EU Refining industry and Hydrogen challenge

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« Hydrogen's Contribution to a Secure and Affordable Decarbonisation of the EU Energy Sector"

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Content

1 Concawe Association

Concawe - Environmental Science for European Refining

Concawe Membership

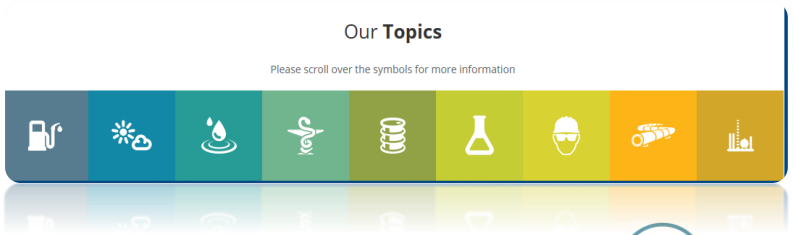
Concawe represents 40 Member Companies ≈ 100% of EU Refining

Open to companies owning refining capacity in the EU

Concawe mission

To conduct **research** to provide **impartial scientific information regarding:**

- **Scientific understanding**
- **Assist** the **development** of technically feasible and cost effective **policies** and legislation
- Allow informed decision making and cost effective legislative **compliance** by Association members



Europe (2020): 77 Mainstream refineries + 16 “Specialized” (13,5 mb/cd capacity)

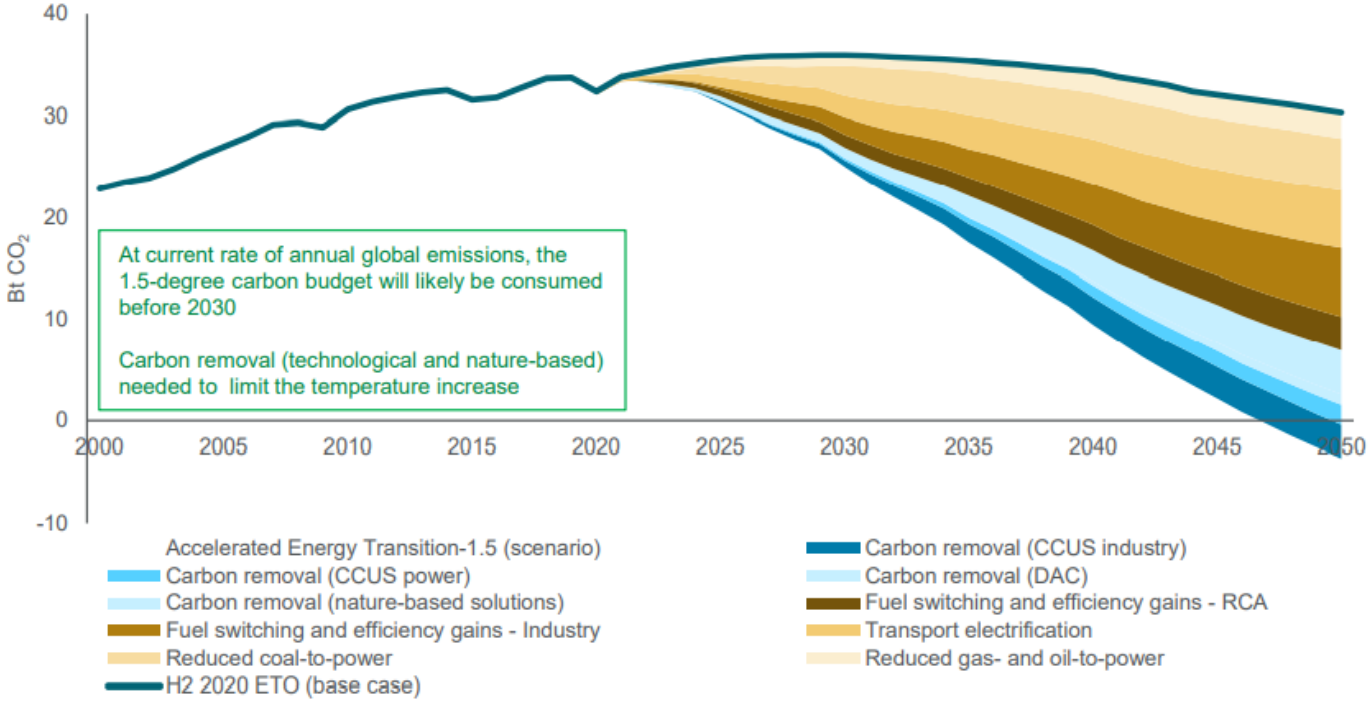
Available on Concawe website

EU27 + UK + NO + CH

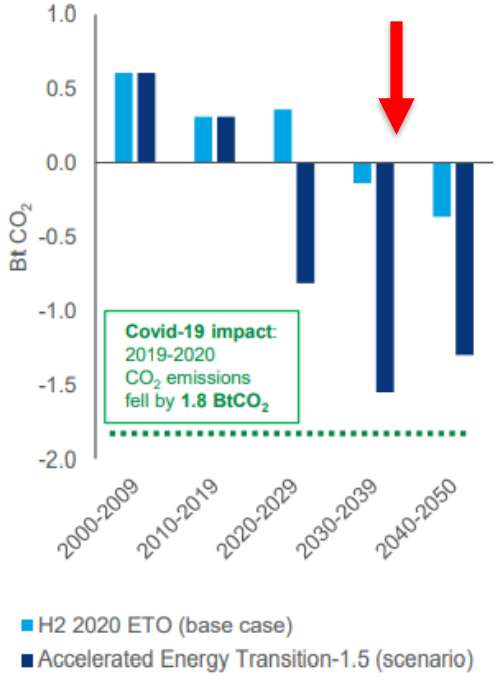
2 The net zero challenge

The net zero 2050 emissions challenge is huge

Global energy-related emissions: base case vs AET-1.5 scenario



Avg. y-o-y change in emissions

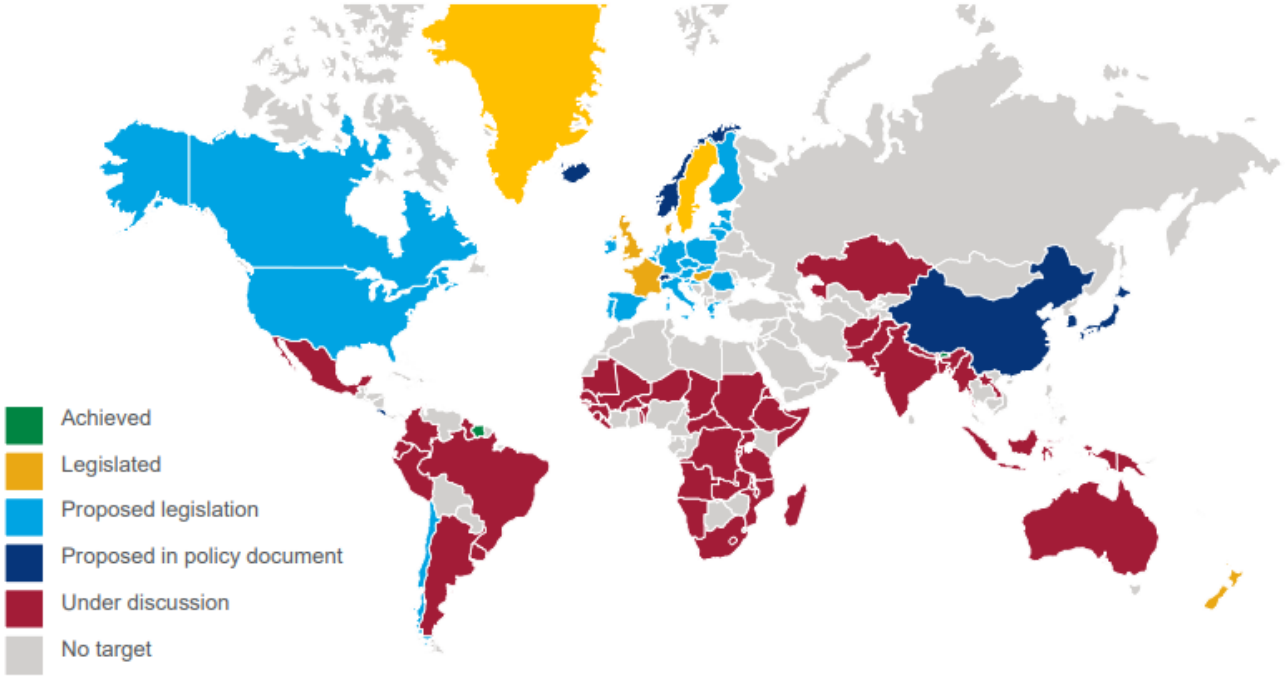


Source: Wood Mackenzie

Countries responsible for 60% of global CO2 emissions have set a net zero target

While more countries are likely to confirm net zero emissions in the run-up to COP26, no major economy is on track to meet the near-term target for 2030

Status of net zero emissions targets by country



Country/ region	Target for 2030 vs baseline*	Achieved by 2020 vs baseline*	Net zero emissions target date
UK	68% reduction	-47%	2050
EU-27	55% reduction	-35%	2050
US	50-52% reduction	-16%	2050
Japan	46% reduction	-16%	2050
South Korea	40% reduction	-7%	2050
Canada	40-45% reduction	-3%	2050
Australia	26-28% reduction	-10%	Under discussion
China	Peak emissions by 2030	+79%	2060
India	No peak before 2030	+69%	Not yet announced

*Targets are set against a range of base years so are challenging to compare on a like-for-like basis

Source: Wood Mackenzie

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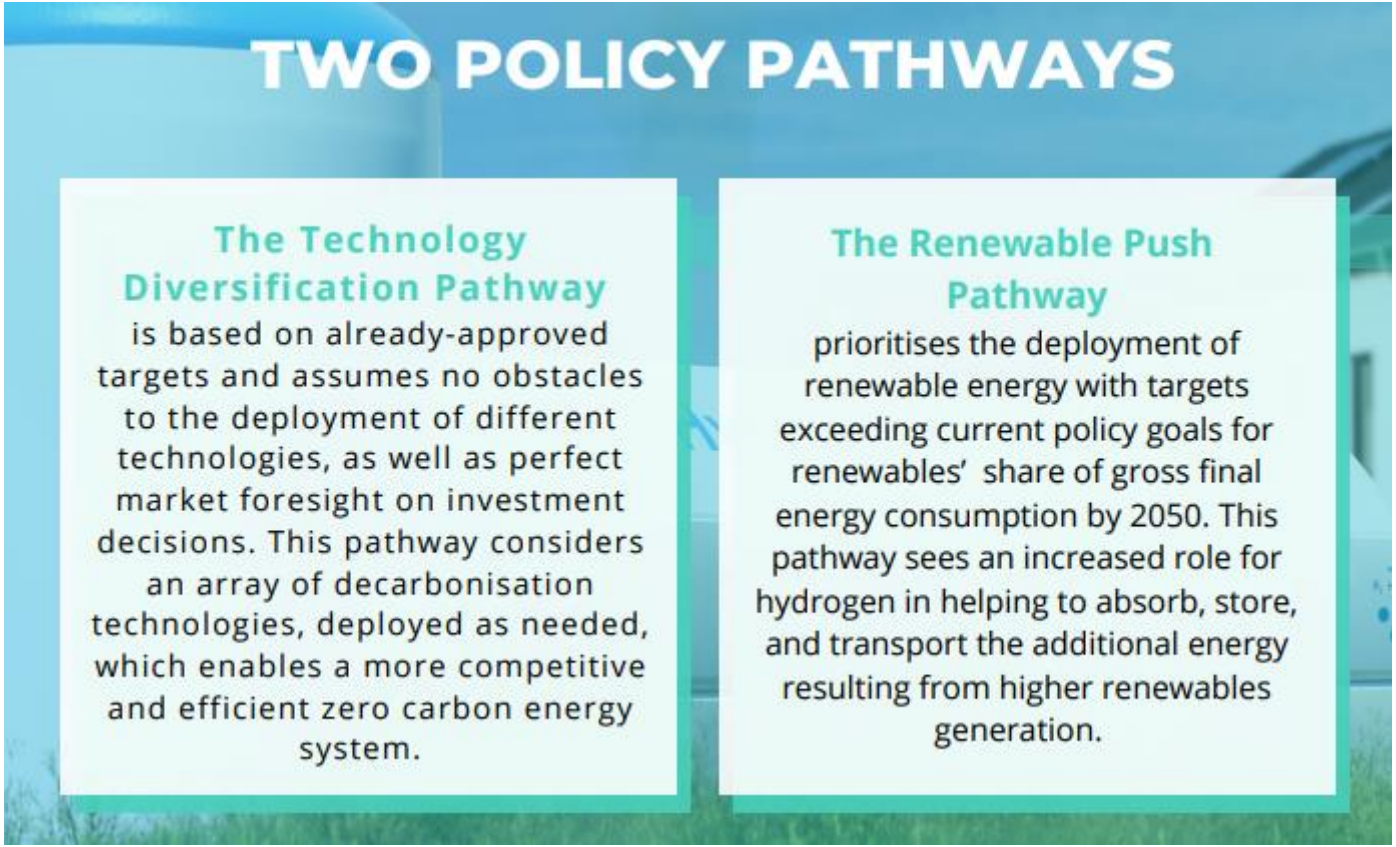
Hydrogen4EU

CHARTING PATHWAYS TO ENABLE NET ZERO

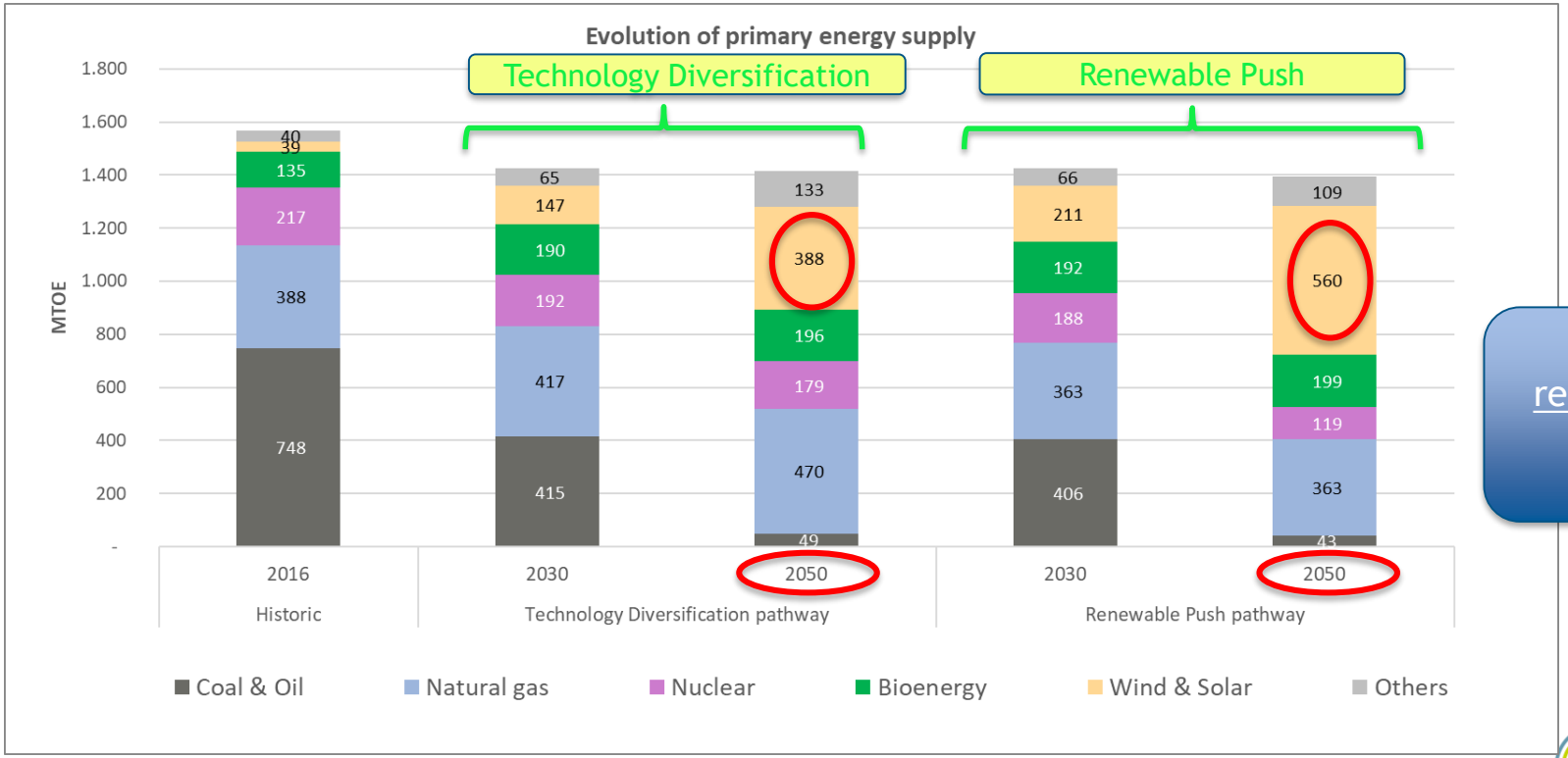
Link to website: https://www.hydrogen4eu.com/

Scenarios



Primary energy supply

Primary energy supply decrease ~0,25% on average 2016 -> 2050



2050 renewables:
TD: 49%
RP: 61%

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A pathway to carbon neutrality

CO_2 storage and re-use as an enabler of low-carbon technologies' full potential

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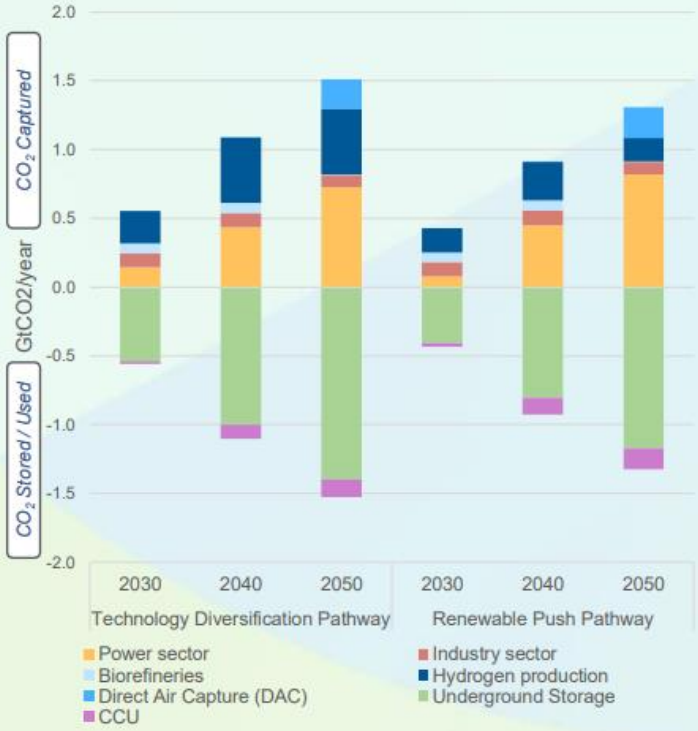
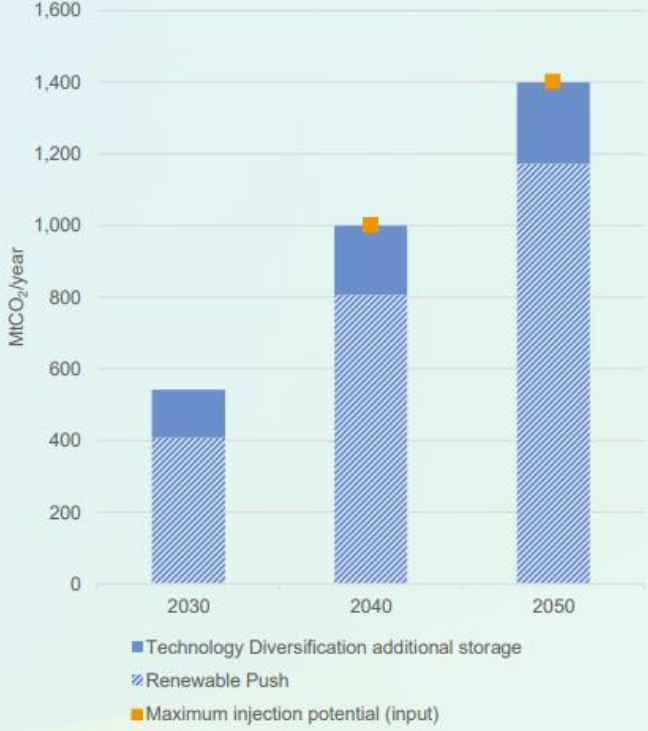
Evolution of CO_2 flows in the CCUS value chain

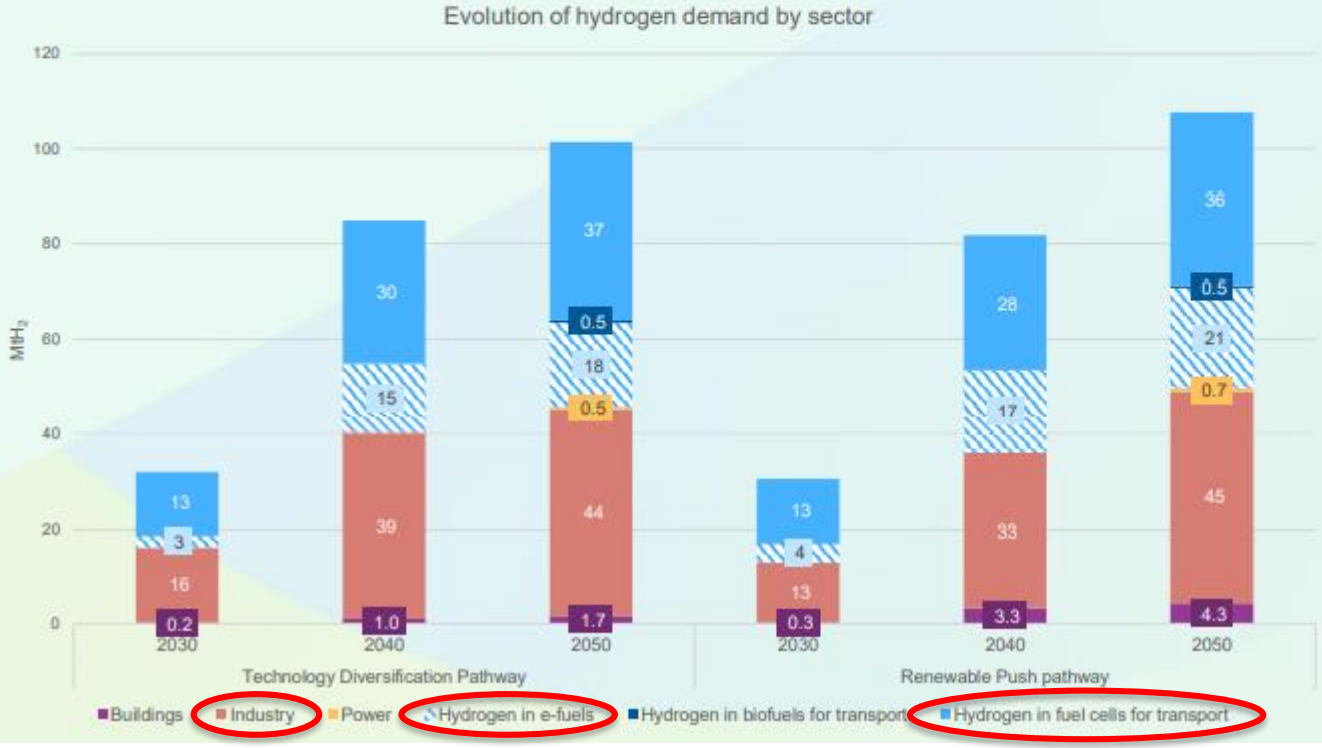


Evolution of CO_2 storage injection rate



Hydrogen demand

Hydrogen plays a similar role in the two scenarios as it proves a robust solution for hard-to-abate sectors

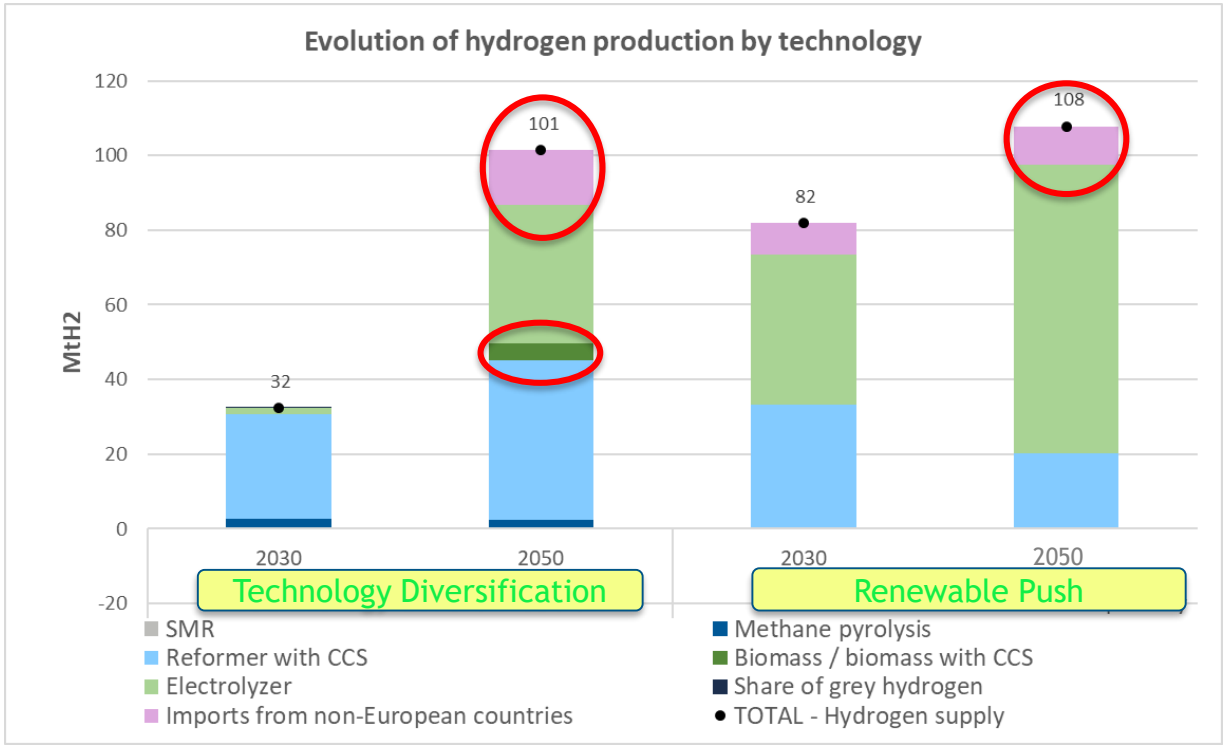


- Hydrogen demand already exceeds 30 million tons in 2030
- The biggest ramp-up phase happens between 2030 and 2040 as the demand is multiplied by more than x2.5.

- Transport and industry make up the vast majority of hydrogen demand in both scenarios, confirming the role of hydrogen in hard to abate sectors.
- Hydrogen also contributes to decarbonization in buildings and power generation<

H2 production (for energy purpose)

Renewable and low-carbon H2 are complementing each other



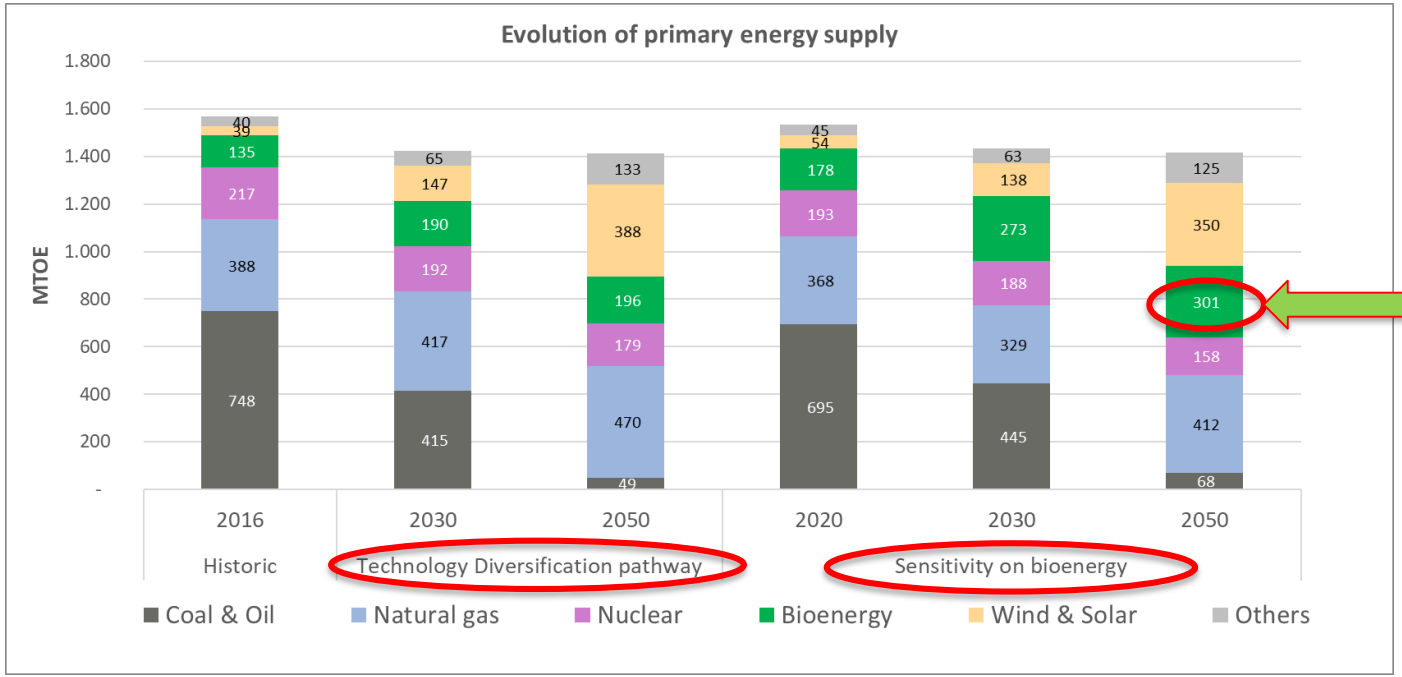
Diversity in hydrogen is essential to the transition to net zero.

Low carbon hydrogen is an enabler for renewable hydrogen as the industry is building up.

Higher potential for Bioenergy

Sensitivity

Sensitivity = ENSPRESO Reference trajectory (12k PJ) for bioenergy potential



Higher potential for bio energy, considering an average scenario for biomass availability

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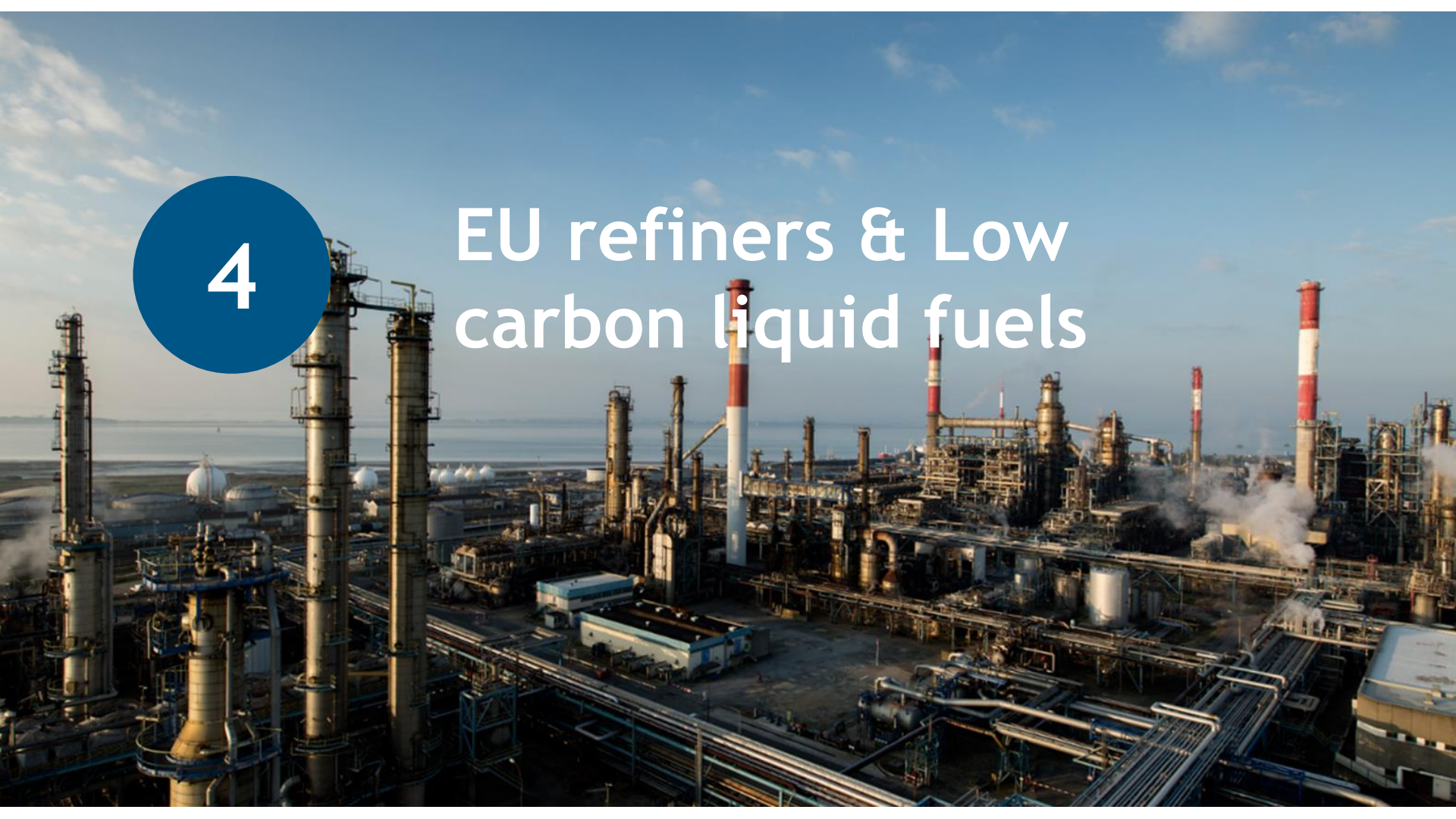
Conclusion



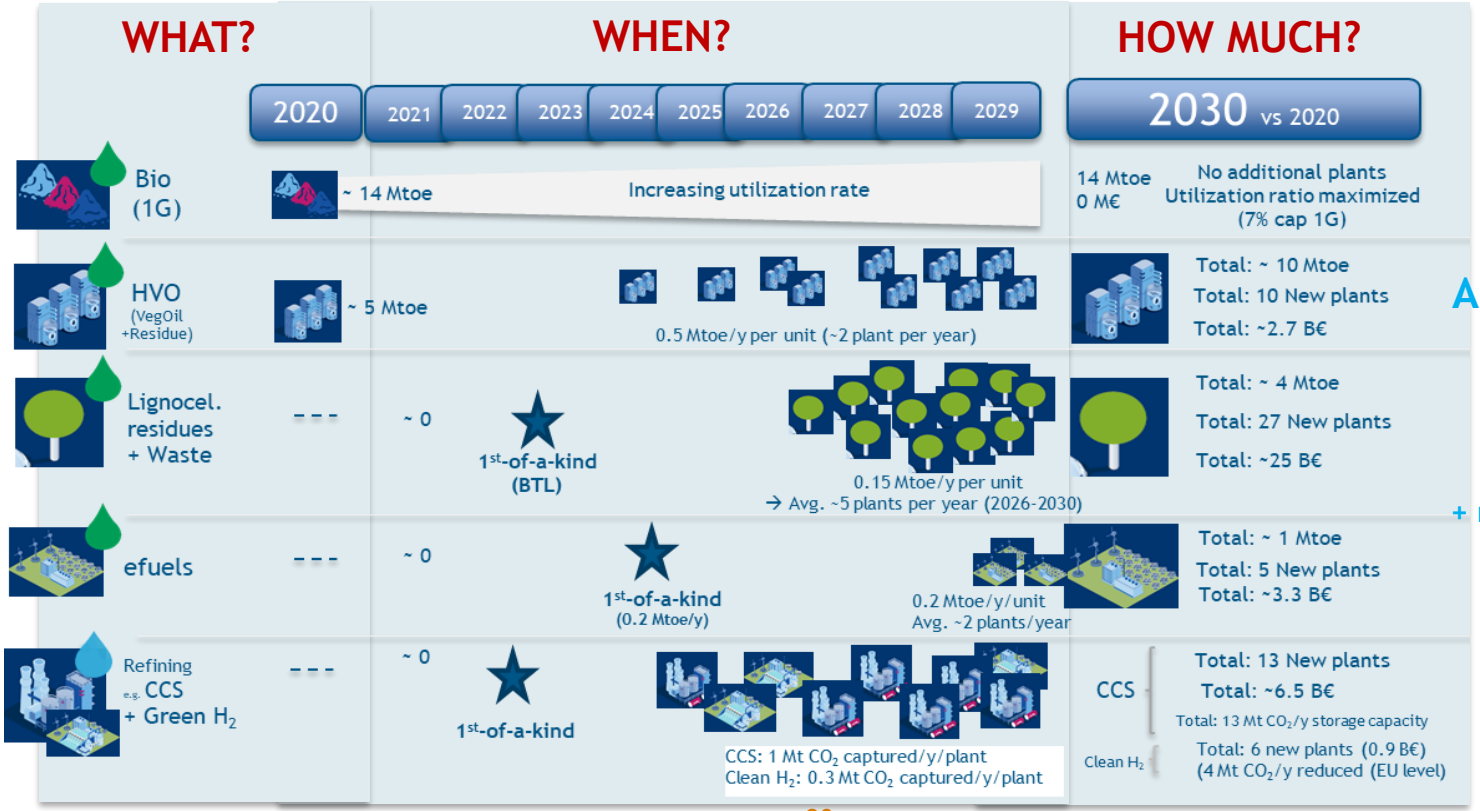
4 EU refiners & Low carbon liquid fuels

All the details on our web site, see report 7/21

https://www.concawe.eu/wp-content/uploads/Rpt_21-7.pdf

The Clean Fuels for All Strategy

Demo and Scale-up is needed!



Accelerating
the pace towards 1st-of-a-kind in parallel to supply chain + market creation!

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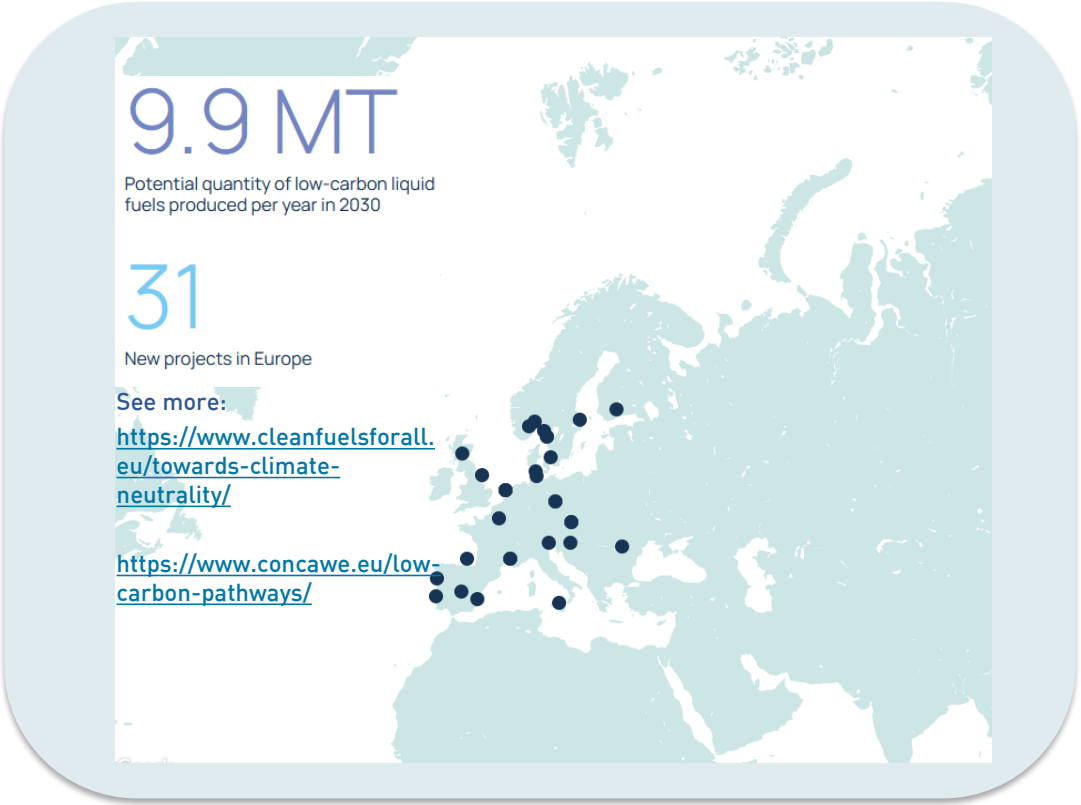
EU refining industry contribution to Green Deal

The journey has already started…

31 projects for low-carbon liquids have already been started or are planned until 2030



Some examples*:

- **8 Advanced biofuel projects,** with capacities between 100.000 and 750.000 tonnes of output.
- **6 CCUS projects,** up to 6 mt. of capacity for CO2 sequestration.
- **12 Green Hydrogen Projects,** some of which lower the GHG intensity of manufacturing processes, others combine the green H2 with captured carbon to produce synthetic fuels with a capacity of up to 3.4 million tonnes of output per year.
- **3 Waste-to-fuel projects,** with a capacity of up to 100.000 tonnes per year in output (derived from urban waste).

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Takeaways

Refiners as long term fuel suppliers

- **Refineries contributing** to the Europe's objective of (net) climate neutrality in 2050 by **delivering low-carbon fuels.**

- The **scenario explored by Concawe** (Refining contribution to EU2050 Climate Ambition) shows **feasibility** to reach **climate neutrality in transport by 2050 with low carbon liquid fuels.**
  - *High investment with R&D efforts on technology scale up and rapid deployment, mobilization of resources across the whole value chain and high engineering/construction resources.*

- These **studies** will be **re-evaluated** on basis of new "Fit for 55" package, published by the European Commission on July 14th, 2021.

Back up's

Emerging technologies break through at different carbon prices

Advanced transportation, then low-carbon hydrogen and CCS have highest technology maturity and lowest abatement cost today – hence likely to move more quickly

Source: Wood Mackenzie

What are Low-Carbon Liquid Fuels?

- Sustainable **liquid** fuels from **non-petroleum origin**, produced from **new feedstock** such as biomass, renewables, waste and captured CO2.

- With **no** or very limited **net CO2 emissions** during their **production** and **use** compared to fossil-based fuels.
- These feedstock's **comply** with the existing **EU sustainability standards**.
- Low-Carbon Liquid Fuels are **complementary** to **electrification and hydrogen**. We will need all technologies to deliver climate neutrality.

Assesment of the role of Low Carbon liquid Fuels in Road Transport - Methodology

Concawe theoretical assessment of the potential contribution of EU refining industry to reach climate neutrality in Road transport by 2050

SCOPE

EU Refining system

EU Transport (Road - Light and Heavy Duty, Aviation & Maritime)

Well-To-Wheels (*Wake/Propeller*) analysis to assess % GHG savings versus a baseline

Demand hypothesis for refining liquid fuels based on the penetration of alternative powertrains and fuel efficiency measures

TECHNOLOGIES

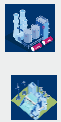
Low Carbon Technologies to reduce WTW GHG intensity at EU Level.

Different scenarios assessed by developing and deploying:

a) **Sustainable low carbon liquid fuels (WTW)**
Boosting R&D and accelerating penetration of:

- 1G biofuels (maximizing current capacity)
- HVO (VEgOil+Residues)
- Lignocellulosic and waste feedstocks (Biomass-To-Liquid technology as a proxy)
- E-fuels (Power-To-Liquids)

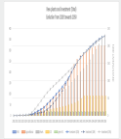
b) **Refining related technologies (WTT)**



- Clean H2 progressively replacing Steam Reformers for H_2 production
- Refining CO2 capture and storage (CCS). When applied to biofuel/e-fuel production processes, this could generate negative CO2 emissions.

RESULTS

From today until 2030, 2035, 2040 & 2050 timeframe, different scenarios provide an initial assessment on:



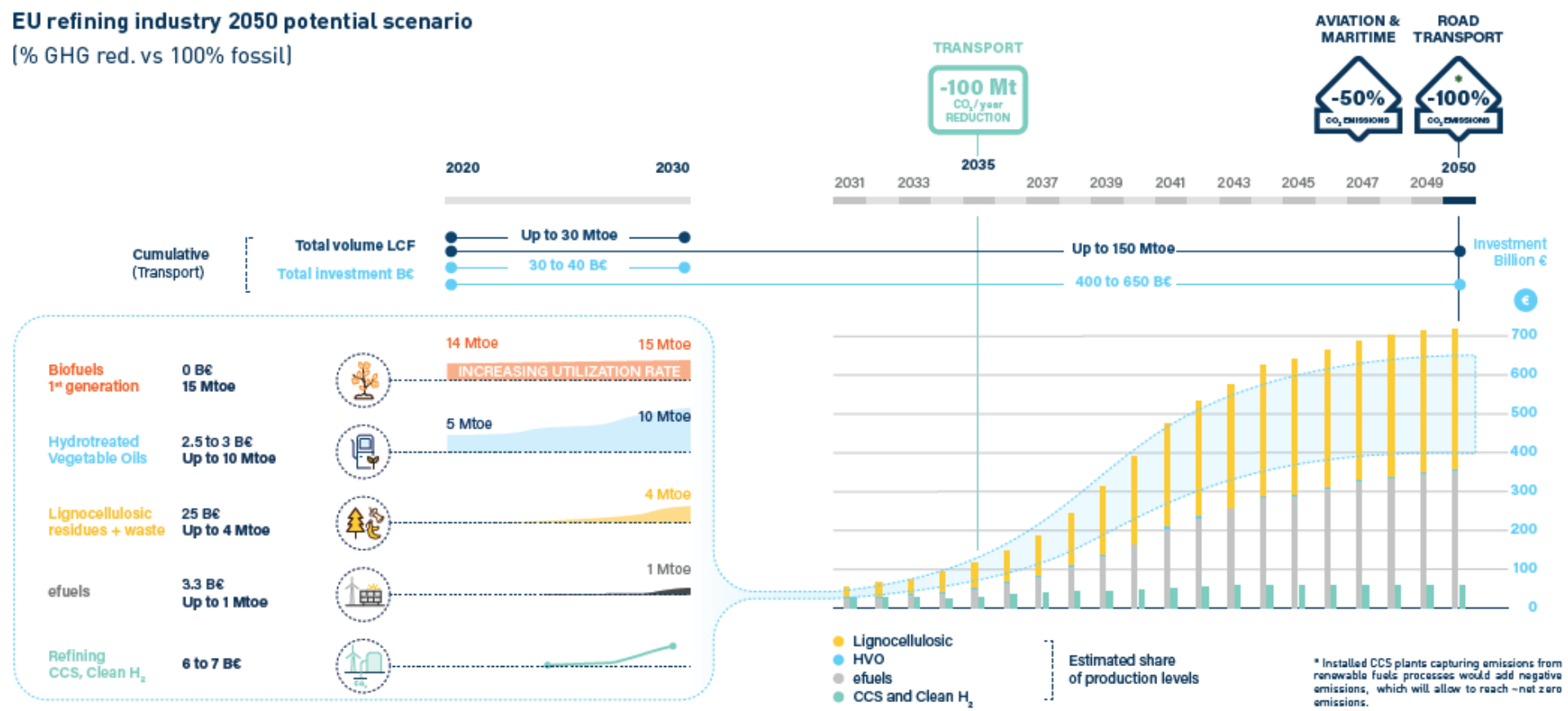
- Level of deployment of low carbon liquid technologies (**number of plants** in the period)

- Total volume of low carbon liquid fuels in transport (Road + estimate for aviation / marine)

- CO_2 emissions savings

- Level of investment

“Clean Fuels for All” in numbers



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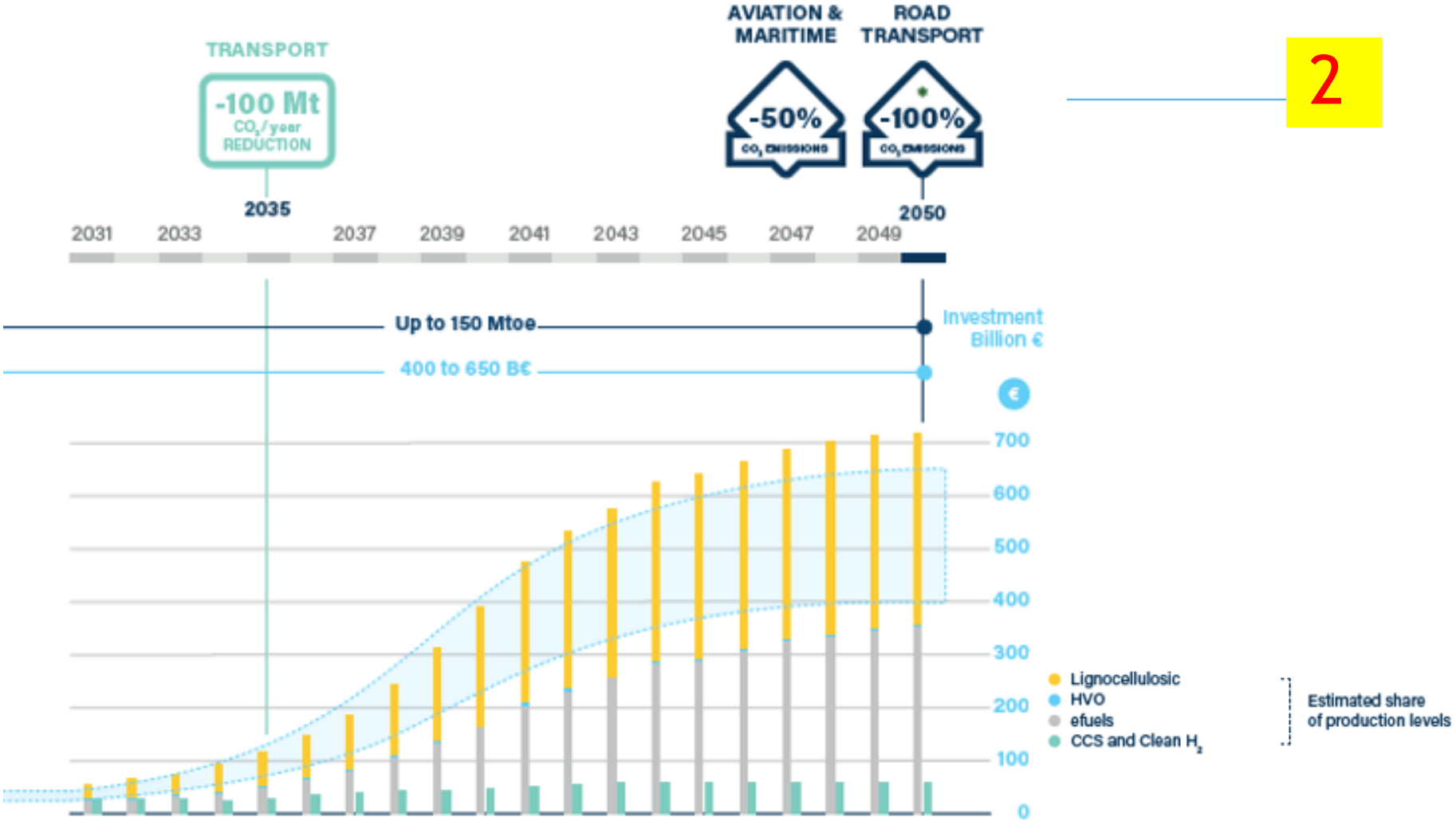
		2020	2030
Cumulative (Transport)	Total volume LCF		Up to 30 Mtoe
	Total investment B€		30 to 40 B€

			2020	2030
Biofuels 1st generation	0 B€ 15 Mtoe		14 Mtoe	15 Mtoe INCREASING UTILIZATION RATE
Hydrotreated Vegetable Oils	2.5 to 3 B€ Up to 10 Mtoe		5 Mtoe	10 Mtoe
Lignocellulosic residues + waste	25 B€ Up to 4 Mtoe			4 Mtoe
efuels	3.3 B€ Up to 1 Mtoe			1 Mtoe
Refining CCS, Clean H_2	6 to 7 B€			

* Installed CCS plants capturing emissions from renewable fuels processes would add negative emissions, which will allow to reach ~net zero emissions.


TRANSPORT
-100 Mt
CO_2/year
REDUCTION
2035
AVIATION & MARITIME
-50%
CO_2 EMISSIONS
ROAD TRANSPORT
-100%
CO_2 EMISSIONS
2050
2031
2033
2037
2039
2041
2043
2045
2047
2049
Up to 150 Mtoe
400 to 650 B€
Investment Billion €
€
700
600
500
400
300
200
100
0
Lignocellulosic
HVO
efuels
CCS and Clean H_2
Estimated share of production levels