Developments of low carbon hydrogen at TotalEnergies
TotalEnergies
The company
Our organisation

- Exploration & Production
- Gas Renewables & Power
- Refining & Chemicals
- Marketing & Services
- OneTech

**H₂ BU**
TotalEnergies in 2050: a vision for a Net Zero company
H2 part of the journey

SALES MIX

<table>
<thead>
<tr>
<th>Year</th>
<th>Biomass, H₂</th>
<th>Natural gas</th>
<th>Petroleum products</th>
<th>Electricity</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>1%</td>
<td>1%</td>
<td>33%</td>
<td>65%</td>
</tr>
<tr>
<td>2020¹</td>
<td>2%</td>
<td>5%</td>
<td>45%</td>
<td>47%</td>
</tr>
<tr>
<td>2021¹</td>
<td>2%</td>
<td>7%</td>
<td>48%</td>
<td>44%</td>
</tr>
<tr>
<td>2030</td>
<td>5%</td>
<td>15%</td>
<td>50%</td>
<td>30%</td>
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Low-Carbon Electricity: Growth and profitability

<table>
<thead>
<tr>
<th>Investment in REN and electricity (in $)</th>
<th>2021</th>
<th>2022</th>
<th>2023</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 3bn</td>
<td>4bn</td>
<td>5bn</td>
<td></td>
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</table>

- 35 GW
- 60% non-operated
- 40% operated

**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 (300 MWp solar)
  - Startup at AGEL in India (≈ 500 MW)
  - Startup of Seagreen in Scotland
  - Various projects in France and China

Al Kharsaah PV plant, 800MW, Qatar
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

* Source: IEA 2023

EXAMPLE OF A LONG CHAIN
Green electricity required to decarbonize the international maritime sector

<table>
<thead>
<tr>
<th>Oil</th>
<th>E-methanol</th>
</tr>
</thead>
<tbody>
<tr>
<td>≈ 5% of global oil demand</td>
<td>≈ 10 times France final electricity consumption</td>
</tr>
</tbody>
</table>

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
The cost of green H$_2$ remains a big challenge

**POWER OPEX** [€/kgH$_2$] = Electricity cost [€/kWh] x Electrolyzer energy efficiency [kWh/kg]

- Electrolyzer Energy Eff. = 60 kWh/kg H$_2$
- Electricity price (Europe) = 0.1 €/kWh

6€/kg H$_2$
The cost of green H₂ remains a big challenge

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\[ 6€/kg H₂ \]

8-9 €/kg H₂ (Green Hydrogen)
1.5-2 €/kg H₂ (Grey Hydrogen)
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: Masshylia (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

500 kt \( \text{H}_2 / \text{y} \)
grey hydrogen consumption

Targeting overall emissions reduction:

5 \( \text{MtCO}_2 / \text{y} \)
by 2030

Benefiting from Green Deal policies and public funding

**Clean \( \text{H}_2 \) projects**

- **Antwerp** - 35 kt \( \text{H}_2 / \text{y} \)
  - Partner in the Antwerp@c \( \text{CO}_2 \) transport consortium

- **Normandy** - 80 kt \( \text{H}_2 / \text{y} \)
  - Axe Seine/Normandy decarbonization project
  - Partnership with Air Liquide

- **Grandpuits/Donges** - 30 kt \( \text{H}_2 / \text{y} \)
  - Partnership with Air Liquide

- **Zeiland** - 90 kt \( \text{H}_2 / \text{y} \)
  - \( \text{CO}_2 \) capture on SMR
  - Project: 150 MW electrolyzer fed by offshore wind farm

- **Leuna** - 10 kt \( \text{H}_2 / \text{y} \)
  - Joint project with Linde/Siemens

- **Feyzin** - 0 kt \( \text{H}_2 / \text{y} \)
  - Already use of low carbon \( \text{H}_2 \)
    by integration of petrochemicals

- **La Mède** – up to 15 kt \( \text{H}_2 / \text{y} \)
  - Masshylia project (JV with Engie):
    120 MW (Commissionning 2026)

**3ème rencontres académie-industrie du CNC_TTE ambition in H2**
07/12/2023
Masshylia Project – first green H₂ project 120MW - 2026

MASSHYLIA

50% ENGIE 50% TotalEnergies

Phase 1: 40 MW
Phase 2: 120 MW

Green H₂: an upside to Renewables investments

La Mède project showcase

Operated Renewable Farms new added capacities

Low cost excess renewable electricity

Electrolyser

Phase 1: 40 MW
Phase 2: 120 MW

Renewable H₂

5 – 15 kt/y

Outlet for La Mède
Renewable Diesel production

H₂ storage

B2B/B2C customers

La Mède BioRefinery
H₂ consumption

1st World Class biorefinery in France
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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

Solar Energy
Wind Energy

1 to 2 GW

Electrolysis
~500 MW

Methanation
Sabatier Process

Biogenic CO2 procurement

CO2

eCH4

100 - 200 ktpa

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 Hysetco (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

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

Questions?