The 'biofuels first, e-fuels later' strategy of European refining sector

What future for European refining?

January 2023

The European refining sector: Shrinking, too much biofuels and a timid start on hydrogen and e-fuels

An increasing share of electric vehicles in Europe will reduce the demand for diesel and gasoline in the long term. This has significant implications for the future of refining in Europe. At the same time, European policies such as the Renewable Energy Directive oblige fuel suppliers to significantly increase the share of renewable fuels in transport.

Going forward, electrification of cars and trucks will start gradually decreasing gasoline and diesel demand, a trend that will be accelerating from 2030, with demand dropping up to -5% per year. As a result, by the official EU phase-out of sales of new Internal Combustion Engine (ICE) cars in the EU, **fossil fuel demand in road transport could be down 31% in 2035, from 2021 levels.** In case of a sharper drop in demand driven by an accelerated uptake of electric vehicles, demand for gasoline and diesel could decrease by 56%, resulting in an estimated 43% refining capacity to close or be converted.

Refiners have already started to respond to this new reality as well as to the policy push to increase the share of renewables in transport. Several oil refineries have already been turned into biorefineries and oil companies are anticipating these trends with additional new investments.

Fuel / novel process	Producing capacity in 2020 (Mtoe)	Scenario for production capacity in 2030 (Mtoe)	Investment for 2030 (€billion)
First generation biofuels	14	15 (by increasing utilisation)	-
HVO	5	10 (approx. 10 new plants)	2.5 - 3.0
Lignocellulosic feedstocks	-	4 (approx. 27 new plants, with 1st-of-a-kind plant from 2023)	25
E-fuels	-	1 (approx. 5 new plants, with 1st-of-a-kind plant from 2025)	3.3
CCS in refineries	-	- (approx. 13 new plants with 1st-of-a-kind from 2022)	6.5
Green hydrogen in refineries	-	- (approx. 6 new plants)	0.9

Note: 1st-of-a-kind refers to the first plants at an industrial scale for specific technologies.

Source: Concawe, 2021

Of the EUR 38.7 billion of investments planned by the refining sector going into new fuels towards 2030, almost 75% will go towards increasing biofuels production capacity: Oil refiners are planning to invest EUR 25 billion in production capacity to process lignocellulosic feedstocks, which will increase biofuel production capacity by 4 Mtoe. EUR 2.5-3 billion will be invested in new HVO plants, doubling the existing production capacity to 10 Mtoe by 2030.

These **investments in HVO will double the refining capacity, resulting in a total capacity that is 4 times higher than the amount of Used Cooking Oil and animal fats that can be sustainably sourced in the EU.** Based on T&E data, this will likely lead to a reliance on feedstocks already being used by other industries (e.g. tall oil, animal fats cat. III, etc.) as well as imported feedstocks like UCO. It is also clear that some projects will continue relying on vegetable oils like rapeseed or soy.

Oil companies are also starting to invest in hydrogen and e-fuels as transport fuels, but **the budget for biofuels refining is about 8 times higher than the investments made in hydrogen and e-fuels** (EUR 28 billion vs. EUR 3.3 billion).

Instead of supplying hydrogen and e-fuels to various transport modes, **oil companies have been mainly focused on reducing the carbon intensity of their refinery operations, focusing on replacing grey hydrogen with blue hydrogen and to a lesser extent green hydrogen**. Instead of using grey hydrogen for hydrotreating and hydrocracking, oil companies are investing around EUR 6.5bn in so-called blue hydrogen by deploying large-scale Carbon Capture and Storage by 2030. Just under EUR 1 billion is spent on replacing grey with green hydrogen.

A rapid scaling up of the production of renewable e-fuels suitable for aviation and shipping is the only option to fully decarbonise these transport modes by 2050. In T&E’s view, the refining industry has not yet shifted its focus towards producing e-fuels for planes and ships. The good news is that there are many synergies between conventional processes and e-fuels production and that existing refinery assets have the technical capacity to produce e-fuels. **A dedicated policy push will be needed to push refiners to supply e-fuels for aviation and shipping.**

1. Introduction

With the full phase-out of the internal combustion engine for cars in 2035 now finally adopted, a significant part of the demand for oil products like gasoline and diesel is now set for a gradual decline. Cars make up 50% of all oil demand in the transport sector. Discussions on CO_2 standards for trucks are still ongoing, but a future zero-emission mandate for trucks will drive electrification of road freight and help reduce the 30% of transport oil demand and diesel in particular used in road freight[1].

Clearly, the wheels are in motion for a decreasing demand for gasoline and diesel in the EU. This new reality begs the question what the future holds for Big Oil and Gas, and their refining sector in particular. In the longer term, the demand for liquid fuels will mainly come from the aviation and shipping sector: Electrification does not provide a credible pathway for the full decarbonisation of planes and ships and technology solutions based on renewable hydrogen are only starting to be developed.[2]

In this briefing, we explore recent trends in the refining sector and outline the implications of decreasing oil products demand. The basis for this briefing is the report "What Future Role For Conventional Refineries In The Decarbonisation Transition?", conducted by Ricardo Energy & Environment (Ricardo) for Transport & Environment in the first half of 2022. This desk-based study was led by Ricardo and delivered with input from Argus Media Limited (Argus). This briefing also draws on other information sources.

Given that liquid fuels will continue to play an important role in non-road transport, the briefing addresses how the refining sector has adapted until now to an increased demand for renewable and low-carbon fuels: what investments have been made or are planned for the sector of biofuel refining? And what is the state of play when it comes to refineries producing liquid e-fuels such as e-kerosene for the aviation sector or e-ammonia or e-methanol[3]?

2. The refinery sector has been shrinking and this trend will continue, accelerating from 2030.

The demand for oil products from refining has declined over the last decades, but that decrease cannot be attributed to the reduced demand in the transport sector (Figure 1 - historical data 1995-2020,

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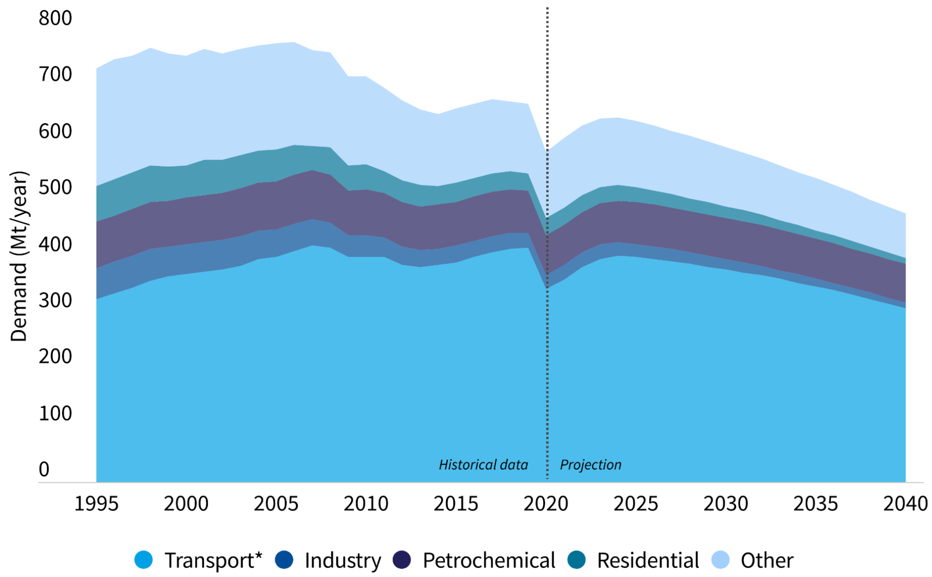
[1] T&E. (2022, Aug.). *How Europe can cut a third of its oil demand by 2030*. Retrieved from https://www.transportenvironment.org/wp-content/uploads/2022/08/2022August-oil-transport-demand-TE.pdf

[2] T&E (2022, Mar.) *Roadmap to climate neutral aviation in Europe* https://www.transportenvironment.org/wp-content/uploads/2022/03/TE-aviation-decarbonisation-roadmap-FINAL.pdf

T&E (2021, Apr.) *Decarbonising European Shipping* https://www.transportenvironment.org/wp-content/uploads/2021/07/202104_Shipping_Technological_Roadmap_to_Decarbonization.pdf

[3] For the purpose of this briefing, e-fuels refer to Renewable Fuels of Non-Biological Origin, as defined in the Renewable Energy Directive, namely liquid and gaseous fuels the energy content of which is derived from renewable sources other than biomass.

projection to 2040 based on Argus data). The decline is mainly due to decreasing demand from the 'other' sectors such as oil consumption used for electricity generation. Despite steadily climbing crude oil prices and EU legislation to improve vehicle efficiency or the promotion of alternative fuels, oil demand from the transport sector increased around the turn of the century and stayed rather stable in the period from 2005 until the start of the global COVID19 pandemic in early 2020. Any fluctuations from 2005 were more related to economic growth or recession.



*Transport includes road transport, aviation and shipping. Source: Argus

Figure 1: Refined product demand by end-use (EU27+UK+NO, Argus)

Despite the stable demand from the transport sector, the refining sector has already undergone a rationalisation, with crude oil distillation unit capacity declining since 2010 as a result. From a capacity of almost 16 million barrels per day (b/d) in 2010, nearly 2 million b/d, or 13%, of European refining capacity has been closed, mostly as a result of poor refining economics, over the last decade. The COVID-19 pandemic and subsequent drop in fuel demand accelerated the closure of some refineries. Figure 2 shows some examples of recent refinery closures in 2021-22 and announced closures. A refinery capacity reduction of 4.4% annually between 2020 and 2025 is expected based on Argus forecasts.

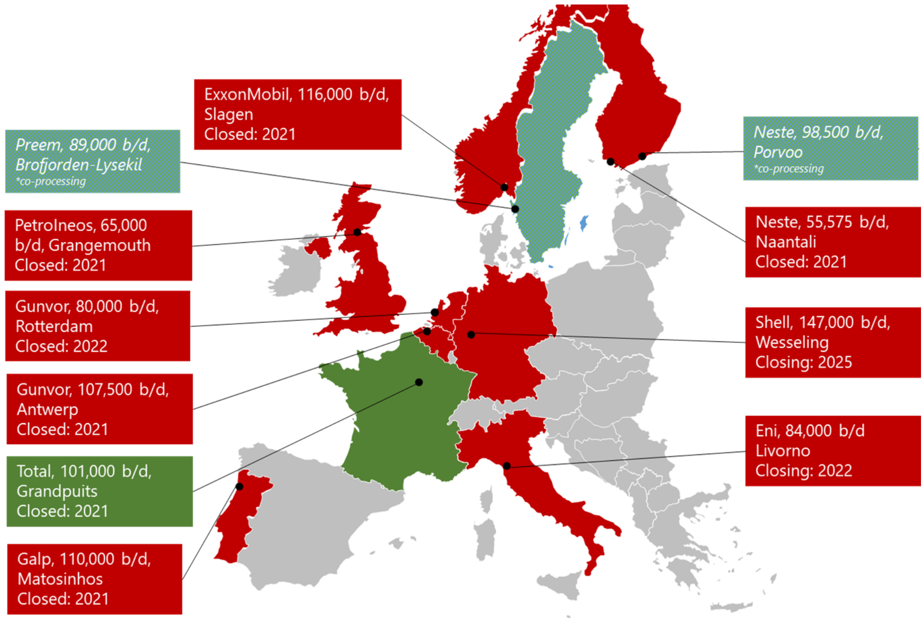


Figure 2: Recent European refinery closures (source: Argus)

The relatively stable demand for oil in the transport sector in combination with the closing of 13% of Europe's refining capacity has resulted in more imports of refined oil products from outside the EU27, UK and Norway. European product imports have been steadily increasing at an average rate of 100,000 b/d between 2010 and 2021. In 2010, product imports comprised 45% of total product demand in Europe. By 2021, that number had grown to 65%. The biggest increase of imported oil products comes from Russia, from ~13% in 2010 to 18% in 2013 and then more or less stable until the COVID-19 pandemic and the EU's embargo on Russian oil following the invasion of Ukraine by Russian troops. Imports of refined oil products from the Middle East doubled in the same period, from 3% to more than 6%.

The shrinking trend of European refining capacity will continue. However, the driver for this rationalisation will be less linked to refining economics, but more by more fundamental shifts driven by important policy decisions such as the phase-out of internal combustion engines for cars in 2035. Argus data used in the Ricardo report show that this would result in the electric car fleet increasing to 100 million cars between 2020 and 2040, up from 5.5 million today. Almost one out of 2 cars in the European fleet is projected to be a Battery Electric Vehicle in 2040. This profound shift would have a major effect on the demand for gasoline and diesel, which would gradually decline. The total demand for refined products is expected to decrease by 2% per year. This trend is projected to accelerate from 2030, with -5% and -4% per year for gasoline and diesel respectively.

	2020	2025	2030	2035	2040
LPG	0%	3%	0%	-1%	-1%
Naphta	-2%	-1%	-1%	-1%	-1%
Gasoline	-1%	-2%	-4%	-5%	-5%
Jet / kerosene	-10%	15%	1%	0%	0%
Gas oil / diesel	-1%	0%	-2%	-4%	-4%
Fuel oil	-4%	2%	-1%	-2%	-4%
Total demand	-2%	2%	-1%	-2%	-2%

Growth and decline rates expressed as compound annual rates, North and Central Europe. Source: Argus

Table 1: Projections of future demand growth/decline rates by product, expressed as compound annual growth rate (North and Central Europe, data provided by Argus).

As a result of the ICE phase-out for cars, **road fuel demand is expected to decline by 31% between 2021 and 2035 from 343 million tonnes to 232 million tonnes**. In that case, further closures beyond the closures already announced and mentioned above would be expected. From 2035, demand for petrol and diesel will continue to drop respectively 5% and 4% year on year. In case of an accelerated uptake of electric vehicles, the demand for road fuels goes down by 56% between 2021 and 2035 (equivalent to a -3.2% decline per year), projecting a decline of 5.8 million b/d. Put differently, the result would be a decline of approximately 43% of the current refining capacity.

The rebound in oil consumption following the COVID-19 lockdowns and the geopolitical tensions following the start of the war in Ukraine led to a spike in oil prices and high margins for the refining operations of the oil majors. Despite this, the long-term outlook for the refining sector is undoubtedly bleak. Refineries do not only produce transport fuels, but also other products which may include asphalt, chemical feedstocks, or solvents. Non-fuel production share can account from 20 to 40% of the product portfolio volume in a refinery but revenues can be larger.[4] These other products can justify maintaining operation of the existing refineries through increasing their crude oil to chemicals conversion units. A shift to producing more petrochemicals may be an option, but is far from a guarantee for success. A drive for a more circular economy is expected to also decrease the demand for petrochemicals (plastics) and increase the use of recycled or biogenic polymers.

If European refiners want to have a long-term future supplying liquid fuels to the transport sectors, a shift to more renewable and other low-carbon fuels will be necessary. As part of the ‘Fit for 55’-package and the increase in the level of ambition following the Russian invasion of Ukraine (RePowerEU), EU decision-makers are finalising discussions to almost double the previous 2030 targets for renewables in transport, with increased targets for advanced biofuels and announced binding targets for the use of renewable hydrogen and e-fuels in transport and industry. To what extent has the European refining sector already moved towards producing more biofuels and which ones? What more can be expected in

[4] Concawe. (2019, Sep). *Refinery 2050: Conceptual assessment. Exploring opportunities and challenges for the EU refining industry to transition towards a low-CO_2 intensive economy.* Retrieved from Concawe: https://www.concawe.eu/wp-content/uploads/Rpt_19-9-1.pdf

terms of biofuel refining in the next decade? What actions have refiners taken to start producing and processing e-fuels?

3. How can the refinery sector transition away from crude oil?

3.1. Stick with what you know: Refiners have mainly invested in biofuels

Ever since targets for renewables in transport were introduced in 2009 in the Renewable Energy Directive, oil companies have started adapting the operations of their crude oil refineries to also produce biofuels. For example, Total converted in recent years two conventional refineries (Grandpuits and La Mède) that were scheduled to be closed into biorefineries able to produce biojet, biodiesel, and bioplastics. But this is more the exception than the rule. A decade after the introduction of biofuel mandates, 80% of biofuel production actually happens outside of conventional refineries, in newly-built dedicated installations, producing FAME biodiesel.[5] These FAME installations produce biodiesel from lipids such as palm oil or Used Cooking Oil (UCO). Going forward, the refining industry does not see any major growth in the capacity to produce FAME (a slight increase of 1 Mtoe by 2030, from 14 to 15 Mtoe, mainly by increasing the utilisation rate of existing facilities). There are 2 reasons why FAME biodiesel is unlikely to grow anymore: First of all, a lot of investment happened in the production of 1st generation crop biofuels, which resulted in an overcapacity, especially since the revision of RED in 2018 capped their contribution at their share in 2020, with a maximum of 7%. Secondly, the 14% target in the 2018 RED for renewables in transport has resulted in reaching the maximum 7% blending wall for FAME B7 biodiesel.[6]

Given the limitations on FAME, oil companies are increasingly investing in their capacity to produce hydrotreated vegetable oils (HVO), which use is not restricted by any blending wall. However, the switch from FAME does not mean that oil companies have decisively shifted away from relying on crop-based biofuels. HVO can be made both from virgin vegetable oils and from waste and residues, but lack of access to transparent information on the type and volumes of different feedstocks used for HVO production makes it difficult to state with confidence that these new facilities won't be using food-based biofuels. The HVO plant of Total in La Mède will rely up to 70% on vegetable oils (rapeseed, palm, sunflower, etc.).[7]

The recently announced plan by Shell in the Netherlands also states that '*A range of certified sustainable vegetable oils, such as rapeseed, will supplement the waste feedstocks until even more sustainable*

[5] T&E. (2021, Jul.). *10 years of EU fuels policy increased EU's reliance on unsustainable biofuels*. Retrieved from https://www.transportenvironment.org/discover/10-years-of-eu-fuels-policy-increased-eus-reliance-on-unsustainable-biofuels/

[6] A blending wall refers to the maximum share of biofuels that can be safely blended with fossil gasoline or diesel, without negative impacts on the performance of the internal combustion engine in terms of efficiency and air pollutants. For example, the B7 blending wall in the EU refers to the maximum FAME content of 7% for diesel. The E10 blending wall refers to a maximum 10% ethanol content for gasoline.

[7] Total (2019, Mar.) *Total Starts Up the La Mède Biorefinery*. Retrieved from https://totalenergies.com/media/news/press-releases/total-starts-la-mede-biorefinery

advanced feedstocks are widely available'[8]. Also, some of the 'waste' claimed by the refining industry are actually residues or by-products already used by other sectors. Similarly, announcements around cellulosic biofuels need to be taken with caution. In the EU, the limited availability of sustainable and scalable sources of truly wasted cellulosic feedstocks will also be a barrier.[9]

Keeping this caveat on HVO in mind, the oil companies are prioritising so-called advanced biofuels in their next investments[10]. **Of the EUR 38.7 billion of investments planned by the refining sector going into new fuels towards 2030, almost 75% will go towards increasing biofuels production capacity**:

- **65% goes to new plants to make biofuels from lignocellulosic feedstocks.** Oil refiners are planning to invest EUR 25 billion in production capacity to process lignocellulosic feedstocks, which will increase biofuel production capacity by 4 Mtoe by means of adding 27 new plants. In contrast to HVO, there are not yet any lignocellulosic residues- and waste-based biofuels production facilities in Europe or in the US that have achieved a commercial scale.
- **The remaining 10% goes to new HVO plants.** Major growth is expected in the production of HVO biodiesel, doubling the production capacity from 5 Mtoe in 2020 today to 10 Mtoe in 2030. This increase will be achieved by investing EUR 2.5-3 billion to build 10 new HVO plants.

These investments will increase total biofuels production capacity from 19 Mtoe/year in 2020 to 29 Mtoe/year in 2030 (see overview in Table 3 below).

The strong investments going into HVO biofuels and in plants producing biofuels from lignocellulosic feedstocks are driven by a number of reasons. For the refining industry, biofuels remain the most typical route for diversification, because they can leverage the existing liquid fuels storage, processing and logistics infrastructure. Secondly, some EU member states may soon reach the cap on the use of food and feed crops for biofuels production and the RED requires all member states to adopt a 1.7% cap on lipid waste-based feedstocks like used cooking oils (UCO) and animal fats (this limit can still be adjusted upwards[11]). This leaves oil refiners with few options other than starting to invest in the processing of feedstocks that are listed in the RED's Annex IX Part A, which are deemed to require additional support for developing the technology, to help them scale up and reduce costs. The lack of sufficient alternative feedstocks, such as UCO and animal fats listed in Annex IX Part B, explains why oil refiners choose to invest mostly in new Biomass-to-Liquids plants, even though the thermochemical conversion routes (gasification, pyrolysis or hydrothermal liquefaction) have a CAPEX intensity that is about 10 times higher than the HVO route (Table 2). If these plants are able to source 'true' wastes without any competing uses, the used feedstocks will be cheaper and - as a result - OPEX costs will be lower. Yet, despite the strong

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[8] Shell. (2021, Sep.). *Shell to build one of Europe's biggest biofuels facilities*. Retrieved from https://www.shell.com/media/news-and-media-releases/2021/shell-to-build-one-of-europes-biggest-biofuels-facilities.html

[9] ICCT (2013, Oct.) *Availability of Cellulosic Residues and Wastes in the EU*. Retrieved from https://theicct.org/publication/availability-of-cellulosic-residues-and-wastes-in-the-eu/

[10] See table 4-8 in Ricardo (2022).

[11] Article 27.1.b of the RED allows member states - where justified - to modify that 1.7% limit, taking into account the availability of feedstock. The Commission needs to to approve this.

focus of investments in the ligno-cellulosic feedstocks, most biofuel volumes will be coming via the HVO route (see Table 3).

Bases (per plant)	Capacity (output) - industrial scale (Mtoe/yr)	Capex (€million)	Capex intensity (€million/Mtoe/yr)
New-built HVO plant	0.5	275	0.55
Biomass-to-liquid plant*	0.15	610 - 900	4.0 - 6.0
E-fuels	0.2	400 - 650	2.0 - 3.3

Note: Due to the cap on food crop-based biofuels, as well as used cooking oil and animal fat, no investment on additional capacity is envisaged towards 2050, increasing utilisation rate of existing plants when required.
*lignocellulosic

Source: Concawe, 2021

Table 2: Estimated Capex for new built plants (Concawe, 2021)

The Argus data underpinning the Ricardo report find that the total biofuels production from repurposed/converted fossil into biofuels refineries and co-processing capacity from other refineries amounted in 2021 to circa 4.4 million t/y or 1.3% of fossil fuel-based road fuel production. Following the adoption of higher targets in the 2018 RED, this number is forecast to more than double by 2025 to 8.9 million t/y or 2.6% of fossil-based road fuel production.[12].

However, ICCT and T&E estimate that the actual availability of sustainable HVO biofuels feedstocks - considered here as animal fats category 1 and 2 as well as UCO sourced in the EU - is around 2.5 Mt/yr in 2030 in the EU[13]. **The forecasted investment to increase the HVO production will result in a refining capacity that is 4 times higher than what can be sustainably sourced in the EU.** As a result, the industry's refineries will very likely rely on unsustainable materials. This would mean relying on large amounts of feedstocks already being used by other industries (e.g. tall oil, animal fats cat. III, etc.), leading to market distortion and negative substitution effects or relying on imports of feedstocks like UCO, with high risks of fraud and indirect deforestation[14]. The latter option also implies that these feedstocks would not be available for the decarbonisation of the exporting countries' own transport sector.

[12] See figure 3-9 in section 3.5 of Ricardo (2022).
[13] While animal fats category 1 and 2 production is expected to stay at its current levels (around 0.75 Mt/yr) because of competition with other uses, the production of UCO in the EU is forecasted to increase from 1.3 Mt/yr in 2020 to 1.7 Mt/yr in 2030 thanks to improved collection schemes.
ICCT. (2021). *Estimating sustainable aviation fuel feedstock availability to meet growing European Union demand*. Retrieved from
https://theicct.org/sites/default/files/publications/Sustainable-aviation-fuel-feedstock-eu-mar2021.pdf
[14] T&E. (2021, Apr.). *Europe's surging demand for used cooking oil could fuel deforestation*. Retrieved from
https://www.transportenvironment.org/discover/europes-surging-demand-used-cooking-oil-could-fuel-deforestation/

Infobox: Synergies between conventional and biofuel refining

There are no unsurmountable technical difficulties in integrating biofuels production in existing crude oil refineries. Some crucial steps in the refining process of crude oil (hydrotreating, fluid catalytic cracking and hydrocracking) are also relevant for the refining of lipids (virgin and waste oils), sugar, starch or lignocellulosic feedstocks. These processes remove the oxygen or convert long chain hydrocarbons into shorter chain molecules. In particular, hydrotreating is essential for the processing of bio-based feedstocks, as these contain significantly higher levels of oxygen than fossil-based feedstocks.

Below is a list of some investments by European oil majors that are planned in the near future in their refining operations:

- **Shell**: An Energy and Chemicals Park will be built in Rotterdam, the Netherlands, with an 820,000 t/y biofuels facility
- **BP**: The company aims to approximately double its current bioenergy production of 25,000 b/d by 2025, and doubling that again to 2030 to reach over 100,000 b/d.
- **ENI**: Eni plans to increase its bio-refining capacity from 1.1 million t/y in 2020 to 2 Mt/yr in 2024, and further increase it to 5-6 Mt/yr by 2050.
- **TOTAL**: The company has a 500,000 t/yr HVO plant at La Mede, where it recently began SAF production, and is converting its Grandpuits facility into a 400,000 t/yr biorefinery that it has scheduled to start up in 2024. This will produce 170,000 t/yr of SAF, 120,000 t/yr of biodiesel and 50,000 t/yr of naphtha for bioplastics. In 2020, TotalEnergies said it planned to add 300,000 t/yr of HVO capacity in Europe from co-processing at existing facilities.
- **Repsol**: The company's aim is to produce 2 Mt/yr of low carbon fuels by 2030, with a target of 1.3 Mt/yr in 2025, producing advanced HVO biofuels.

Infobox: Job impacts[15]

The EU refining industry supports approximately 130,000 employees directly, with many more indirect jobs. Most of the jobs involved - about 80% - are plant operators and staff that supports them (e.g. maintenance, safety and laboratory teams). For the refining capacity that will start converting to renewable fuels, the impact of such a transition will be limited, since plant elements (valves, instruments, tanks) remain similar. Limited re-skilling might be required for plant operators and manufacturing teams, since gradual uptake of novel processes is expected as a matter of course under business as usual. For the engineers (about 10% of the refinery's workforce), training will be needed to understand new equipment and new product specifications. A bigger challenge for the refinery sector is to replace its ageing workforce and attract new talent: Just 4% of workers in the oil and gas industry are aged between 18-24, while 20% are over 55. Employees in the refinery sector are also sensitive to

[15] For more details, see chapter 6 of Ricardo (2022) *What future role for conventional refineries in the decarbonisation transition?*

ensure a sustainable pathway for their future jobs, sometimes mobilising against some of the conversion strategies of oil companies into biofuels. The case of the Grandpuits refinery in France operated by Total is one example. Some trade unionists mobilised against the project of reconversion, because of job losses but also because the reliance on biofuels for the project were not seen as a green or socially just move[16].

3.2 (Not yet) Charting new territories: Renewable and low-carbon hydrogen mostly used to clean up conventional oil refining

Based on an analysis of the announcements by the European oil majors in their refining operations, it is clear that **the overwhelming majority of the investments is going into biofuels, about 8 times more than for investments made in renewable hydrogen and e-fuels (EUR 28 billion vs. EUR 3.3 billion)**.

Some 30 European refineries plan to implement green hydrogen capacity at their facilities. However, most of the investments do not go to producing e-fuels for planes and ships, but 88% or ~EUR 6.5bn of the investments go to deploying Carbon Capture & Storage (CCS). The CCS will be used to clean up the hydrogen produced from natural gas (so called grey hydrogen) used in the refining process, by storing the CO2 resulting from the steam methane reforming of fossil gas underground. Currently, the CO2 is vented to the atmosphere in the production of grey hydrogen. **Only 12% or ~EUR 0.9bn for H2 is spent on replacing grey with green hydrogen in refining**. In other words, oil refiners continue to prioritise investments in low-carbon fuels as a feedstock for their refining operations.

In contrast, e-fuels made from renewable electricity are still not a major priority. Refiners will be investing EUR 3.3 billion in e-fuels such as green hydrogen as a transport fuel or as a feedstock to develop other liquid e-fuels like e-kerosene. This attitude by refiners reflects the current legislative framework: The current RED obliges member states to count renewable hydrogen and e-fuels (RFNBO) towards the obligations of fuel suppliers also “when used as intermediate products for the production of conventional fuels”.

[16] Amis de la terre. (2021, Jan.). *Reconversion de la raffinerie de Grandpuits pourquoi le projet de total n'est ni écolo, ni juste*. Retrieved from https://www.amisdelaterre.org/wp-content/uploads/2021/01/decryptage-plan-raffinerie-grandpuits.pdf

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Note: 1st-of-a-kind refers to the first plants at an industrial scale for specific technologies.

Source: Concawe, 2021

Table 3: Timeframe and investment requirements for low carbon fuels development in the EU

A rapid scaling up of the production of e-fuels suitable for aviation and shipping is the only option to fully decarbonise these transport modes by 2050. However, the current focus by oil suppliers to use renewable hydrogen in their refineries will prolong reliance on fossil fuels in these sectors. It is often presented as a starting point to deploy green hydrogen but refiners need to start shifting the focus to the production of e-fuels as soon as possible. There are many opportunities and synergies between conventional processes and e-fuels production, especially economic drivers such as sharing feedstocks, assets and utilities. The technical capacity to manufacture e-fuels based on green hydrogen and renewable carbon in the future is not limited by any existing refinery feature nor any existing refinery asset (e.g. hydrocracker or hydrogenation unit).

Even stronger, existing refineries are likely to play a key role in co-processing the synthetic crude - produced via the Fischer-Tropsch synthesis process - into a usable fuel that meets industry specifications ASTM D1655 for e.g. jet fuel. Similar to how different biofuel feedstocks can be co-processed and undergo hydrocracking in refineries processing fossil crude.[17] At least in the scale-up phase, e-fuel producers will not invest in their own hydrocracker and rely on existing capacities. The synthetic crude is likely to be co-processed with fossil crude in a hydrocracker of an existing refinery. Existing refining operations are likely to be key assets for scaling up e.g. e-kerosene or e-methanol production.

The critical element to de-bottleneck production of e-fuels is the up-front investment for these novel processes. Green hydrogen production, for example, requires a significant initial investment, which private stakeholders may seek to avoid due to high risks and lack of clear policy support. The maximum e-fuel manufacturing capacity in Europe will thus mainly depend on the policy measures implemented and their impact on the market, as well as on the economic viability of the investment and the availability

[17] See table 4-2 in Ricardo (2022).

of key feedstocks, such as green H2 and sustainable sources of carbon. A dedicated policy push will be needed to push oil refiners to supply e-fuels for aviation and shipping.

However, there is one key e-fuel - especially relevant for shipping - where refineries will not have much of a role to play: e-ammonia.[18] At the refinery level, the opportunity for synergies with ammonia production appear to be limited. For ammonia as a shipping e-fuel, greenfield projects are more likely or will be combined with fertiliser plants. Past analyses by Ricardo show that e-ammonia is one of the cheaper e-fuels to produce compared to other carbon-based e-fuels like e-methanol and e-diesel.[19] If the shipping sector would switch to e-ammonia, shipping bunker fuels would be another product that 'dries up' for the refining sector and that would result in further decreased demand for refined products.

4. Conclusion

The COVID-19 pandemic had a dramatic, albeit short-lived impact on the transport sector's demand for refinery products. However, the European refinery sector is facing even bigger challenges ahead, as the EU's decision to phase-out the internal combustion engine by 2035 will lead to a more fundamental and long-lasting shift. From 2030, road transport demand is expected to drop by -5% and -4% per year for gasoline and diesel respectively.

The refinery sector will not only shrink; It will also need to make the switch away from exclusively refining fossil fuels to also processing more renewable fuels to secure its longer-term future. The refining sector already started integrating production of drop-in HVO/HEFA biofuels in its existing refineries and is looking to double current HVO capacity by 2030. In the past, refiners prioritised investing in HVO over other advanced biofuels, like from lignocellulosic feedstocks. The latter's capital costs are about 10 times higher. However, the increased HVO capacity comes with significant sustainability risks, as that 2030 capacity will be 4 times higher than domestic supplies of sustainable feedstocks.. This should serve as a cautionary tale for the EUR 25 billion that refiners are investing in lignocellulosic advanced biofuels: major uncertainties persist about the sustainable quantities from the agricultural and forestry industries.

Despite the ongoing hype about hydrogen, refiners are not jumping on the bandwagon yet. Planned investments in biofuels are about 8 times higher than investments made in renewable hydrogen and e-fuels. And with regard to hydrogen, most of the investment is aimed at reducing the carbon intensity of fossil fuel by replacing grey hydrogen with mostly blue hydrogen and some tentative first steps towards using green hydrogen. This is unfortunate, as there are many opportunities and synergies between conventional refining and e-fuels production. A strong mandate for e-fuels production will be necessary to get refiners investing in e-fuels for the hard to abate transport sectors like aviation and shipping. The ongoing negotiations on the RED and the proposed ReFuelEU and FuelEU regulations for aviation and shipping need to provide a clear regulatory framework, ensuring e-fuels are prioritised for planes and ships.

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[18] See section 4.2.1. in Ricardo (2022).
[19] Ricardo. (2020, Dec). *Electrofuels? Yes, we can if we're efficient*. Retrieved from https://www.transportenvironment.org/discover/electrofuels-yes-we-can-if-were-efficient/

On the basis of the evidence presented in this briefing and the accompanying report, **T&E calls on policy-makers to consider the following recommendations**:

- The EU should decisively reduce the refining sector's use of crop-based biofuels by phasing out support for them under the RED's renewable transport fuel obligations for fuel suppliers.
- Refiners have plans to invest in more biofuels refining infrastructure, but there remains a lack of transparency about the feedstocks that will be used. The oil industry should be obliged to disclose feedstocks they use and to what extent. A swift implementation of the EU's product database can play an important role here.
- Given the strong focus on investing in new advanced biofuel production, the RED must keep the target for the contribution of Annex IX Part A feedstocks at a realistic level and in line with domestic availability in the EU.
- The 1.7% cap on Annex IX Part B for waste-based feedstocks is to be maintained. Adherence to the cascading principle needs to be strengthened in the RED to avoid diverting waste feedstocks from other industries.
- The RED targets for renewables in transport should focus exclusively on the delivery of final fuels. The use of green hydrogen to reduce the carbon intensity of crude oil refining should be deleted from the RED's transport targets, as they would fit better under the RED targets for renewables in industry. That would enable the RED targets to focus exclusively on supplying RFNBOs to planes and ships, where electrification is not an option.
- A stronger policy push for fuel suppliers to deliver e-fuels to the aviation and shipping sector will be needed by including a 2% e-kerosene mandate under the ReFuelEU regulation and a shipping e-fuels subtarget under the RFNBO mandate in the forthcoming RED.

Further information

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