Green Hydrogen - Opportunities in the EU Refining system

ETIP Wind workshop

21st Feb 2019 - Brussels

Alba Soler

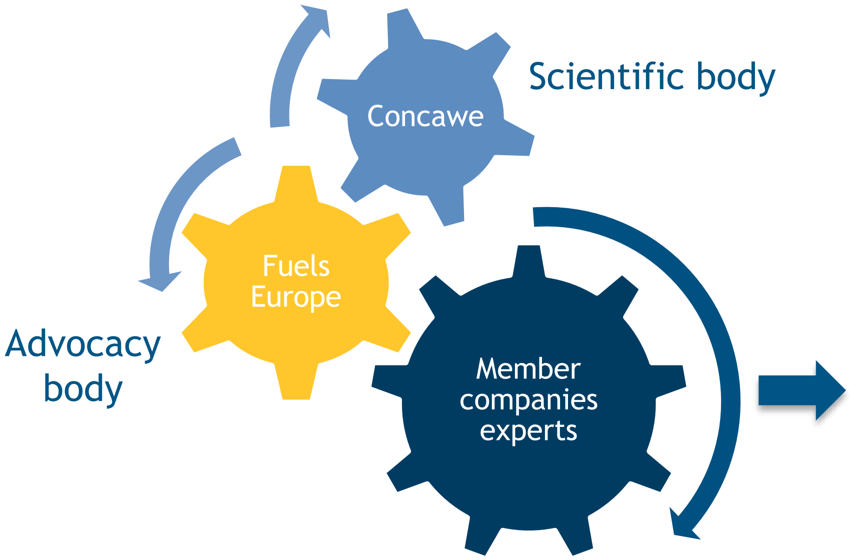
Concawe
Environmental Science for European Refining

Agenda

Concawe - Who we are

Scientific body of the European Petroleum Refiners Association

The Association represents 40 Member Companies ≈ 100% of EU Refining



Role of H_2 in the current EU Refining system

Background

Technologies

H_2 is used in the refining process to:

- remove sulphur of the final products
- maximize the conversion

Currently, at the scale required for a refinery, the most **economic and technically reliable** way of producing hydrogen is via **"SMR" process** (steam methane reforming) using natural gas as feedstock.

CO_2 balance

Overall hydrogen production is highly CO_2-intensive.

Steam methane reforming releases **≈10 tCO_2/tH_2** (half of this being "chemical" CO_2 which cannot be avoided).

H_2 ad-hoc production accounts for **≈15% of the total CO_2 emissions** from EU refining system.

Onsite vs Offsite

Hydrogen is **mostly produced on-site** as part of the refinery.

In recent years, however, **third party operators** have built and operated large hydrogen plants serving refineries.

In such cases the corresponding CO_2 emissions become **"indirect"** as they are actually incurred outside the refinery.

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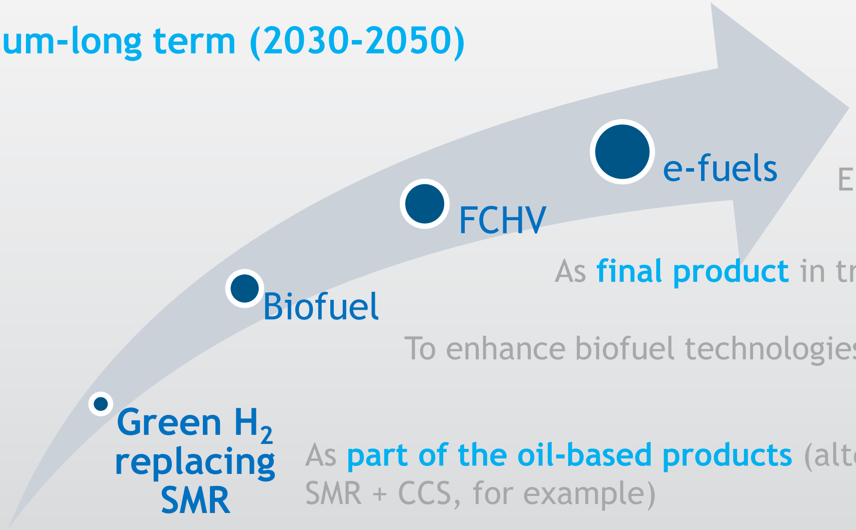
Perspectives across the EU refining system

Green Hydrogen as a pathway to decarbonize the refining industry

Green H_2 is foreseen as one of the **key enablers** of the future low-carbon economy in Europe.

In the EU **refining and transport system**, Green H_2 enables different opportunities:

Medium-long term (2030-2050)



Enabler of Power-to-fuels technologies (**e-fuels**)

As **final product** in transport (FCHV)

To enhance biofuel technologies' carbon efficiency

As **part of the oil-based products** (alternative to other technologies to produce H_2: SMR + CCS, for example)

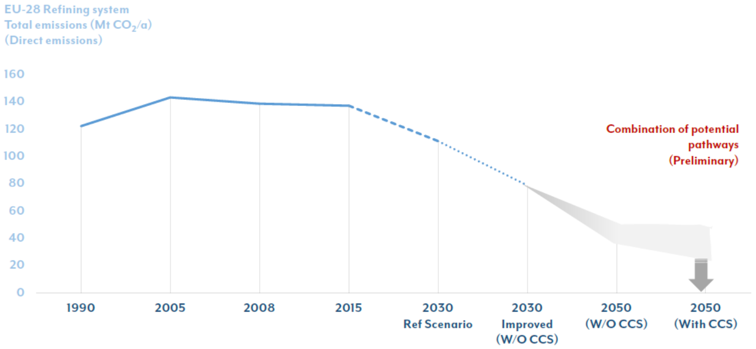
Perspectives across the EU refining system

Other Concawe Low Carbon Pathways

On-going work (preliminary data)

% CO_2 savings, EU refining system		
	2030	2050
Energy efficiency	15%	20%
Use of low-carbon sources	10%	25%
Carbon capture	1-2%	25%
TOTAL	**25%**	**70%**

- **Green hydrogen**
- **Increased use of direct imported low-carbon electricity**
  - Use of electricity for general operations (rotating machines)
  - Substitution of fired heaters by electric heaters
  - Replacement of refinery cogenerations by imported renewable electricity



Potential electricity needs (Refinery 2050):

Potential electricity needs		
	2030	2050
Electricity consumption (GWh/y)	≈30,000	Up to 20/50 times vs 2030

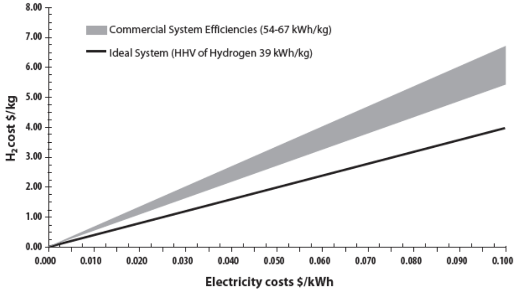
Source: https://www.concawe.eu/wp-content/uploads/EII-data-collection-refining_final.pdf

Challenges / Key enablers

To enhance Green H_2 volumes and economic competitiveness

- Availability of RES and reduction in electricity costs
  - Electricity represents > 80% of the final production cost of the hydrogen.
- Scale-up and reduction in capital costs
  - Today's largest electrolysers are too small
  - Capacity to be scaled up x 10+ to contribute significantly to the refining system
- Efficiency enhancement
  - Improving electrolyser efficiency from 65% to 75% would reduce production costs by ~15%.
- Utilization rate
  - The electricity demand of a "refinery-scale" electrolyser is ~100MWe (significantly above peak output of average onshore wind farm, significantly below peak output of average offshore wind farm)
  - Low utilisation rates of wind farms (24% average onshore and offshore wind in 2018) require energy storage or an alternative source of hydrogen for a continuous use in refineries.
- Policy framework
  - Green H_2 is recognized as renewable under RED II when used as intermediate for the production of conventional fuels but it does not say how to account for them
  - Guarantee of origin mechanism

Figure 1. Hydrogen costs via electrolysis with electricity costs only



Green H_2 demo project

REFHYNE

REFHYNE
CLEAN REFINERY HYDROGEN FOR EUROPE

Launch of Refhyne, world's largest electrolysis plant in Rhineland refinery

on JANUARY 18, 2018

- ❑ Electrolyser capacity of 10 MW (1,300t H_2/year)
- ❑ H_2 used at Shell's Rheinland refinery in Germany
- ❑ First polymer electrolyte membrane (PEM) technology on a large industrial scale
- ❑ Will be built by Shell and ITM power
- ❑ Scheduled to be in operation in 2020

FUNDED PROJECT

FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

- ❑ Project's total investment (including integration into the refinery): ≈20 million euros
- ❑ 10 million euros of European funding from the FCH JU

[…] "We are proud to see the scaling-up of PEM electrolysers to 10 MW to decarbonise the industry sector". FCH JU Executive Director

Source: https://refhyne.eu/news-item-heading/

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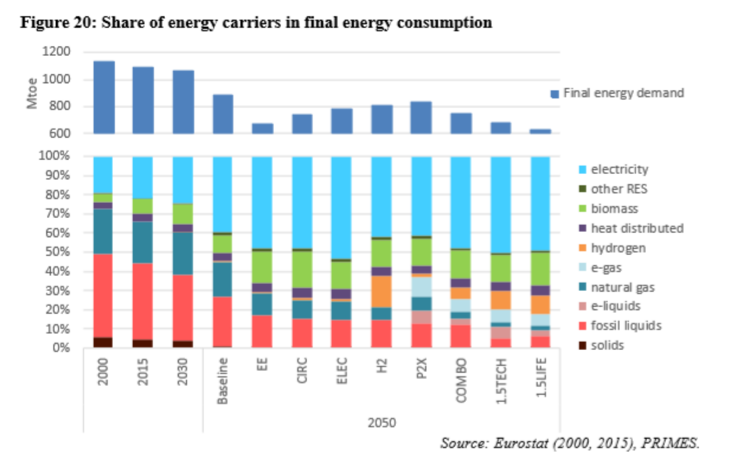
Key messages

1. We need multiple solutions being developed and playing their role…

A Clean Planet for all - DG Clima (2018)

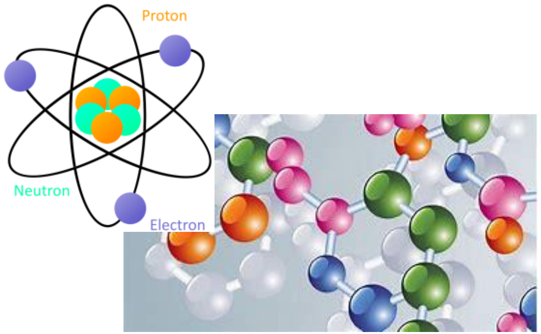


- Electricity becomes the dominant energy carrier in all pathways
- E-fuels, biomass and fossil fuels also play a role: used mainly in aviation and shipping sectors where no electricity-based alternatives can be easily found

Key messages

1. We need multiple solutions being developed and playing their role…

2. We are also part of the solution



Role of the low-carbon fuels:
Molecules have significantly higher energy density than electrons
and they are
easy to store!

Key messages

1. We need multiple solutions being developed and playing their role

2. We are also part of the solution

3. We need the collaboration of the power sector

The journey has already started…………….

Key messages

Vision 2050 and Low Carbon Pathways programme

FuelsEurope

https://www.youtube.com/watch?v=OtKcTs_A1cw

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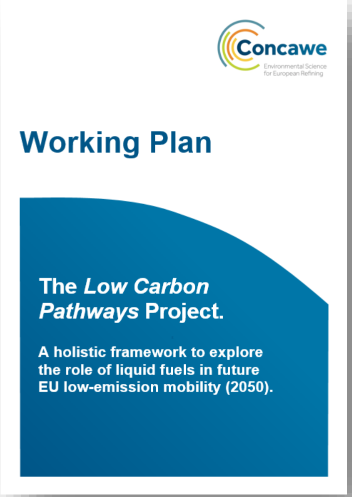

The Low Carbon Pathways Project. A holistic framework to explore the role of liquid fuels in future EU low-emission mobility (2050).

Low Carbon Pathways CO2 efficiency in the EU Refining System. 2030 / 2050 – Executive Summary (Interim report)

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for European Refining

www.concawe.eu

Thank you for your attention

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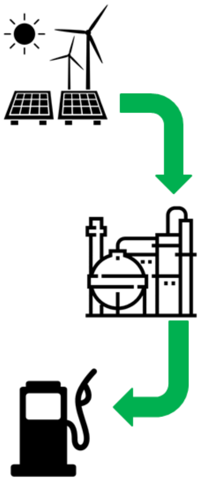
Perspectives across the EU refining system

E-fuels

Power-to-Liquids, Power-to-Industry (as final products)

e-fuels



From renewable energy to Liquid fuels

- Exploring synergies between renewable electricity (RES) and transport. For example:

CO2 **(from air or other sources)**
Electricity **(Renewable)**
Water

↓

Water electrolysis → Green H2 into refining process (Transporting renewable electricity in the form of liquid fuels)

↓ (Green) **H2**, O2

Methanol
Fischer-Tropsch

Different pathways

↓

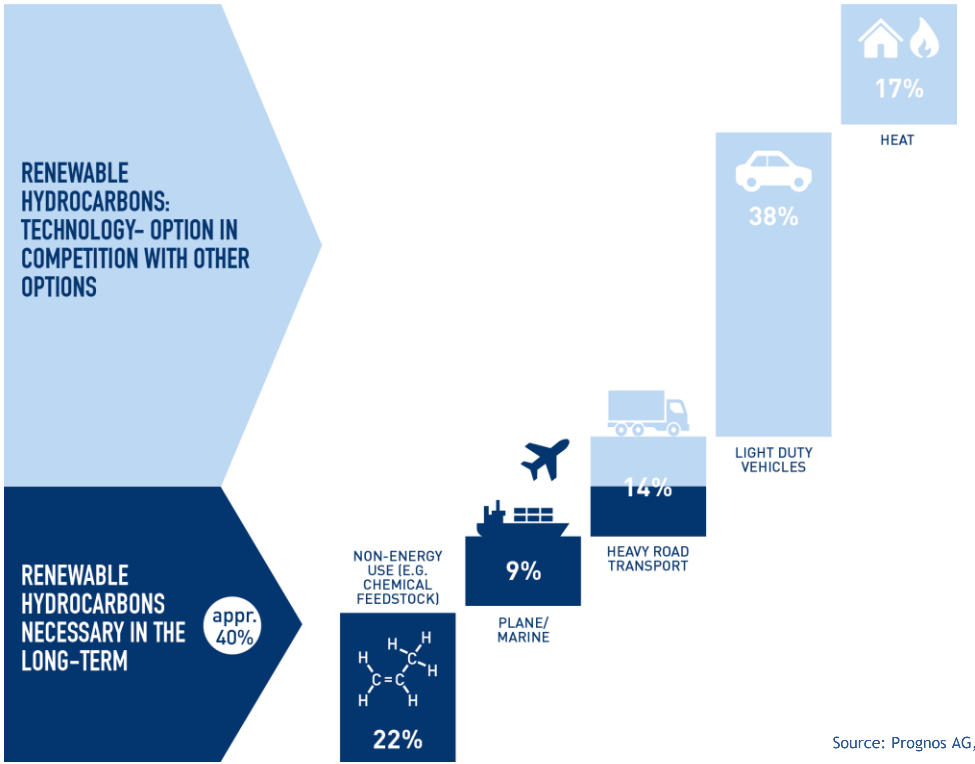
Liquid fuels (e-fuels)

Low-carbon liquid fuels and products

65%
Mobility

25%
Other products

10%
Petrochemical feedstocks



Source: Prognos AG, Berlin

Energy storage - Limitations of batteries

A look into transport modes: Aviation

Boeing 787

230 tons at take-off

Jet fuel

JET FUEL

100 tons[1]

Electric battery

2000 tons[1]

(1) http://www.latimes.com/business/la-fi-electric-aircraft-20160830-snap-story.html