POWER TO LIQUIDS - PTL

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Key takeaways

POWERPOINT STRUCTURE (x10slides)

x3 slide

1. Context

- Net Zero emission
- What´s PtL
- Why PtL

x5 slide

2. Demonstration plant PtL

- Key Magnitudes
- Process scheme and TRL
- Location

x2 slide

3. Scale Up- Challenges and opportunities

ANNEXES (x1)

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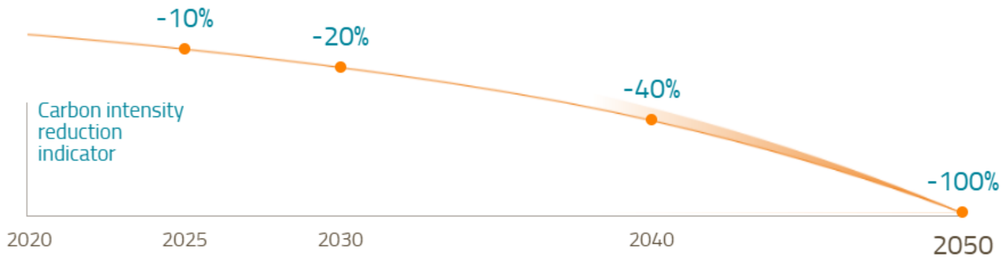
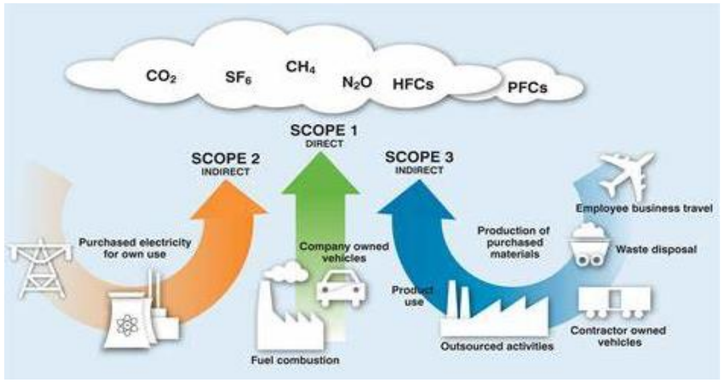
NET ZERO EMISSION

Committed to accessible and affordable low-carbon energy

REPSOL ROADMAP TOWARD NET ZERO EMISSIONS BY 2050…



...NOT ONLY THOSE DERIVED FROM OUR OPERATIONS



TECHNOLOGICAL NEUTRALITY

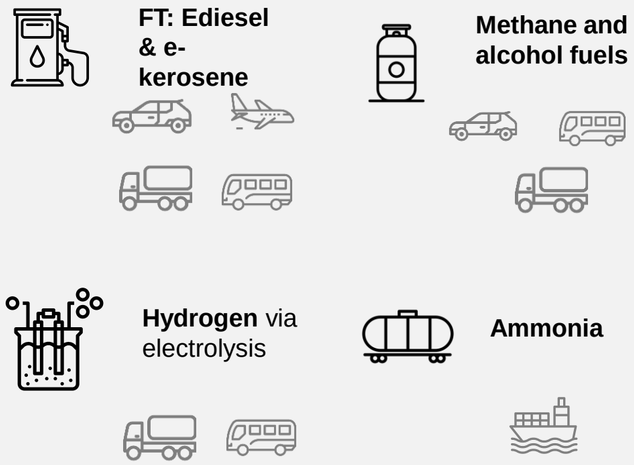
Energy	Source	Technology
Electricity	Renewable electricity	• Solar PV • Wind turbine • Hydro
Advanced biofuels	Waste and residual biomass	• Fermentation (alcohols) • Transesterification of waste lipids (UCOME) • Hydrogenation of waste lipids (HVO, HEFA) • Pyrolysis + upgrading • Hydrothermal liquefaction + upgrading • Gasification + Fischer-Tropsch
Negative footprint biofuels	Waste and residual biomass	• Fermentation with CCUS • Lignocellulosic route with biochar • Lignocellulosic route with CO2 mineralization • Lignocellulosic route with CCS
Recycled carbon fuels	Non biologic residues (NFU, SRF, plastics	• Pyrolysis + upgrading • Hydrothermal liquefaction + upgrading • Gasification + Fischer-Tropsch
PTL	Renewable electricity and CO2	• Fischer Tropsch Route • Methanol route • Methane route
Hydrogen	Renewable enregy	• Electrolysis (alkaline, PEM, SOEC) • Photoelectrocatalysis

WHAT´S PTL?

DRIVERS OF PTL ADOPTION

E-fuels

E-Fuels are synthetic fuels, resulting from the combination of "**renewable or e-hydrogen**" produced by electrolysis of water with renewable electricity and **CO_2 captured** either from concentrated source or from the air (DAC). E-fuels are also referred as power-to liquid (PtL), power-to-X (PtX) or power-to-gas (PtG) and synthetic fuels(1).



FT: Ediesel & e-kerosene

Methane and alcohol fuels

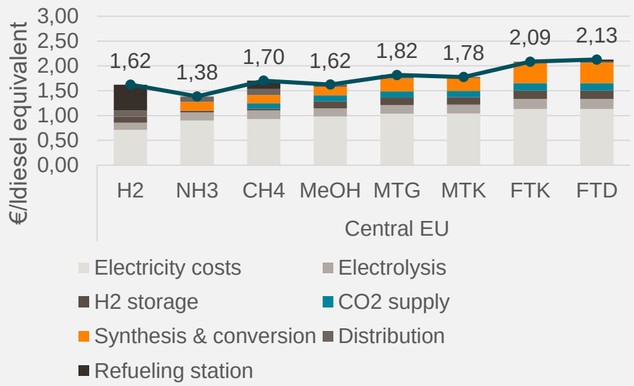
Hydrogen via electrolysis

Ammonia

Cost drivers

Key enablers for a cost-competitive and credible e-fuel are:

- **Price of electricity,**
- **CO2 source,** whether its DAC or from a concentrated source will impact final e-fuel cost.
- **CAPEX** either electrolysis and process unit has an intensive capital requirement



Regulatory action

REDII: Renewable Energy Directive

Legislation currently requires 14% of energy in **transport fuels** to come from **renewable sources** by 2030.

New proposal changes objectives to **13% carbon footprint reduction** and a specific target of 2,6 %e/e for RFNBO.

FuelEU Maritime Initiative

Initiative regulates use of low-carbon fuels in maritime transport, including RFNBO[3].

ReFuelEU: Sustainable Air Transport

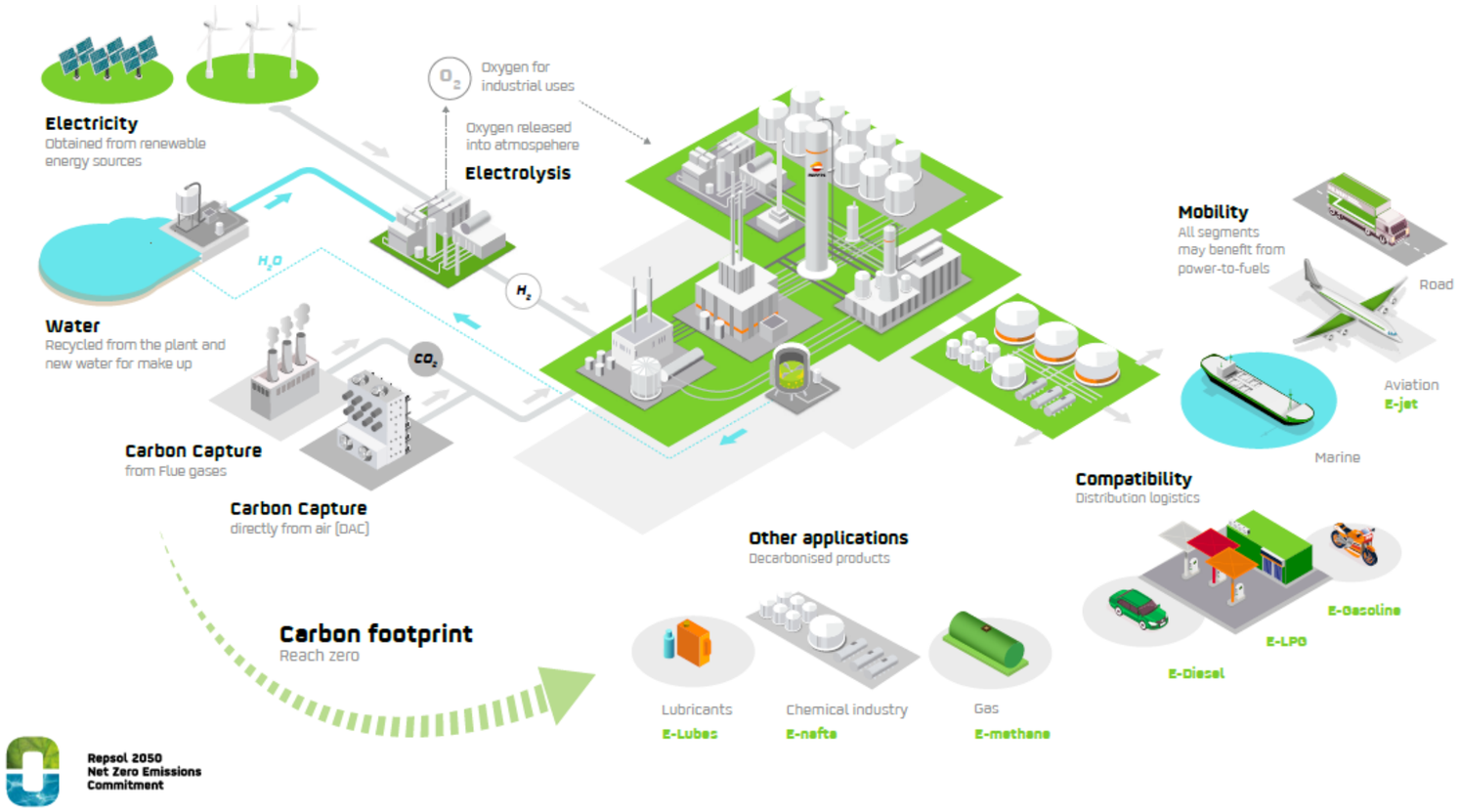
Aircrafts departing from EU must have a **kerosene-SAF blend** from 2025 including 0,7% from 2030 of e-fuel under the ReFuelEU legislation, reaching **63% share of SAF in 2050**[2].

1 A look into role of e-fueks in the transport system in Europe (2030-2050). Concawe Review ; (2) Anticpated ReFuelEu aviation proposal for Fit for 55 climate package

WHY POWER TO FUEL?

DRIVERS OF PTL ADOPTION

1. **Net Zero Emission**
2. **Compatibility with existing infraestructure and fleet**
3. **Serving fuels to wide range of sectors**
4. **Virtually unlimited potential**
5. **Alternatives for non-fuel products (e-chemical, e-lubes)**
6. **Renewable energy vector**



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DEMONSTRATION PLANT PTL

DEMONSTRATION PLANT

Operational date

2024 (Demo)

Project capacity

2,3 kton/y (Demo)

CO_2 abatement

6,9 Kton/y (Demo)

Renewable electricity

10 MW (Demo)

Objective

Development of **first of a kind eFuels plant** using captured CO_2 and green hydrogen.

Key insights

- **Drop-in** fuel that can be blended in existing engines in LDVs, HDVs, airplanes and ships.
- Demonstrate the **whole value chain of producing synthetic fuel** from CO_2 and renewable hydrogen.
- Perform **real fleet test** market/clients/partners.

Project overview

6,9 kt/y of CO2 already captured in Petronor refinery

10MW of renewable energy to produce the renewable hydrogen needed in the process either from a PGP or PPA.

Synthetic fuel plant consisting on RWGS + Fischer Tropsch unit and Upgrading whit capacity to produce **2,3Kt/y** of e-gas, e-gasoline, e-jet and e-diesel.

Flexibility scheme to produce e-lubricants, e-paraffin wax or chemical feedstock.

Partnership

AOC: Technology partner

Operation and refinery integration

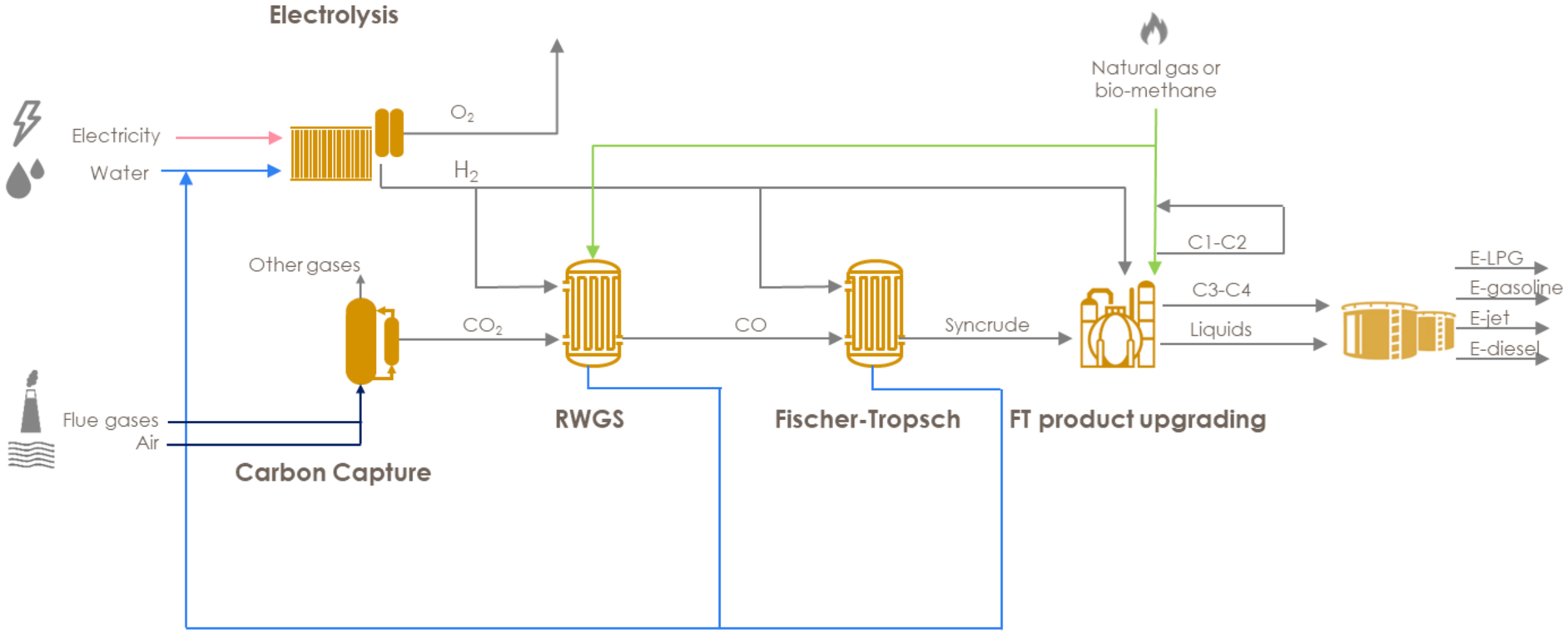
Technology partner

DEMONSTRATION PLANT PTL

SCOPE

Demonstrate **technical and economical feasibility** of synthetic fuel production through Fischer Tropsch pathway, integrating and operating the technologies to produce (**e-Fuels**) from green hydrogen and CO_2 as raw material.

The Demo (**50bbd**) allocated in Bilbao shall allow reduce the risk on future scale up to Industrial unit while producing e-fuel to homologate and perform fleet test in real condition on those transport considered as hard to abate (aviation, HDR, Marine).



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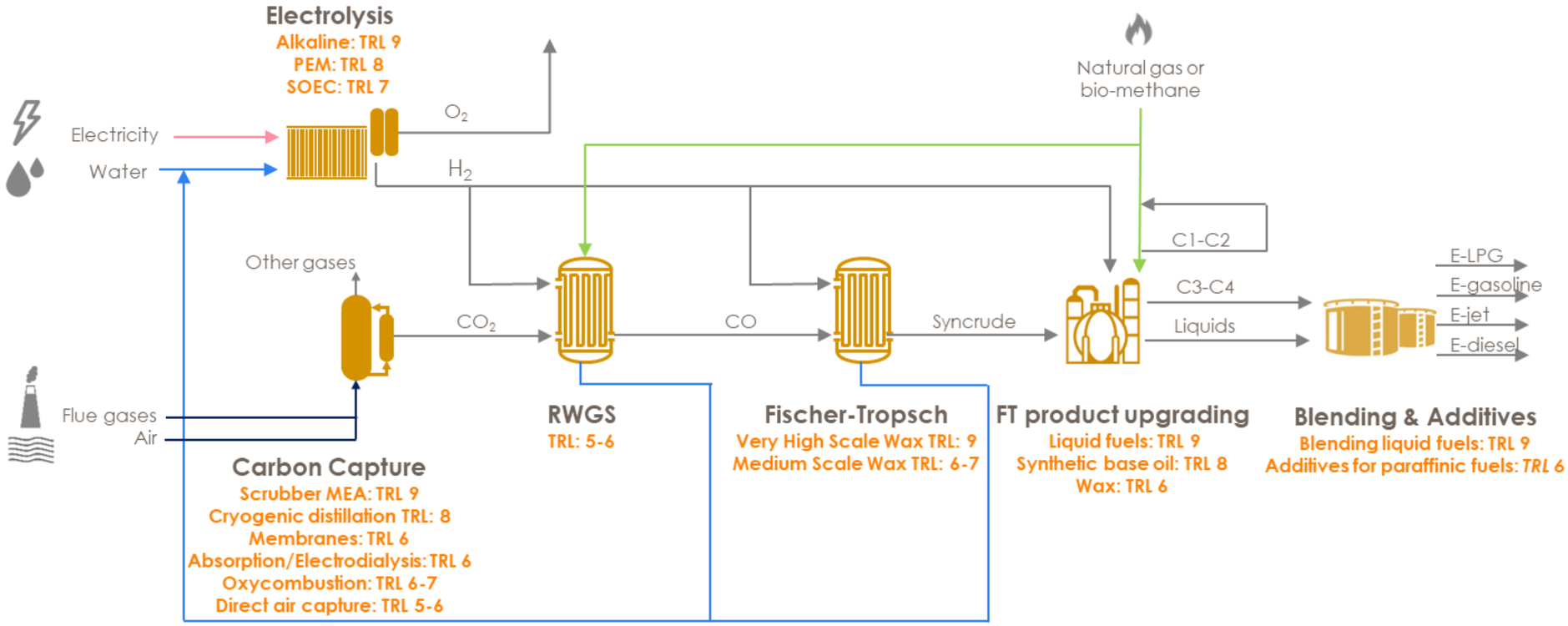
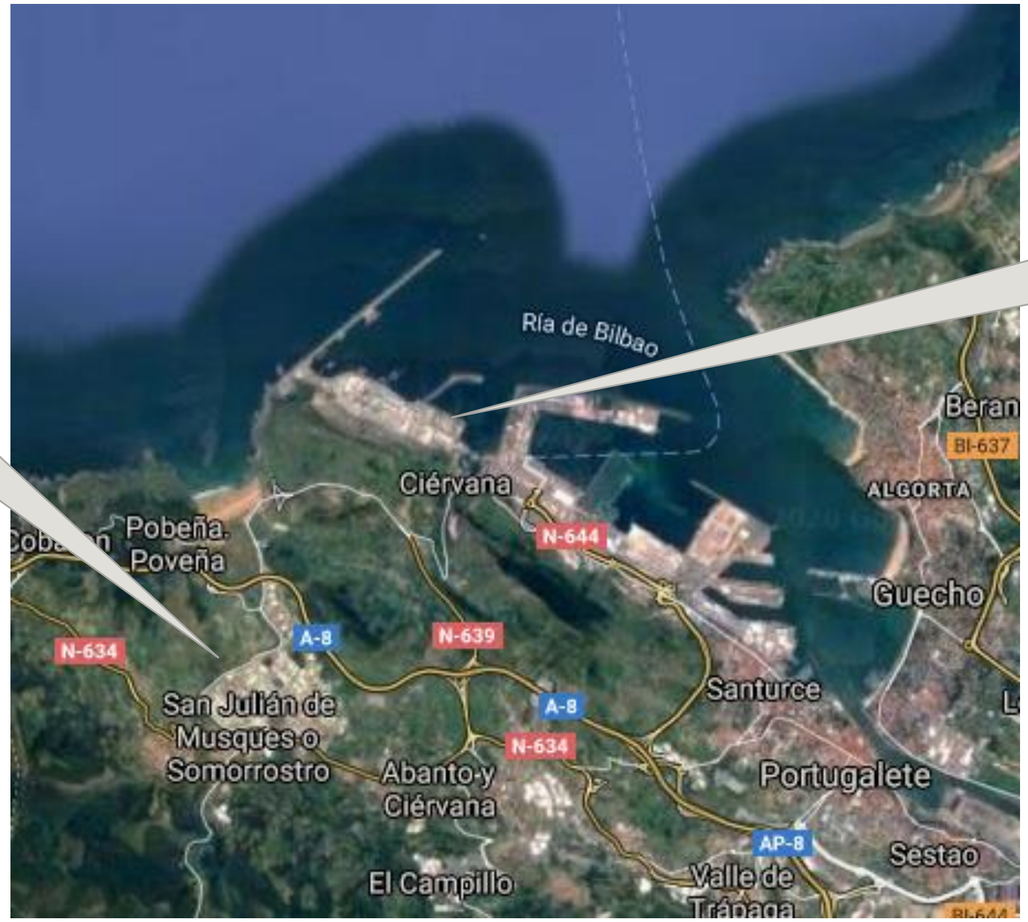


DEMONSTRATION PLANT PTL

LOCATION



Petronor refinery

Demo Plant

The Demo plant is located at Bilbao´s Harbor and interconnected with Petronor Refinery by means of a reverse pipeline to share the following streams:

- **CO_2** from refinery to Demo asset. CO_2 currently captured from SMR
- **Hydrogen** from the Demo asset to Refinery when efuels turndown, catalyst changes. This line is reversible to provide H_2 to the Demo in case of electrolyzer failure or turndown.
- **Off gas & Purges** from Demo plant to valorize as e-fuel in Refinery furnaces.

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SCALE UP

CHALLENGES AND OPPORTUNITTIES

Efuels are expected to play a significand role in decarbonizing the transport sector allowing to accomplish the goals established but is still necessary to face some **challenges to scale up the technology**. On the other hand **new opportunities and synergies** shall arise within industrial clusters.

Business Challenges

- Cost and investment necessary for producing PtL.
- Policy framework
  - Obligation of synthetic fuel in transport sector. Fitfor55
  - CO_2 source origin.
- Integration in current assets

Technology Challenges

- Scale up pilot and demo scale technologies (TRL < 7)
  - RWGS
  - Electrolysis (SOEC)
  - DAC (Direct Air Capture)
  - …
- Validation and integration the whole processes in a economically and steady operation. ***First of a kind***
  - Optimization of operation
  - Integration and energy efficiency

Engineering challenges

- Electrical infrastructure needed 20 GWh/Ktony vs 0,08 Gwh/Ktony c.a conventional fossil fuel.
- Electrical heating and compressors above 15-20MW.
- Utilities consumption
  - CW required 30-45 fold than conventional fossil fuel.
  - Feed water 20 fold than conventional fossil fuel

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Business Opportunities

- ReFuelEU legislation set up a minimum synthetic fuel in blended Kerosene SAF from 2030. Drop in fuel blended with fosil kerosene.
- PtL produce high quality products (low density, paraffinic) which would make more flexible the blending allowing *lower qualities streams* in blending
- Integration in current assets: Potential re-use of processes units, utilities in/out of battery limits if conventional fossil fuel demand decrease
- Social impact: direct and indirect employees could compensate potential decrease of fossil fuel demand.

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