

Decarbonizing EII: Opportunities in the refining sector

CCUS and EII Workshop

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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**



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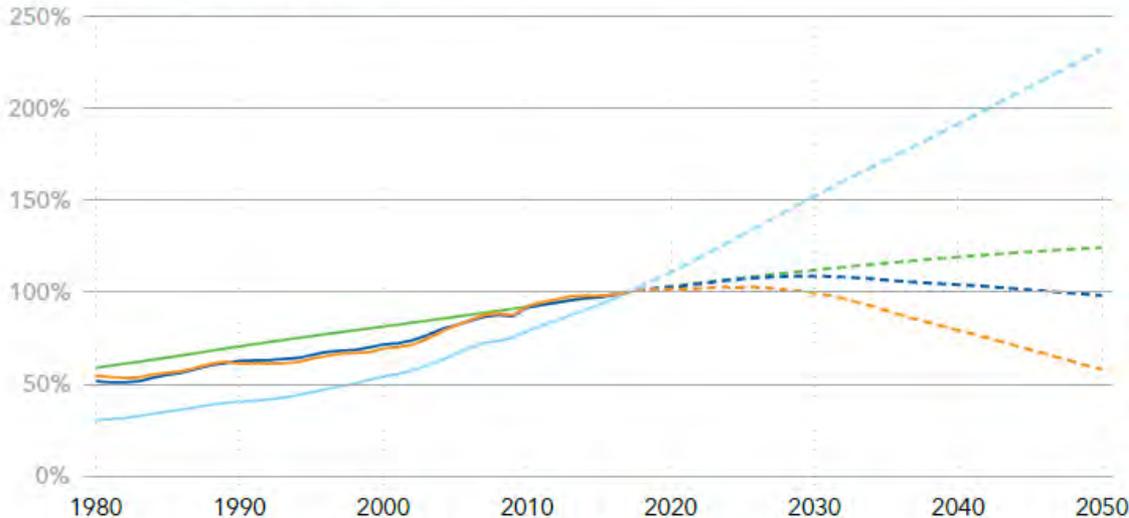
Energy demand & refinery 2050



Decoupling economic growth from other key parameters

DNV GL ENERGY TRANSITION OUTLOOK 2019

Units: Percentages of 2017 levels



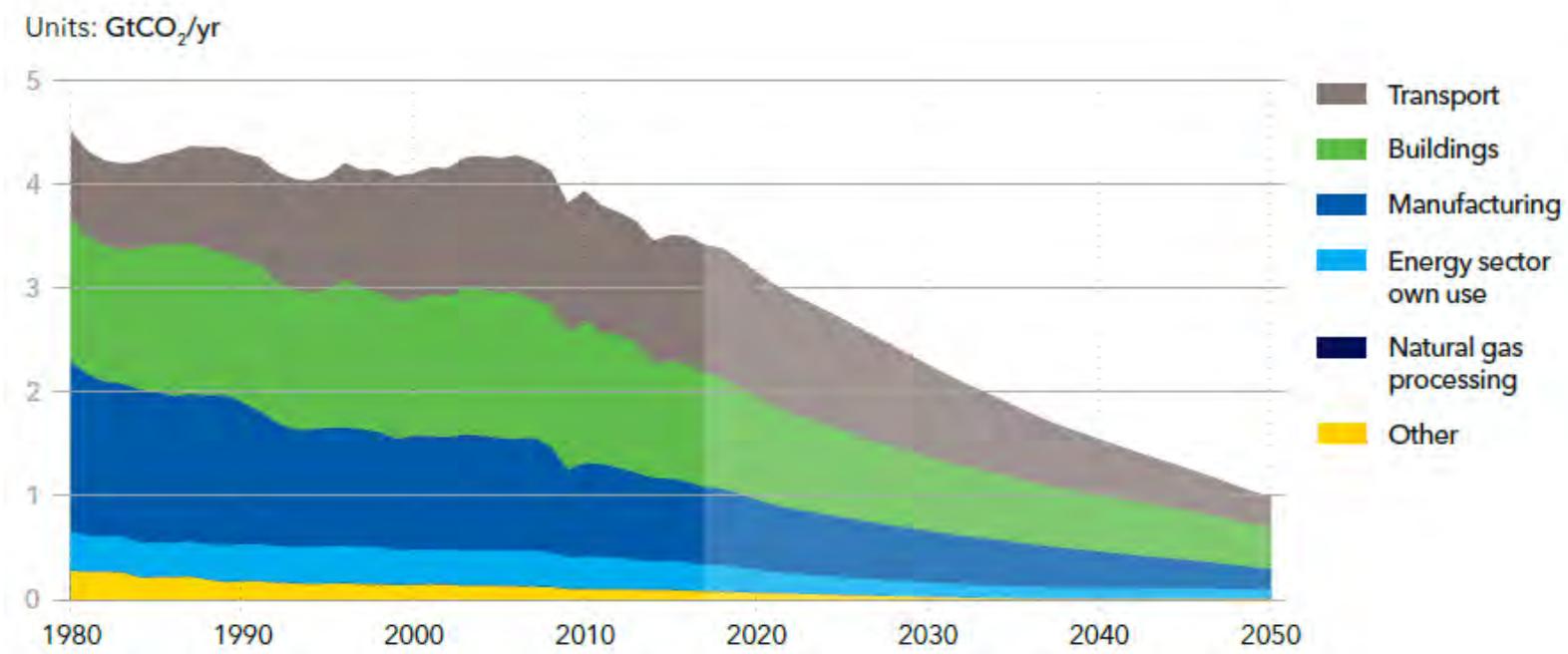
Historical data source: UN (2017), World Bank (2018), Gapminder (2018), IEA WEB (2018)

- GDP
- Population
- Primary energy supply
- Energy-related CO₂ emissions

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

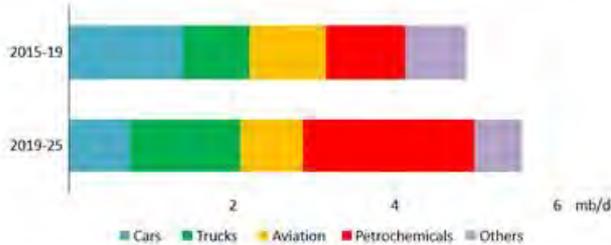
DNV GL ENERGY TRANSITION OUTLOOK 2019



Peak oil demand: range from ~2022 to ~2040 ...

No imminent peak in global oil demand

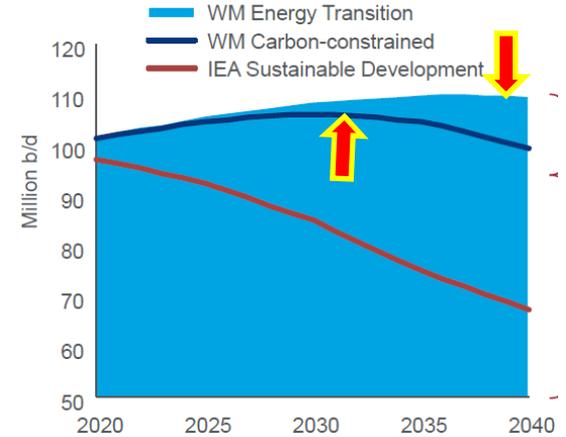
Growth in oil demand by sector



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

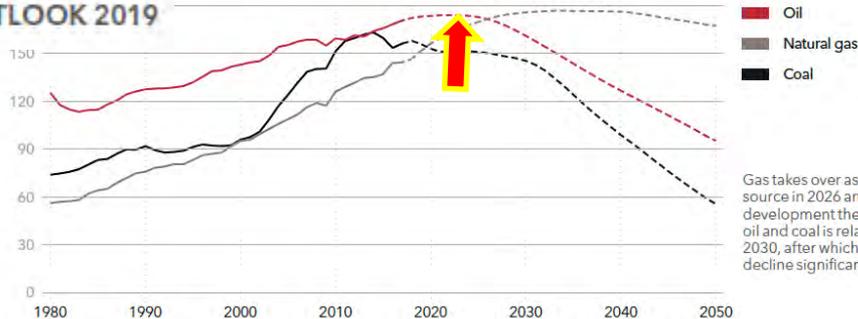


Source: Wood Mackenzie

World primary fossil fuel supply by source

Units: EJ/yr

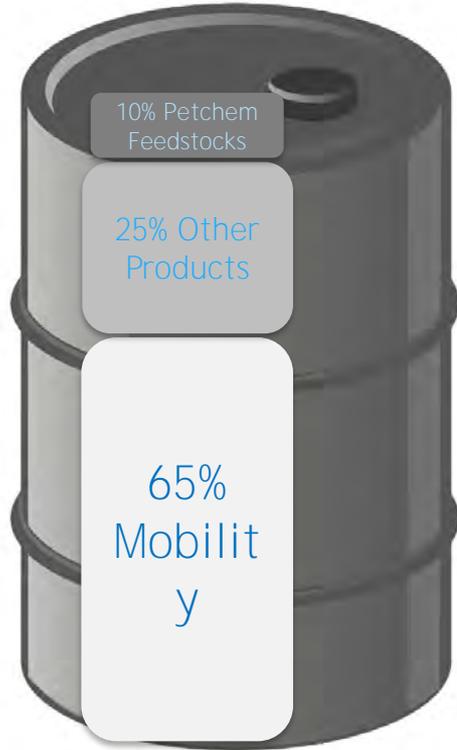
DNV GL ENERGY TRANSITION OUTLOOK 2019



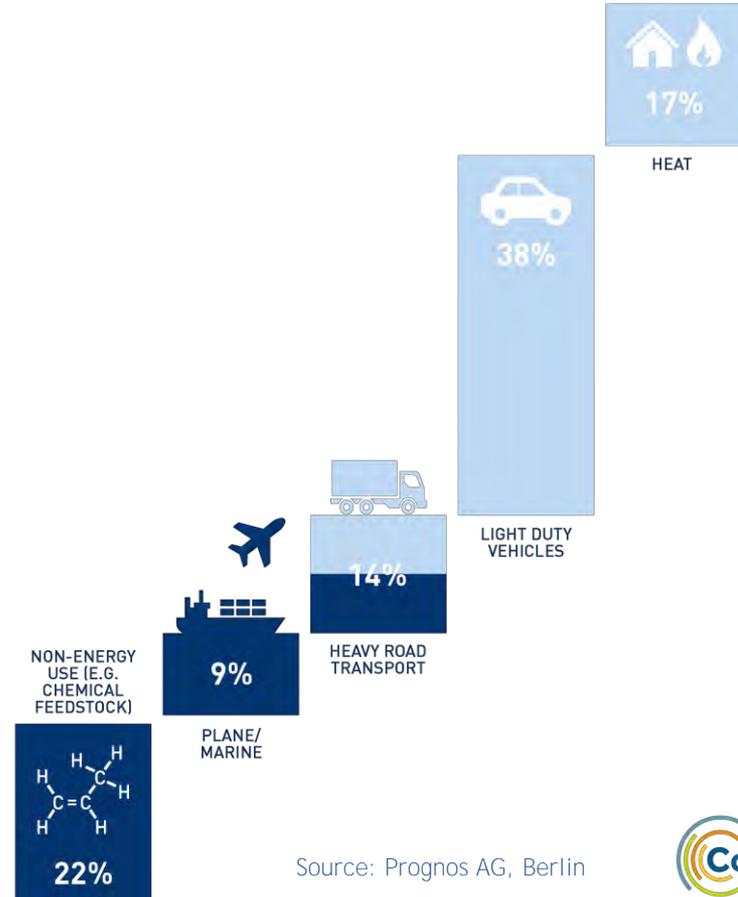
Gas takes over as the largest energy source in 2026 and has a relatively flat development thereafter. The use of oil and coal is relatively flat towards 2030, after which both sources decline significantly.

Low-carbon liquid fuels and products

EU refining system

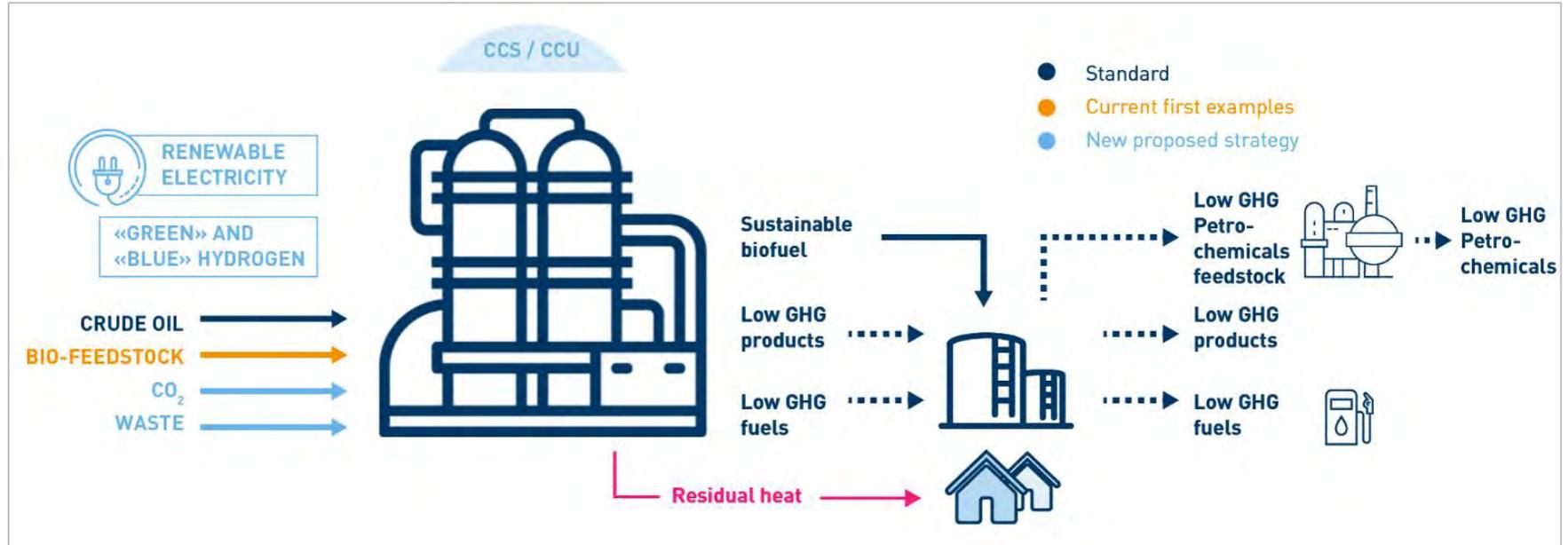


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Vision 2050: The refinery as an ENERGY HUB...

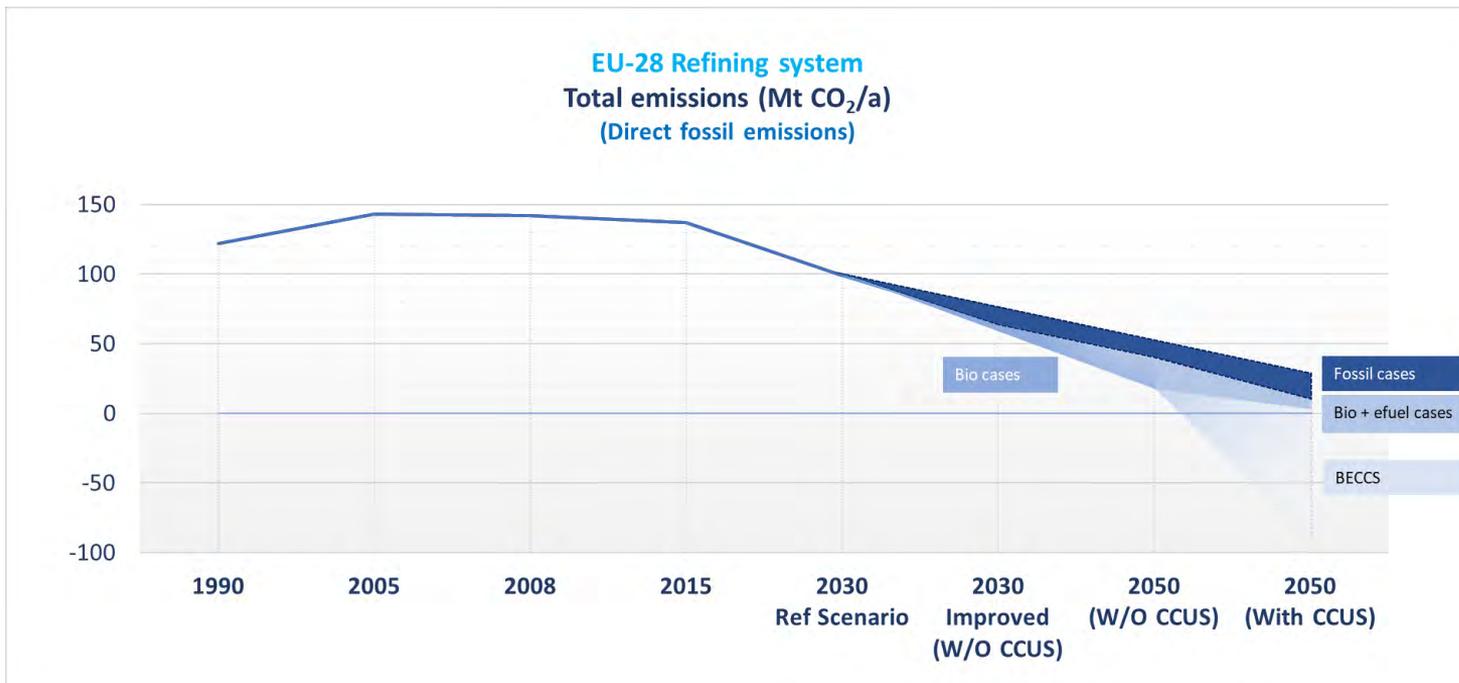
... within an INDUSTRIAL CLUSTER,



Reducing emissions within the site + the final use of our products

Refinery 2050

EU-wide scale



- 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 € for the limited penetration cases, and between 6 - 15 € for the extreme cases.

<https://www.concawe.eu/publication/refinery-2050-conceptual-assessment-exploring-opportunities-and-challenges-for-the-eu-refining-industry-to-transition-towards-a-low-co2-intensive-economy/>



3

Retrofitting CO₂ Capture in an integrated oil refinery



Project participants (report issued in 2017)



Energy Research – Project Owner



Sub-Contractor

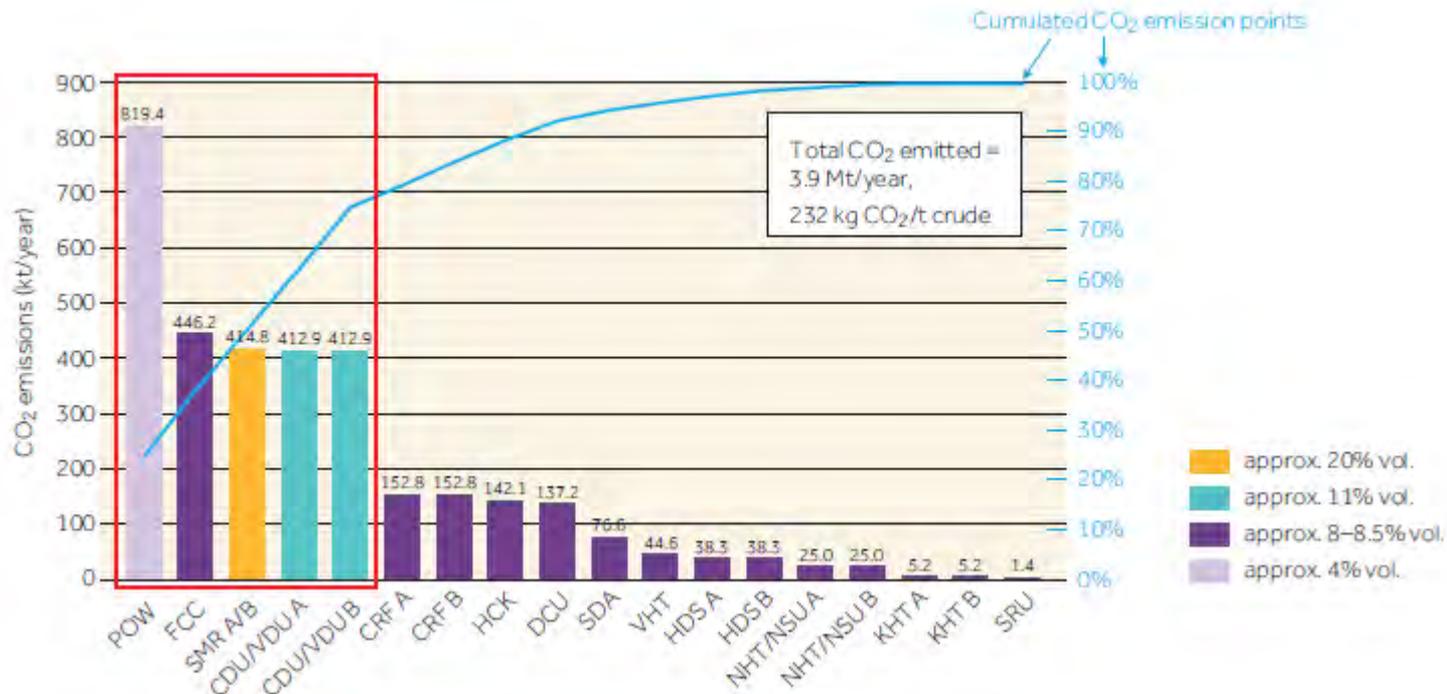


Main Funding body



Connected to the
Research Council
of Norway

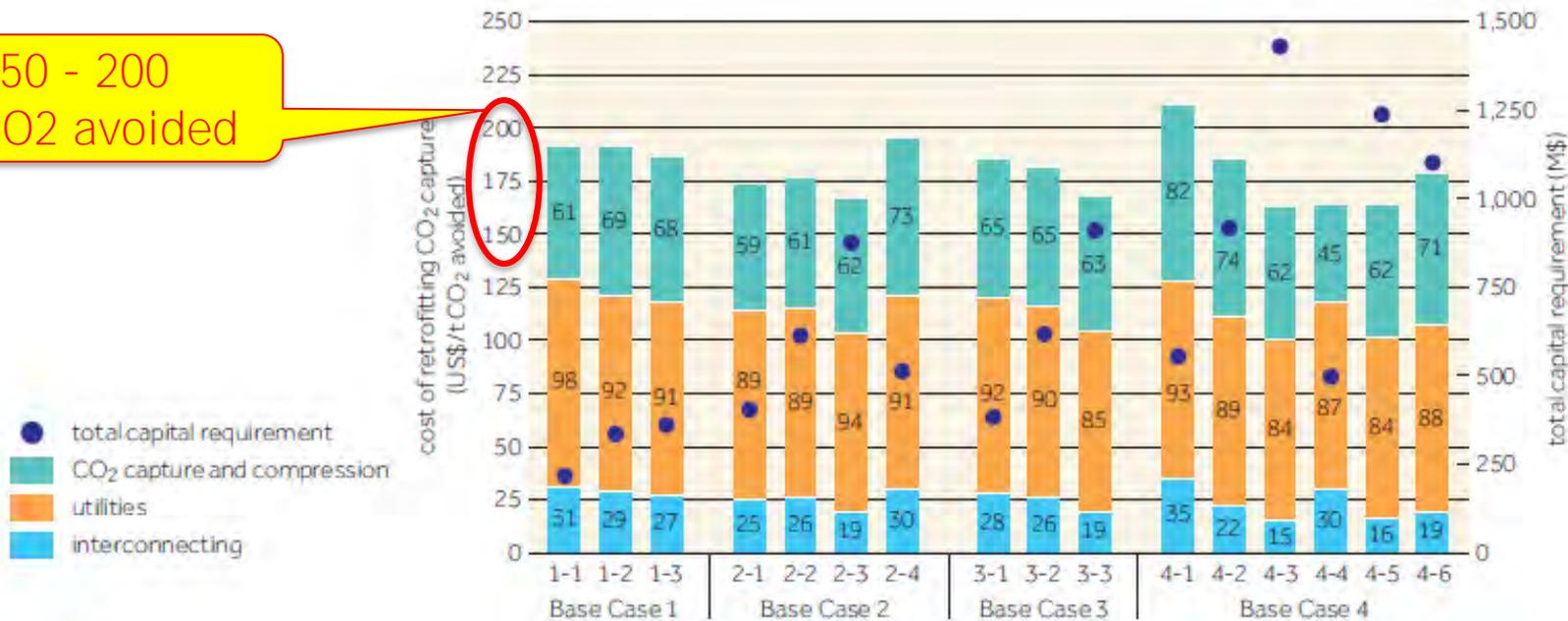
The main CO₂ emission sources for a typical complex refinery with a nominal capacity of 350,000 bbl/day



Source: Adapted from SINTEF (2017). ReCAP Project—Evaluating the Cost of Retrofitting CO₂ Capture in an Integrated Oil Refinery: Description of Reference Plants. <https://www.sintef.no/recap>

Costs of retrofitting CO₂ capture for all cases considered for the four refinery bases cases, by section

150 - 200
\$/tCO₂ avoided



Source: Adapted from SINTEF (2017). ReCAP Project—Evaluating the Cost of Retrofitting CO₂ Capture in an Integrated Oil Refinery: Description of Reference Plants. <https://www.sintef.no/recap>

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Takeaways



The conceptual assessments ...

Next step = « blue H2 study »

- 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 EII, the paths towards 2050 require carbon Capture
 - *As shown in EU Commission report “A clean planet for **All**”, every scenario includes CO₂ captured*
 - *EII are key building blocks in all economies and are actively working to reduce emission (directly from their process and from product use)*
 - *On-going effort and challenges: industrial scale, capital intensive technology, opportunities for CO₂ utilization, carbon leakage*



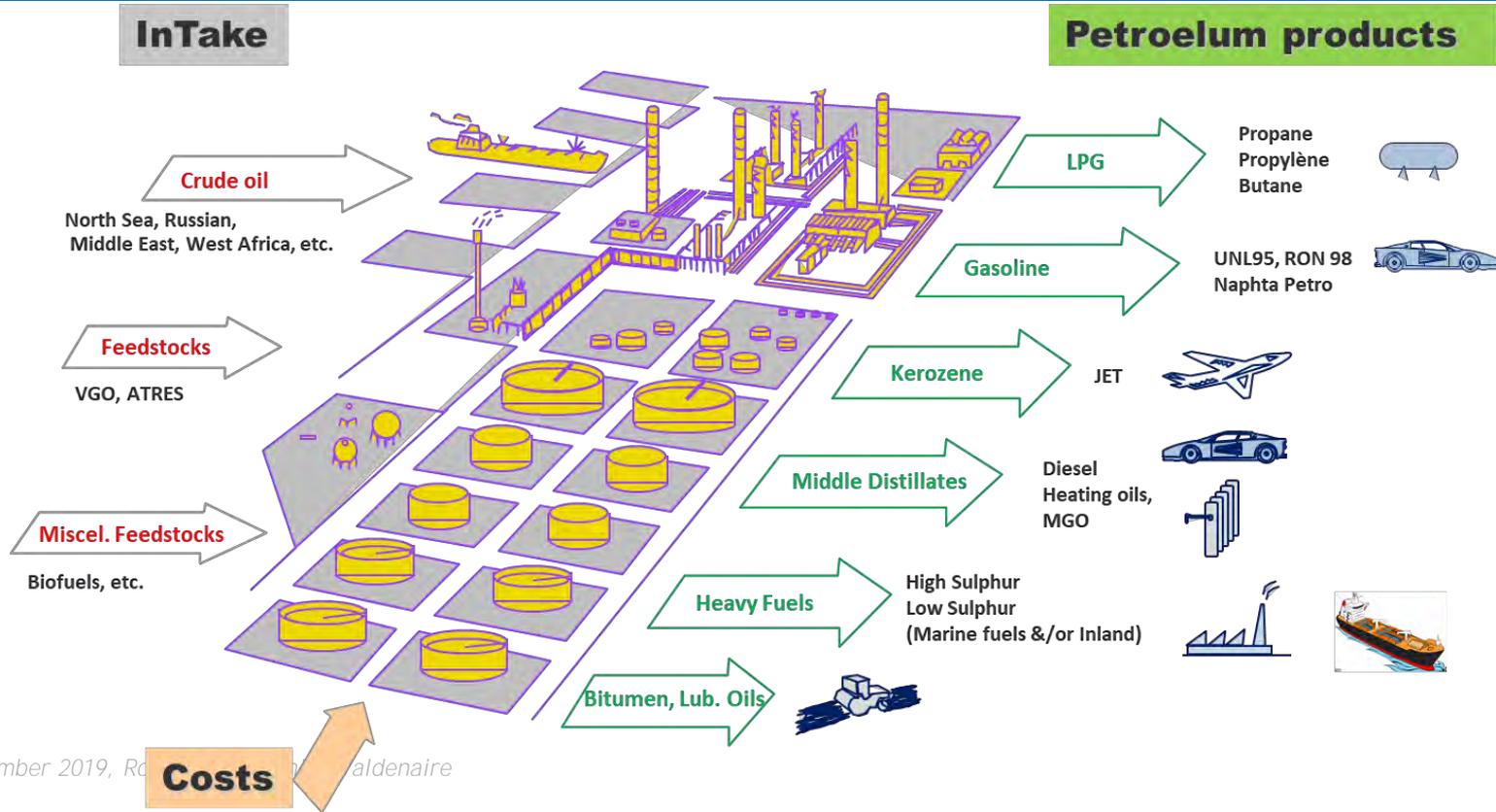
Liquid fuels deliver
happiness everyday...

...and they can
be low-carbon



Appendix

Oil refining: operating principle

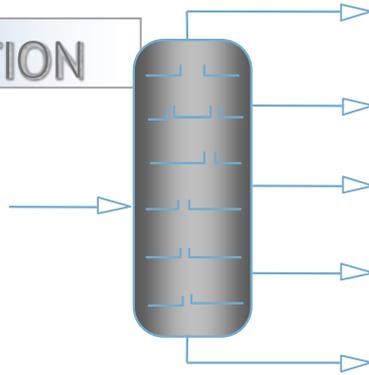


September 2019, Road to the future, Alain Renaud, Journal de l'Industrie pétrolière

Crude oil refining

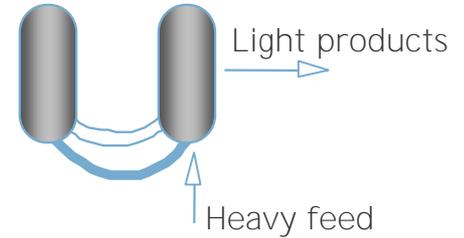
1 DISTILLATION

- Crude Oil (LS & HS)
- Condensate



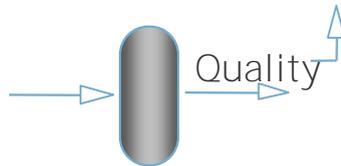
2 CONVERSION

- FCC
- Hydrocracking
- Coking
- Visbreaking

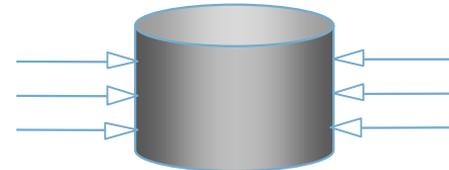


3 IMPROVEMENT

- Reforming
- Hydrotreating
- Alkylation
- Isomerisation

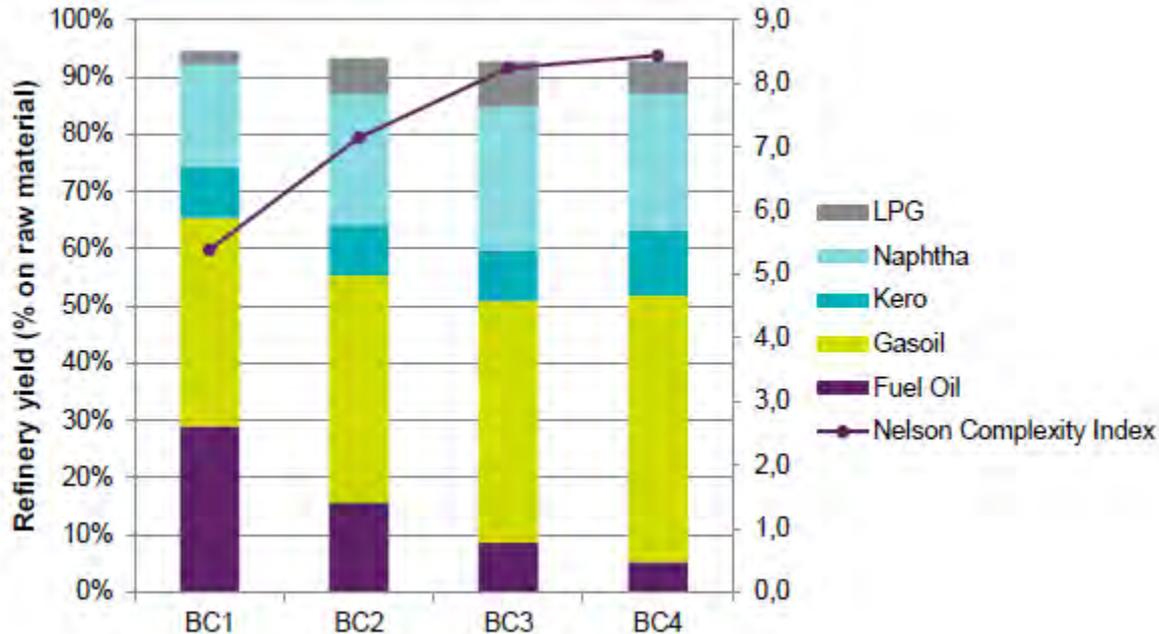


4 BLENDING



September 2019, Rotterdam, Damien Valdenaire

Refinery yields in different European Base Case configuration



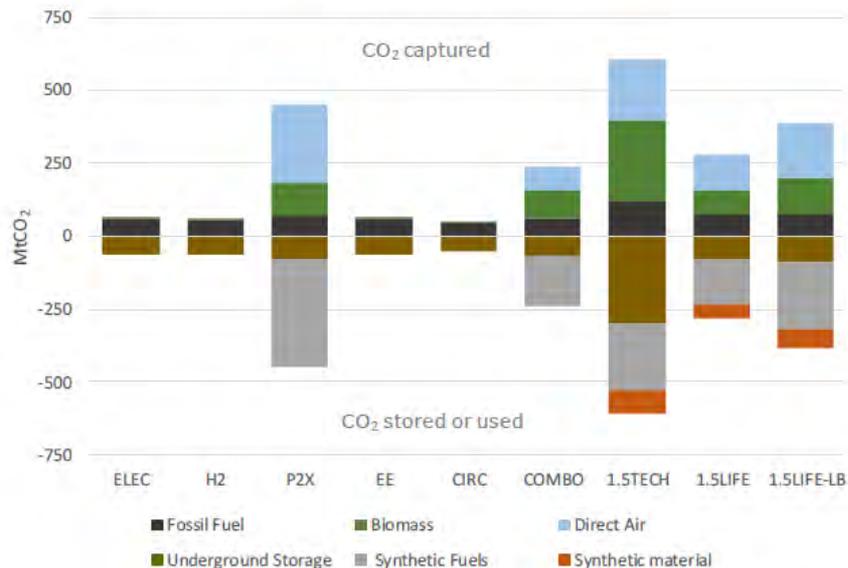
BC1 = Hydroskimming (simple)
BC2 = Medium complexity
BC3 = Highly Complex (220kbbbl/d)
BC4 = Highly Complex (350kbbbl/d)

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

« A clean Planet for All »

CO₂ captured is present in every scenario

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



Source: PRIMES.

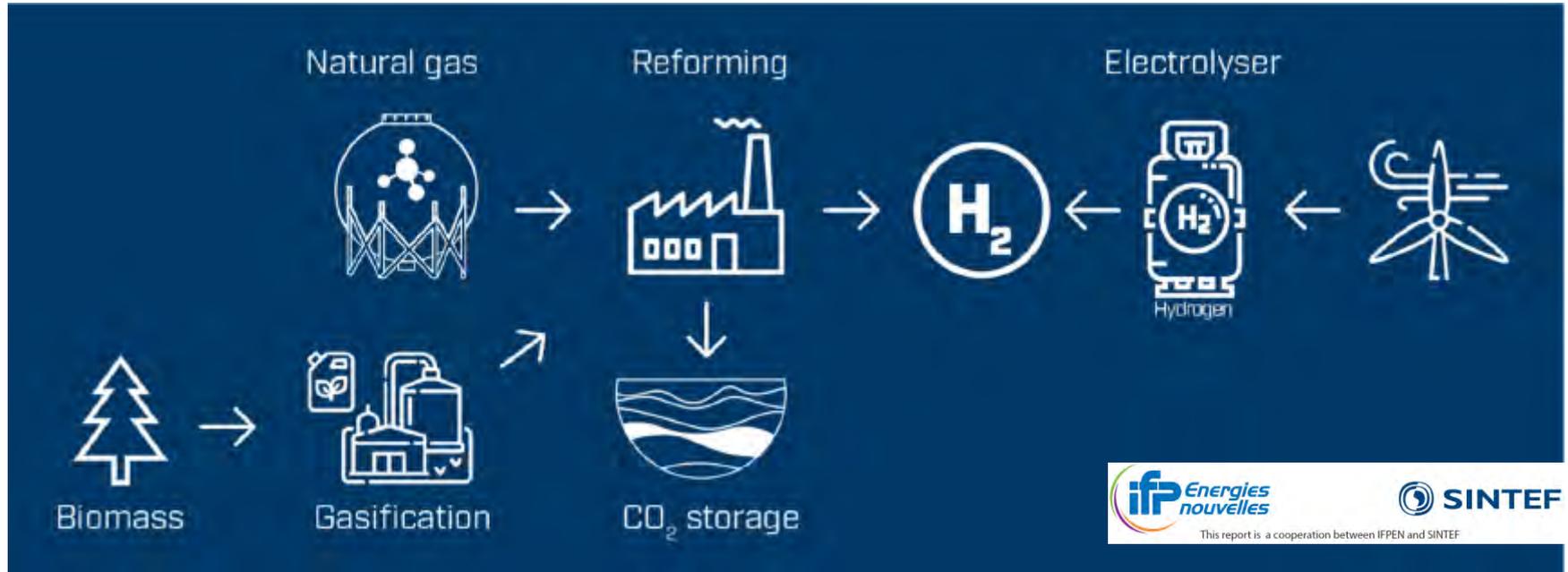
https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_analysis_in_support_en_0.pdf



Project: “Hydrogen for Europe”

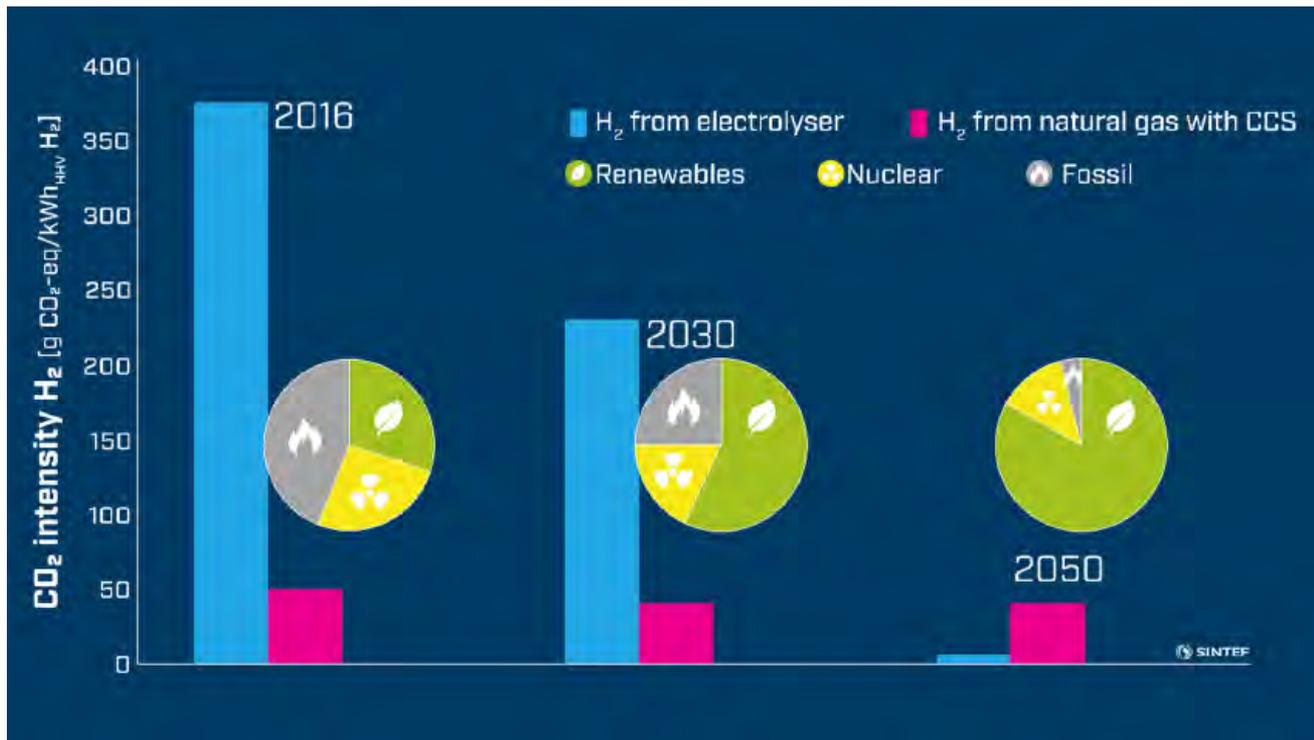
Pre-study results

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



Comparison of the CO₂ intensities of hydrogen production using electrolyzers 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

