Views from Industry: Oil Refineries towards 2050

Workshop on Hydrogen Production with CCS

6th November 2019

Damien Valdenaire, Science Executive, Refining Technologies
Concawe Association
Concawe - Science for European Refining

Concawe Membership

Concawe represents 40 Member Companies ≈ 100% of EU Refining
Open to companies owning refining capacity in the EU

Concawe mission

To conduct research to provide impartial scientific information regarding:

- scientific understanding
- feasible and cost effective policies and legislation
- legislative compliance
2 Energy demand & refinery 2050
Decoupling economic growth from other key parameters

**DNV GL ENERGY TRANSITION OUTLOOK 2019**

Units: Percentages of 2017 levels

Economic activity (GDP) will continue to grow rapidly compared with population growth, which will rise relatively slowly. Energy use (primary energy supply) will first increase, and then essentially flatten out; meanwhile, energy-related CO₂ emissions will almost halve by 2050.

EU related CO2 energy by sector

DNV GL ENERGY TRANSITION OUTLOOK 2019

Units: GtCO₂/yr

- Transport
- Buildings
- Manufacturing
- Energy sector own use
- Natural gas processing
- Other

© Concaew 8
Peak oil demand: range from ~2022 to ~2040 ...

No imminent peak in global oil demand

Although slowing down, oil consumption continues to rise with petrochemicals, SUVs, aviation and trucks taking the lead, while oil demand for traditional cars is tailing off.

Oil demand under low-carbon scenario

Source: Wood Mackenzie

World primary fossil fuel supply by source

Oil takes over as the largest energy source in 2026 and has a relatively flat development thereafter. The use of oil and coal is relatively flat towards 2030, after which both sources decline significantly.
Low-carbon liquid fuels and products

RENEWABLE HYDROCARBONS: TECHNOLOGY- OPTION IN COMPETITION WITH OTHER OPTIONS

RENEWABLE HYDROCARBONS NECESSARY IN THE LONG-TERM

© Concaew

Source: Prognos AG, Berlin
Vision 2050: The refinery as an ENERGY HUB...

... within an INDUSTRIAL CLUSTER,

Reducing emissions within the site + the final use of our products
Potential CO₂ savings range from 50 to 90% vs 1990 and 85% vs 2030 improved scenario (~70% Optimized oil-based cases). Pathways enabling negative emissions through Biomass + CCS.

Total electricity consumption from 150 to 550 TWh/y in 2050 multiplied by 5-18 times vs 2030 improved scenario.

Total Hydrogen consumption (from 7 to 15 Mtoe/y) multiplied by 2-5 times vs 2030 improved scenario.

Estimated CAPEX could range between 1 - 10 G€ for the limited penetration cases and between 6 - 15 G€ for the extreme cases.

EU-wide scale

Project: “Hydrogen for Europe”

Pre-study results
Hydrogen production pathways from renewable sources and natural gas

The full pre-study report can be accessed here: https://www.sintef.no/Hydrogen4Europe
Comparison of the CO2 intensities of hydrogen production using electrolysers and grid electricity (blue bars) and natural gas with carbon capture (pink bars). The pie charts illustrate the desired electricity mix according to the REmap case for 2030 and the decarbonised scenarios from "A Clean Planet for all" for 2050.
A scenario for future production of hydrogen from natural gas, electricity from renewables and biomass
4 Takeaways
The conceptual assessments ...

- Refinery 2050:
  - low-GHG intensive hydrocarbons
  - New opportunities for new business models

- Capture costs for dedicated streams (ex SMR for example) expected to drop well below $100/tCO₂ avoided

- As for other Energy Intensive Industries, the paths towards 2050 require carbon Capture
  - As shown in EU Commission report “A clean planet for All”, every scenario includes CO₂ captured

Next step = « blue H2 study »
Liquid fuels deliver happiness everyday...

...and they can be low-carbon

FuelsEurope

#Vision2050
#Going4LowCarbonLiquidFuels
Oil refining: operating principle

InTake

Crude oil
North Sea, Russian, Middle East, West Africa, etc.

Feedstocks
VGO, ATRES

Miscel. Feedstocks
Biofuels, etc.

Costs
Energy, chemicals, steam, etc.

Petroleum products

Propane
Butane

LPG

Gasoline

Kerozene

JET

Diesel
Heating oils, MGO

Middle Distillates

Heavy Fuels

High Sulphur
Low Sulphur
(Marine fuels &/or Inland)

Bitumen, Lub. Oils

UNL95, RON 98
Naphta Petro
Crude oil refining

1. **DISTILLATION**
   - Crude Oil (LS & HS)
   - Condensate

2. **CONVERSION**
   - FCC
   - Hydrocraking
   - Coking
   - Visbreacking
   - Light products
   - Heavy feed

3. **IMPROVEMENT**
   - Reforming
   - Hydrotreating
   - Alkylation
   - Isomerisation
   - Quality

4. **BLENDING**

September 2019, Rotterdam, Damien Valdenaire
Refinery yields in different European Base Case configuration

**AMEC FOSTERWHEELER**: ReCAP Project, Evaluating the Cost of Retrofitting CO2 Capture in an Integrated Oil Refinery, September 2017

- **BC1** = Hydroskimming (simple)
- **BC2** = Medium complexity
- **BC3** = Highly Complex (220kbb/d)
- **BC4** = Highly Complex (350kbb/d)
« A clean Planet for All »

CO2 captured is present in every scenario

Figure 89: CO2 capture and storage or reuse (2050)