Green Hydrogen - Opportunities in the EU Refining system

ETIP Wind workshop
21st Feb 2019 - Brussels

Alba Soler
Agenda

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02  Role of H₂ in the current EU refining system

03  Perspectives of Green H₂ across the whole EU Refining system

04  Challenges / Key enablers to enhance Green H₂

05  Green H₂ demo plant

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Concawe - Who we are

Scientific body of the European Petroleum Refiners Association

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

Scientific body

Advocacy body

Member companies experts

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https://www.concawe.eu/
Role of H$_2$ in the current EU Refining system

Background

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.

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.

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.
Perspectives across the EU refining system

Green Hydrogen as a pathway to decarbonize the refining industry

Green $\text{H}_2$ is foreseen as one of the key enablers of the future low-carbon economy in Europe. In the EU refining and transport system, Green $\text{H}_2$ enables different opportunities:

- As part of the oil-based products (alternative to other technologies to produce $\text{H}_2$: SMR + CCS, for example)
- To enhance biofuel technologies’ carbon efficiency
- As final product in transport (FCHV)
- Enabler of Power-to-fuels technologies (e-fuels)

Medium-long term (2030-2050)

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Perspectives across the EU refining system

Other Concawe Low Carbon Pathways

<table>
<thead>
<tr>
<th>% CO₂ savings, EU refining system</th>
<th>2030</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy efficiency</td>
<td>15%</td>
<td>20%</td>
</tr>
<tr>
<td>Use of low-carbon sources</td>
<td>10%</td>
<td>25%</td>
</tr>
<tr>
<td>Carbon capture</td>
<td>1-2%</td>
<td>25%</td>
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<tr>
<td>TOTAL</td>
<td>25%</td>
<td>70%</td>
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On-going work (preliminary data)

- 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):

<table>
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<tr>
<th>Potential electricity needs</th>
<th>2030</th>
<th>2050</th>
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<tbody>
<tr>
<td>Electricity consumption (GWh/y)</td>
<td>≈30,000</td>
<td>Up to 20/50 times vs 2030</td>
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Challenges / Key enablers

To enhance Green H₂ 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 H₂ 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
Green H₂ demo project

REFHYNE

Launch of Refhyne, world’s largest electrolysis plant in Rhineland refinery on JANUARY 18, 2018

- Electrolyser capacity of 10 MW (1,300t H₂/year)
- H₂ 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

- 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/
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

Concawe

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

Concawe

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

**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

  1. **Water electrolysis**
  2. **Methanol Fischer-Tropsch**

  Different pathways

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

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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: 100 tons
- Electric battery: 2000 tons