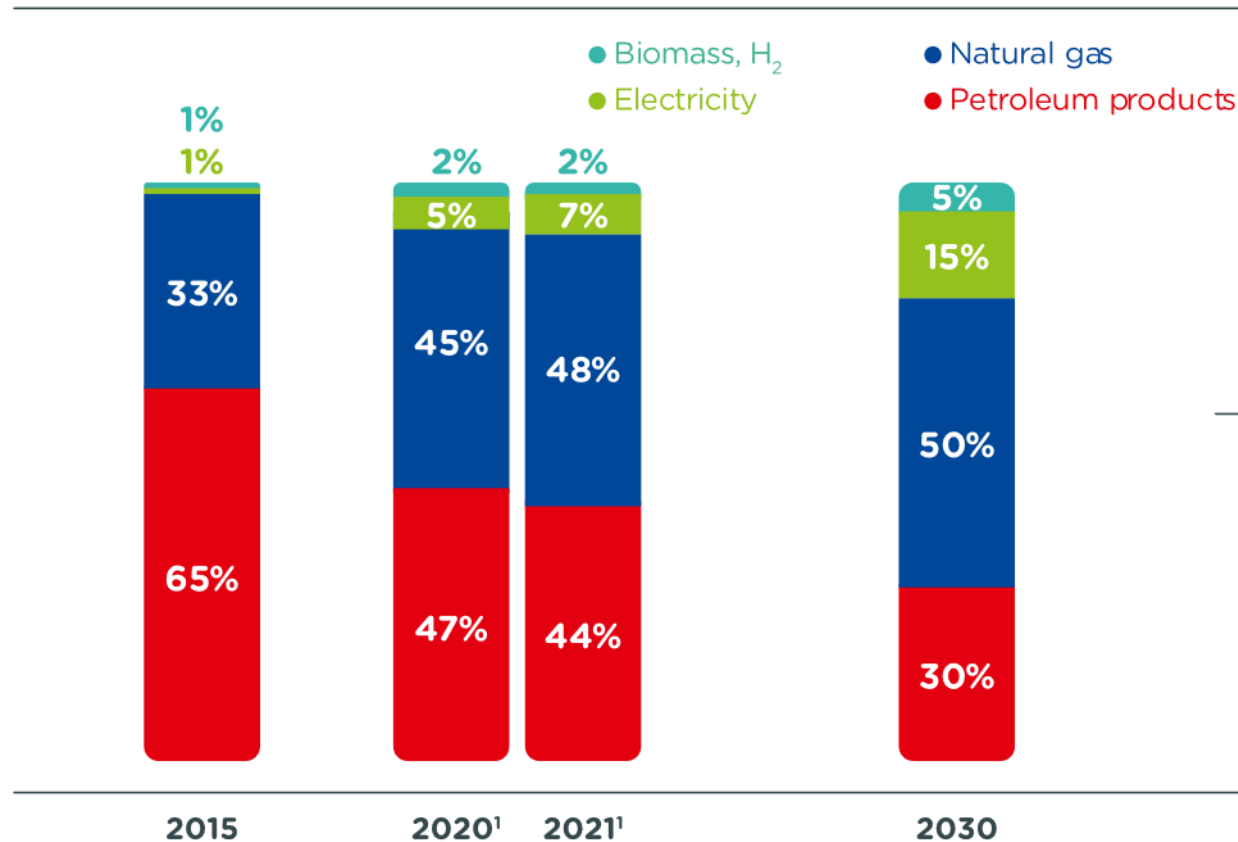


TotalEnergies in 2050: a vision for a Net Zero company

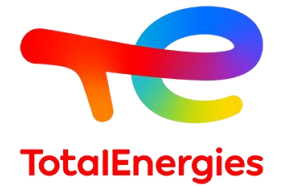
H2 part of the journey



SALES MIX



Low-Carbon Electricity : Growth and profitability



	2021	2022	2023
Investment in REN and electricity (in \$)	> 3bn	4bn	5bn



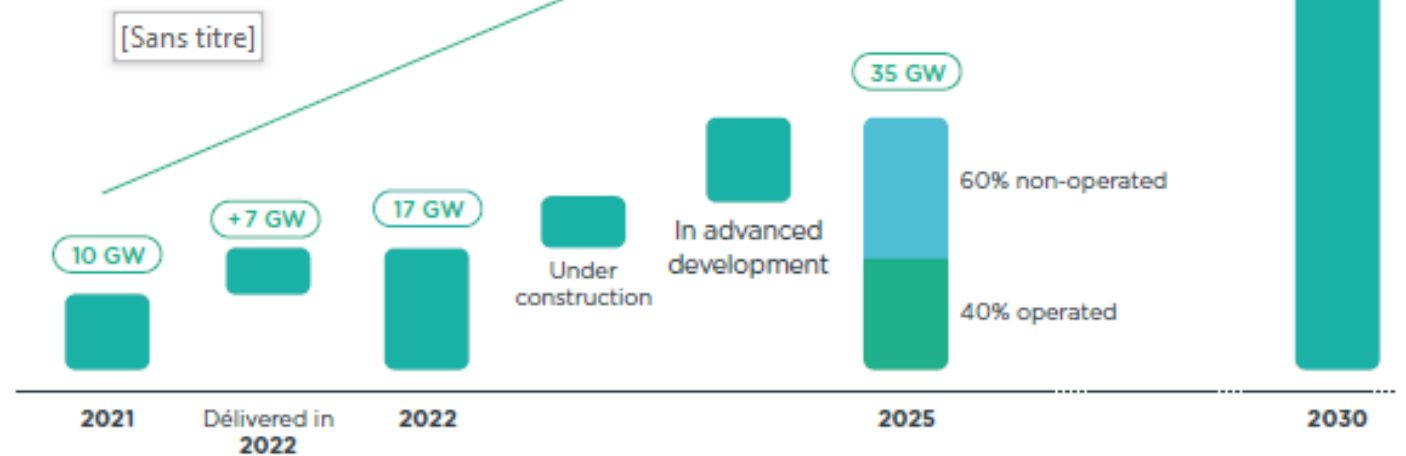
Al Kharsaah PV plant, 800MW, Qatar

GROSS INSTALLED CAPACITY FOR RENEWABLE ELECTRICITY

GW

+7 GW IN 2022

- ClearWay installed capacity in the U.S. (> 4 GW)
- Startup of Al Kharsaah in Qatar (800 MWp solar)
- Startup at AGEL in India (> 500 MW)
- Startup of Seagreen in Scotland
- Various projects in France and China



What role of hydrogen in the transition?

TODAY

- 80 Mt of fossil-fuel based H₂* (grey) used mainly in refining and chemicals (fertilizers)

TOMORROW

Clean H₂

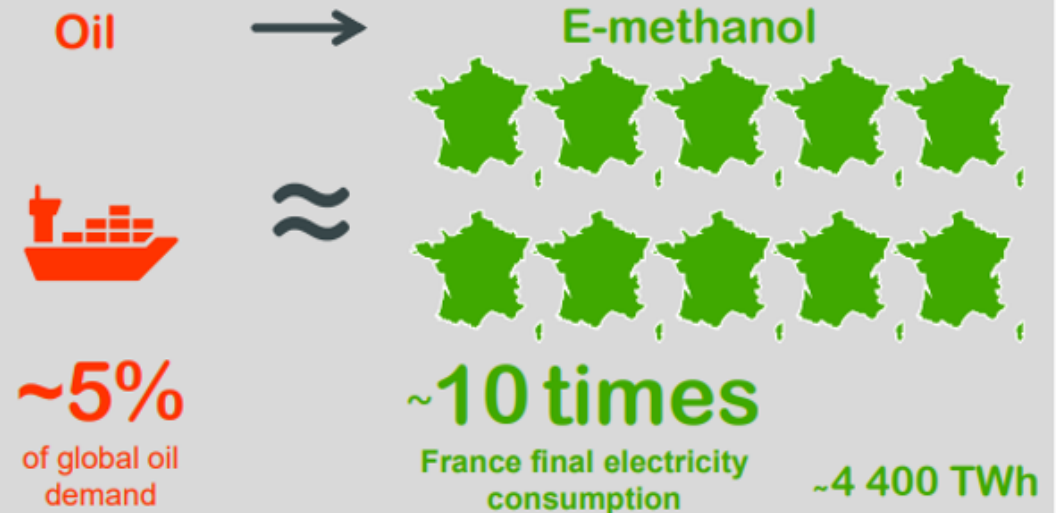
- **Proven demand** to decarbonize specific heavy industries: refining and chemicals (substitution), steelmaking, etc.
- **Demand to be confirmed** as it competes with other energies:
 - Road mobility ↔ Electricity
 - Electricity generation ↔ Natural gas + CCUS

AFTER TOMORROW

- **Demand for hydrogen-derived synthetic fuels (e-fuels):** aviation, marine and road transport
- The processing chain is long and, to date, inefficient and energy-consuming
- Green H₂ consumes water, space and renewable energy; 4 to 5 times more expensive

EXAMPLE OF A LONG CHAIN

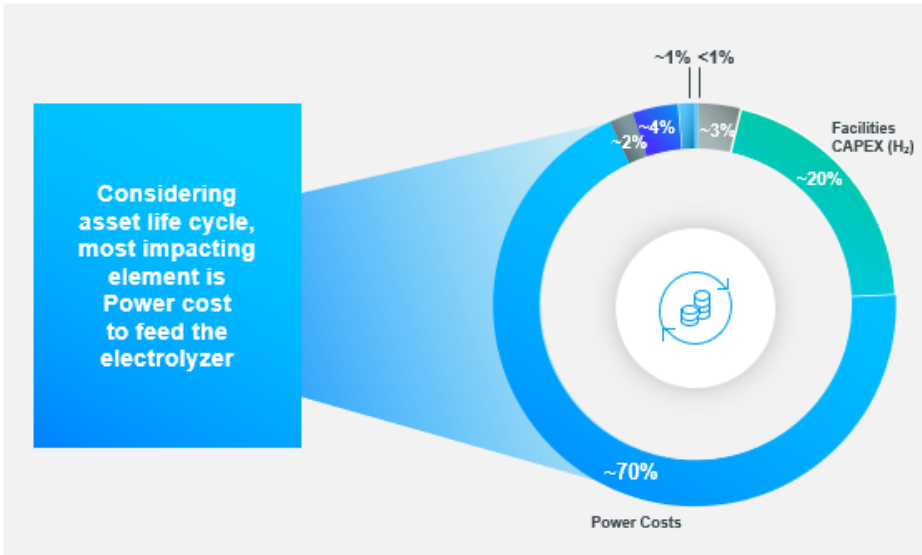
Green electricity required to decarbonize the international maritime sector



Converting all the world's ocean-going vessels to e-methanol would require as much electricity as the entire current production of the United States or 10 times that of France ... with green electricity only

* Source: IEA 2023

The cost of green H₂ remains a big challenge

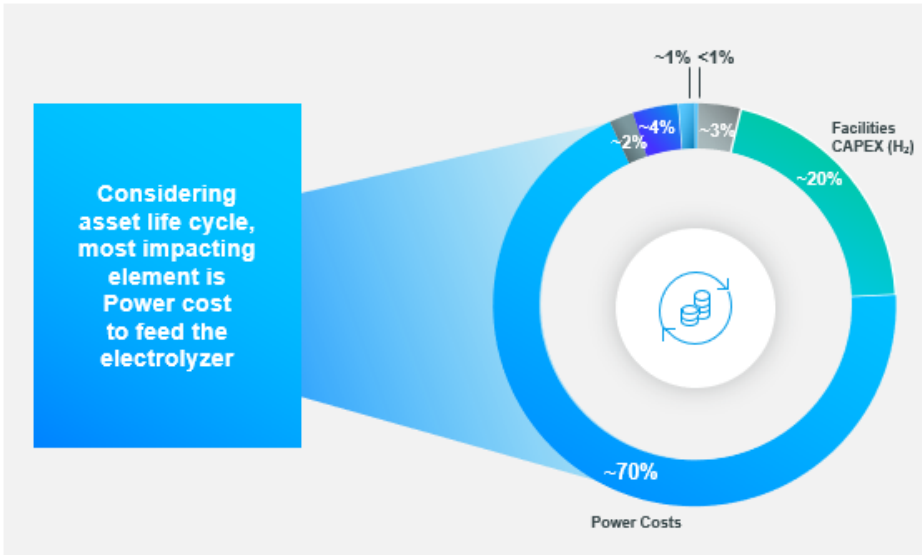


POWER OPEX [€/kgH₂] =
Electricity cost [€/kWh] x Electrolyzer energy efficiency [kWh/kg]

Electrolyzer Energy Eff. = 60 kWh/kg H₂
Electricity price (Europe) = 0.1 €/kWh

} **6€/kg H₂**

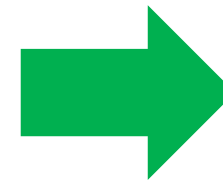
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H₂
 Green
 Hydrogen

8-9 €/kg H₂

H₂
 Grey
 Hydrogen

1,5-2 €/kg H₂



**TotalEnergies
ambition in
Hydrogen**

TotalEnergies' ambition in renewable and low-carbon H₂: to pioneer and become a leader in its mass production






1 Kick-start by addressing our refining demand

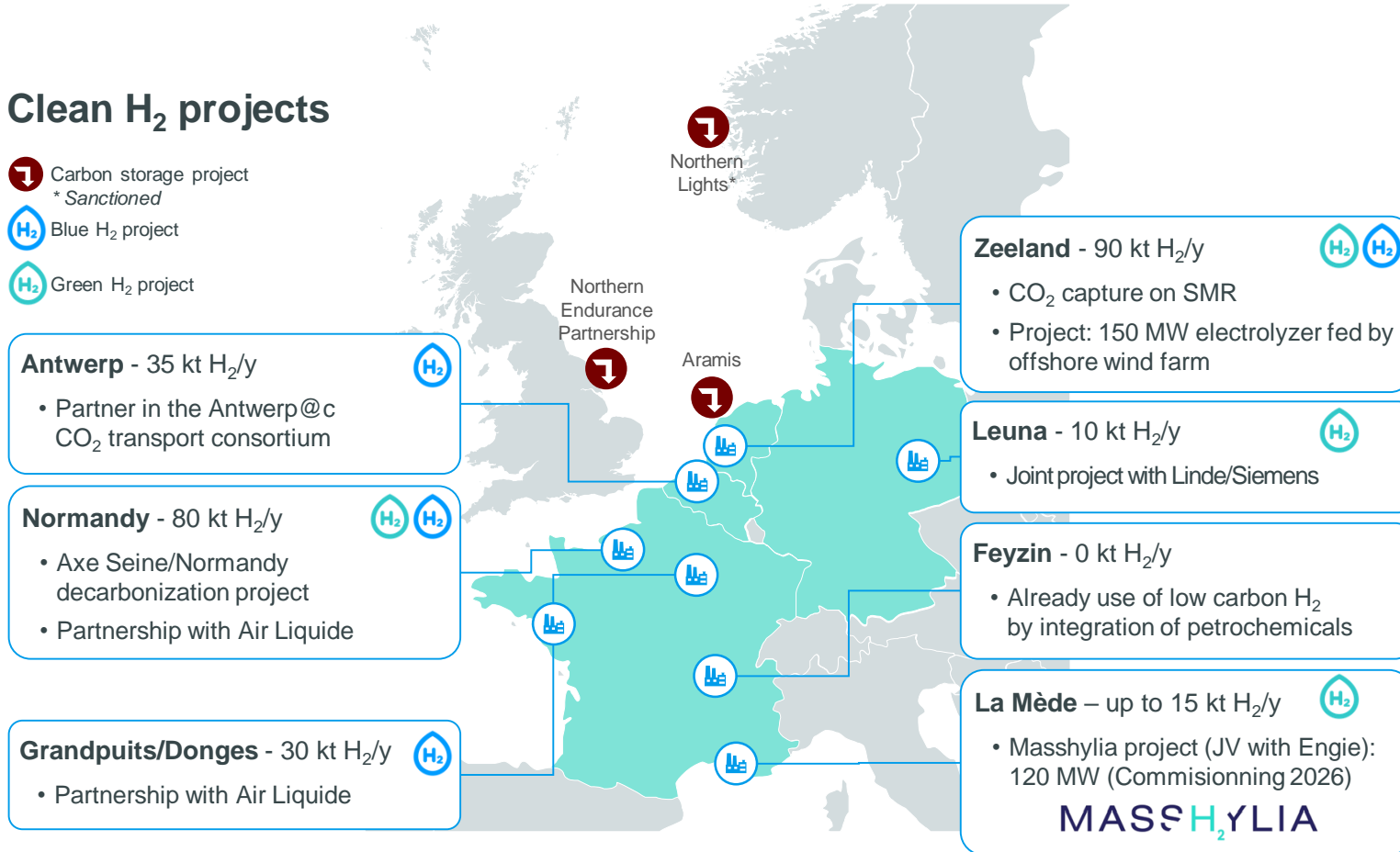
- > La Mède Bio-Refinery: Masshyla (120 MW electrolyser) ; Zeeland Refinery: EnergHys (250+ MW electrolyser)
- > Tendering 500 kt/y of clean H₂ by 2030 for all our European refineries
- > Renewable H₂ on Normandy, Leuna, Grandpuits: projects sanctioned

On the way to decarbonize all grey hydrogen used in our European refineries by 2030



Clean H₂ projects

-  Carbon storage project
* Sanctioned
-  Blue H₂ project
-  Green H₂ project



500 kt H₂/y
grey hydrogen consumption

Targeting overall emissions reduction:

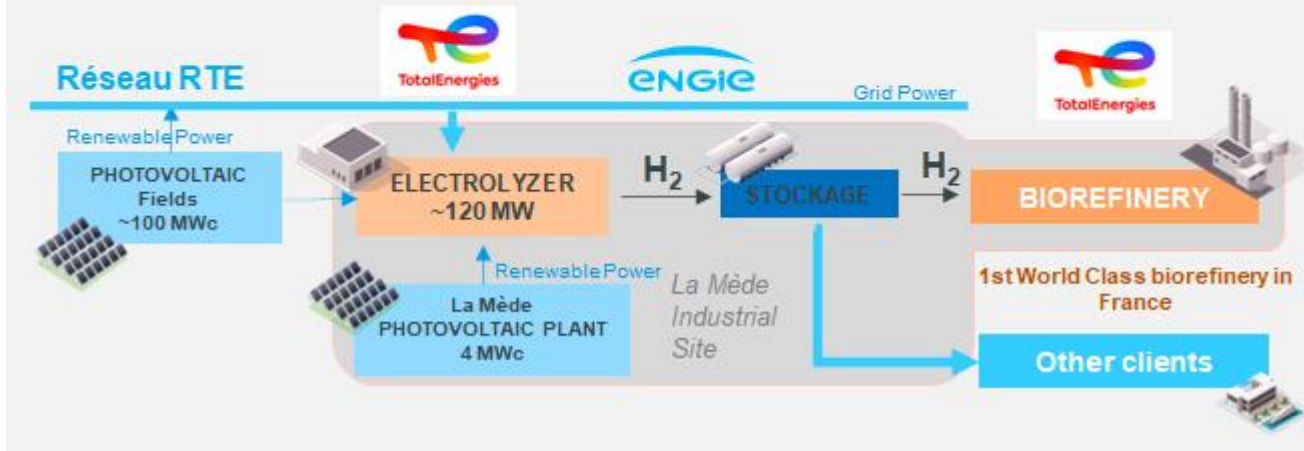
5 MtCO₂/y
by 2030

Benefiting from Green Deal policies and public funding

Masshyla Project – first green H₂ project 120MW - 2026



MASSH₂YLIA



Green H₂: an upside to Renewables investments

La Mède project showcase



TotalEnergies' ambition in renewable and low-carbon H₂: to pioneer and become a leader in its mass production



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2 Develop mass production targeting other end markets

- > Assess large-scale production of low-carbon hydrogen in all geographical areas with cheap renewable power: creation of TEH2
- > Innovate to substitute fossil energy (e-Methane project in United States, assessment of e-SAF opportunities)
- > Position in areas with existing supports to accelerate the scale-up (USA with IRA, Europe)

Massive GW Project – horizon 2030 ex: Magallanes project – TEH2



H2 MAGALLANES KEY FACTS & FIGURES



Up to

10 GW

Wind capacity

8 GW

of Electrolyzers

47,000 GWh

Generated per year

800,000 tonnes of H₂

Produced per year

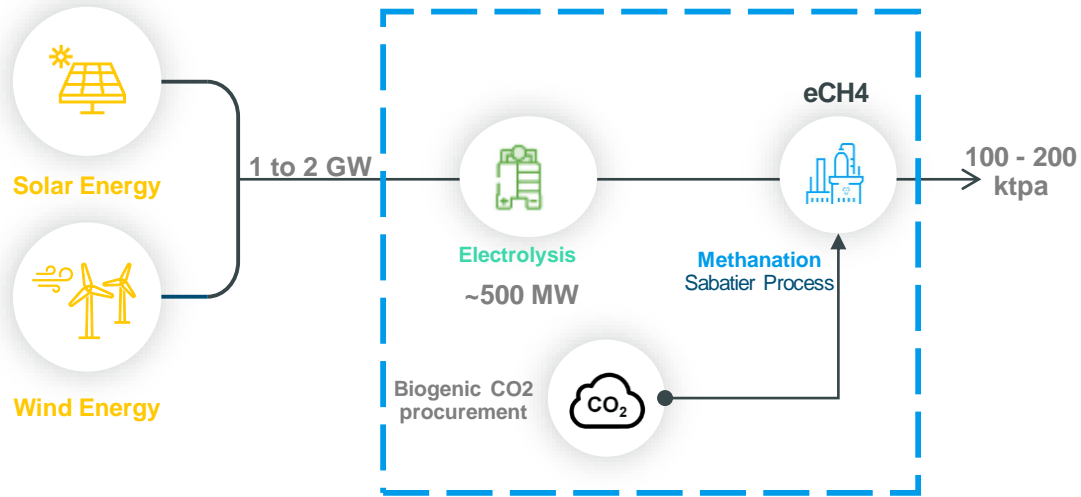
~4.4 million tonnes of NH₃

Exported per year

~ 5 million tonnes of CO₂

Emissions avoided annually

eNG project in US: demonstrating the industrial scale



Our Partner Tree Energy Solution



Founded in 2019, Headquarters Belgium, privately owned

Location targeted in Matagorda county, TX



Benefitting from the proximity to CO2 network, NG pipelines and electrical network

Key Challenges

- Adapt Methanation, (a mature catalyst process used for synthetic methane production from coal gasification / coke oven gas), for the first time at industrial scale with CO2 and green H2 feedstock
- Scale up electrolysis to 500MW using several suppliers

TotalEnergies' ambition in renewable and low-carbon H₂: to pioneer and become a leader in its mass production



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3 Act on hydrogen infrastructure and demand

- > Anchor investor in Hy24: world's largest clean hydrogen infrastructure fund at €2 billion
- > Work with utilities and industrials to decarbonize other hard-to-electrify sectors
- > Decarbonize heavy-duty transport (Joint Venture with Air Liquide), investments in Hyssetco (H₂ taxi fleet), Hyzon (H₂ trucks).

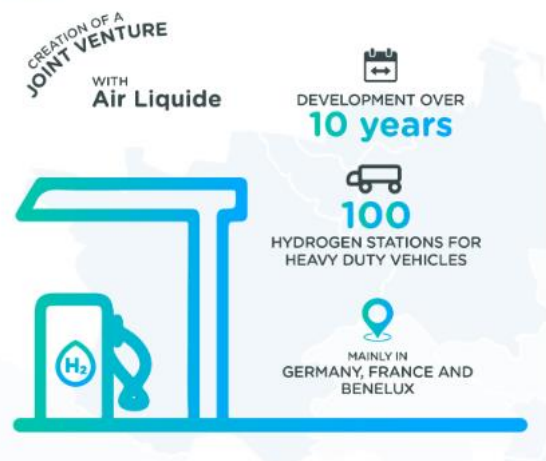
Air Liquide and TotalEnergies join forces to create a European network of hydrogen stations

Together, the partners aim to deploy more than 100 hydrogen stations for heavy-duty vehicles on major European roads in the coming years.

February 2, 2023



Hydrogen (H2)
strong driving force behind the decarbonization of road transport in Europe



The partners aim to deploy more than 100 hydrogen stations on major European roads - in France, Benelux and Germany - in the coming years. These stations, under the TotalEnergies brand, will be located on major strategic corridors.



Thank You



OIL



GAS



ELECTRICITY



HYDROGEN



BIOMASS



WIND



SOLAR

Questions?