Leveraging technology to accelerate the energy transition

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01. Why do we need disruptive Technologies to support the Energy Transition?

02. What are our capabilities: Technology & Corporate Ventures in Repsol

03. Key examples of disruptive technology developments

- Hydrogen
- Renewable fuels
- Circular chemicals
- Renewable electricity supply 24/7
Why technology?
01. Why do we need disruptive technology developments?

Main challenges to boost the Energy Transition

- Improve economics
  - Extend the limits of what is possible
  - Improve added value of products
  - Minimize energy consumption and GHG footprint
  - Optimize CAPEX holistically along the value chain
- Manage renewable resources (quantity, availability and variability)
- Make sustainable products available to users

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02. What are Repsol capabilities?
Repsol Technology and Corporate Ventures

Our internal R&D

233 Experts
of 17 Nationalities

+64 million euros invested in 2021

Capabilities in multiple fields such as:
- Advanced Mobility
- Bio-Energy and Low Emissions
- Advanced Mathematics
- Geophysics
- Process Design

Repsol Deep Tech Fund

Endowed with 50 million euros for investment in startups

Investment in 20 startups with disruptive Technologies

Open Innovation
Our door is open to innovation in the Energy Sector

9 new patents families registered in 2021
We are focused on working on
70 new Technology Products
We provide more than 180 technology solutions
+200 alliances with partners around the world to transform the energy sector

+50,000 m² dedicated to innovation around the world
+20 Specialized Laboratories and 35 pilot plants
03.
Key examples of disruptive tech developments
Key examples of disruptive technology developments

Hydrogen by photoelectrocatalysis

How is electrolytic hydrogen produced?

Challenges for the current scheme:
• Improving overall efficiency.
• Reducing complexity and CAPEX.
• Leading to a reduction of production cost.

Photoelectrocatalysis

• Combines established high-performance PV cell and alkaline electrolyzer technologies into a single panel.
• Proprietary photoelectrode and PEC cell technology.
• No need for rare or scarce materials.
03. Key examples of disruptive technology developments

**Photoelectrocatalysis. Where are we?**

<table>
<thead>
<tr>
<th>LAB SCALE PROTOTYPE</th>
<th>cm² scale</th>
<th>TRL 1-4</th>
<th>2012 - 2018</th>
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<tbody>
<tr>
<td>REPSOL</td>
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<td>Proof of concept</td>
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<td>Photoelectrochemical cell design and optimization</td>
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<td>Photoelectrode optimization</td>
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<td>Lab scale validation</td>
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<thead>
<tr>
<th>PILOT PLANT</th>
<th>m² scale</th>
<th>TRL 4-6</th>
<th>2019 - 2021</th>
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<tr>
<td>REPSOL</td>
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<tr>
<td>Optimization and fabrication of pilot plant-size photoelectrodes</td>
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<td>Cell design, construction and validation</td>
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<td>Module design</td>
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<tr>
<td>Pilot plant design, construction, commission and start-up</td>
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<td>Cost estimation of base materials for next stages</td>
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| DEMO PLANT | ~1 ha scale | TRL 6-9 | 100kg of H₂ per day | 2021 - 2025 |
|------------|-------------|---------|---------------------|
| REPSOL     |             |         |                     |
| Incorporate learnings from Pilot plant | | | |
| Employ industrial manufacturing process | | | |
| Pre-commercial validation | | | |

**GLOBAL COMMERCIALISATION**

- **2025: MEDIUM SCALE**
  - Commercial roll out
  - Medium size plants

- **2028: LARGE SCALE**
  - Commercial roll out
  - Large size plants 600 ha scale

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- **€4.5M Innovation Funds Small Scale**
  - 2025: MEDIUM SCALE
  - 2028: LARGE SCALE
03. Key examples of disruptive technology developments

Synthetic fuels

Context:

- Demand for renewable liquid drop-in fuels
- Limited biowaste to produce advanced biofuels
- Objectives based on net GHG emissions of marketed fuels

Synfuels through Fischer-Tropsch route

Challenges:

- Scale up RWGS technology.
- Integrate the complete scheme.
- Demonstrate product quality and competitive cost.
- Validate products in real field tests.
03. Key examples of disruptive technology developments

**Synfuels. Where are we?**

- Partnering with Aramco
- Demo plant in Bilbao with 50 bbl/d capacity (2.3 kt/a)
- Basic engineering ongoing with FID in early 2023
- Expected start-up date in 2024
- CAPEX €103M
Key examples of disruptive technology developments

Direct production of circular olefins

Context in plastics:

- Physical recycling of plastics limited by:
  - Stringent requirements on sorting of plastic waste (quality of feedstock)
  - Penalty on quality of final product

- Direct production of ethylene in the gas phase.
- Possibility to use unsorted plastic waste.
- Electrical heating for a fine control of temperature and enabling the decarbonization of energy supply.
- Modular technology adaptable to plastic waste availability.

Need for chemical recycling:

- Gasification well suited for big plants
- Pyrolysis suited for smaller plants, but current technology (low temperature) requires upgrading of pyrolysis oil to feed the cracker

Reduce plastic waste (recycling)
Reduce GHG footprint of plastics
Make recycled plastics affordable

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03. Key examples of disruptive technology developments

**Plastics2Olefins project**

- **Horizon Europe call granted**
- **Core partners** ETIA and Técnicas Reunidas
- **Extended international consortium**
- **Pilot plant** commissioned in 2023 in Tech Lab
- **Demo plant** (8 kt/a) planned for 2027 in one of our petrochemical sites
- **Budget** 33 M€
03. Key examples of disruptive technology developments

Supply of renewable electricity 24/7

Emerging requirements from legislation:

The proposed European delegated regulation for electrolytic hydrogen establishes strict requirements for renewable electricity supply from remote plants:

• Dedicated newly built plants (additionality).
• Electricity generation and electrolyzer+storage in the same bidding zone (with some exceptions).
• Energy balance of production, storage and consumption of electricity in 1 h periods from 2027.

Requirements under revision within the context of the Renewable Energy Directive update.
Boundary conditions of the problem:

- Industrial processes (e.g., RFNBO) need to operate 24/7.
- Wind and solar PV production is not firm and cannot be forecasted with total accuracy.
- To use the electrical grid to exchange electricity, a production-consumption plan must be submitted 24-48 h in advance to identify and eliminate restrictions (bottlenecks).
- To satisfy the 1 h energy balance condition, accurate short-term forecast of electrical production is required accounting for local conditions at the plant (e.g., clouds, gusts of wind).
- Storage of electricity introduces flexibility (buffering) but comes at a high investment cost.
- Excess electrical production can be sold to third parties.
03. Key examples of disruptive technology developments

**H2 Opera project**

- **Internal development** based on modelling and optimization expertise

- **Flexible algorithms** to cover different balance periods (from 3 months to 1 hour)

- **Automated system** designed to maximize economic revenues while ensuring legal and technical requirements

- **Deployment synchronized with electrolyzers commissioning:**
  - MVP by end of 2022
  - Fully operational by end of 2024
  - Optimized in real operation by 2027
The role of technology in Repsol’s approach to Energy Transition

- **Technology is key** to boost the energy transition and reach decarbonization.
- **Repsol is at the forefront of technology** tackling the biggest challenges.
- **Combining internal expertise and partnerships with the best.**
- **Developing world-scale projects** to mature the technology and quickly reach the final user.
- **Maintaining technology neutrality and pursuing different alternatives to minimize risks and adapt to different situations.**
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October 4th, 2022