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NEXT **GENERATION** FUELS

Powering the future of greener transport

CONTENT

While our shrinking world has had manifold benefits, such as technology globalisation reducing transport costs alongside increasing interconnectedness and collaboration between economies worldwide, this has come at the expense of global carbon emissions. The reliance on fossil-fuels to transport people and goods currently represents more than 7 billion tons of CO2 equivalent, i.e. around 17% of the global total. With forecasts indicating ever-growing travel demand and exacerbated logistics needs in the future, a drastic decoupling of transport-related GHG emissions and economic growth is required, and there is a pressing need for more efficient answers to increasing global energy demand by 2050. This calls for broad electrification, switching away from today's almost two-thirds of thin-aired primary energy due to fossil fuel combustion.

Nonetheless, while the transition is already underway for easier-to-abate mobility, key strategic challenges arise from technical gaps in hard-to-abate segments. As such, bio-and alternative fuels have emerged as pivotal solutions in the quest for sustainable energy, with multiple sectors currently using or having intentions to rely on bio- and synthetic feedstock to drive their decarbonisation efforts. Whether derived from biological materials such as plant biomass, animal waste, and algae, they represent complementary drop-in alternatives both for the remaining fleets under transition and heavy-duty vehicles for which no other technological alternatives are yet available. Currently, biofuels account for only around 4% of total energy consumption in transport and are mostly used on roads. However, scaling new biofuels is challenging due to insufficient sustainable biomass availability, which requires better resource management – such as preferring one production pathway over another, experimenting with new bio- and e-inputs, and building alternative fuels infrastructure.

At the same time, renewed momentum in the bio- and alternative fuels sector is driven by tightened emissions targets, new green fuel mandates, and penalties such as ReFuelEU Aviation and FuelEU Maritime (in addition to RED III, which targets 29% renewable energy in transport) in Europe, or the SAF Grand Challenge in the US. These initiatives are attracting interest from strategics and investors, either betting on meeting quotas or on new, forward-looking technologies. With targets set for at least 6% of SAF by 2030 (including 1.2% e-SAF) and 2% RFNBO in maritime by 2034, dramatic changes to overall production and fuelling infrastructure are expected over the next decade.

Challenges therefore remain, particularly regarding supply chain inefficiencies, which may shift from centralised to decentralised production hubs to adapt to local feedstock constraints. This involves different logistics and infrastructure, and the need for policy interventions to level the playing field between fossil and sustainable fuels, especially in terms of carbon cost reflection. From infrastructure providers to fleet operators, and technology providers to energy suppliers, every company in the value chain can embrace the shift by leveraging advanced production technologies, renewable energy systems, and circular economy principles. This approach can maximise profitability, transform feedstock security into downstream profits, and pave the way for a greener future in transportation.

TRANSPORT IS ON THE VERGE OF A **RADICAL TRANSITION**

SECTION 1

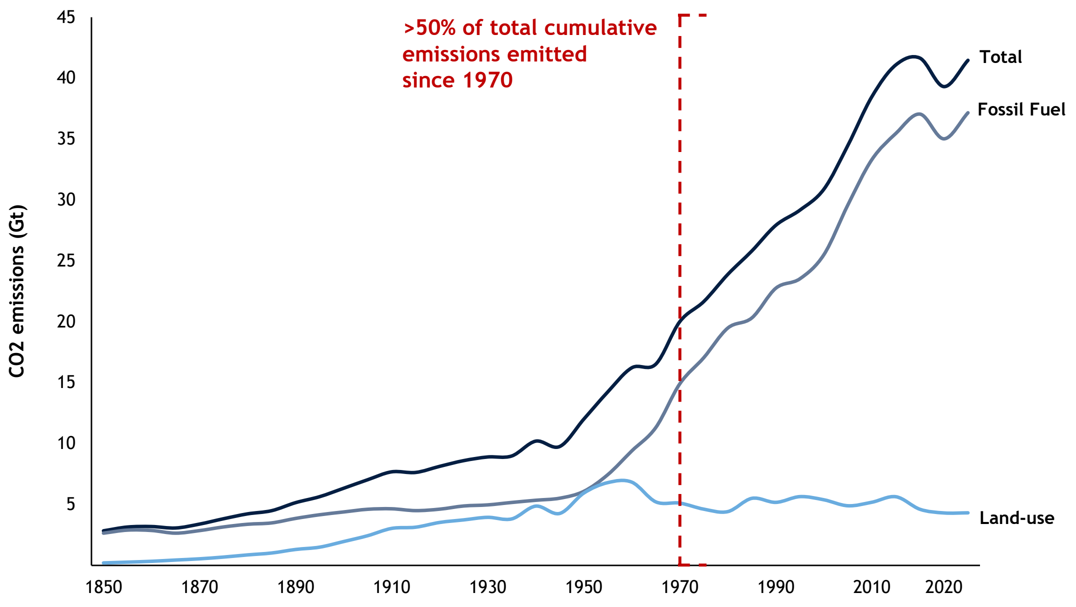
TAKING THE PULSE OF **DECARBONISATION EFFORTS** IN TRANSPORT

Deep dive into overall CO2 emissions

Addressing climate change requires a collaborative effort from governments, industries and society. Carbon dioxide (CO2) is estimated to be the largest contributor to global warming, responsible for around two-thirds of the increase in temperature since the pre-industrial era. CO2 emissions have doubled over the past 50 years, with nearly 42 billion tonnes of CO2e (which includes the impact of all greenhouse gases) released into the atmosphere worldwide in 2023. During that year, global CO2 emissions related to the use of fossil materials increased by 1.1%, adding another 410 million tonnes to reach a record high of 37 billion tonnes.

Although fossil CO2 emissions are decreasing in developed regions, they continue to rise overall, highlighting that actions taken to bend the curve are insufficient to drastically reduce fossil fuel utilisation at a global scale. This can be seen in 2023 data, where emissions increased by 8% and 4% respectively in India and China while declining by 7% and 3% in the EU and USA. Even though China is installing far more renewable capacity, its energy-hungry industrial sector continues to grow fast, ultimately exacerbating intermittency issues and grid flexibility requirements, which hampers net renewable capacity factors and grid decarbonisation potential.

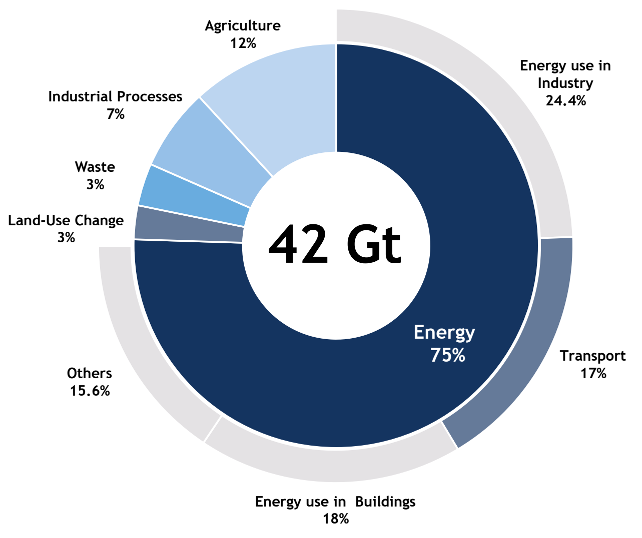
FIG 1: GLOBAL CO2 EQUIVALENT (CO2E) EMISSIONS FROM 1850 TO 2023 (GT/YEAR)



*Source: Global Carbon Budget, Stifel**

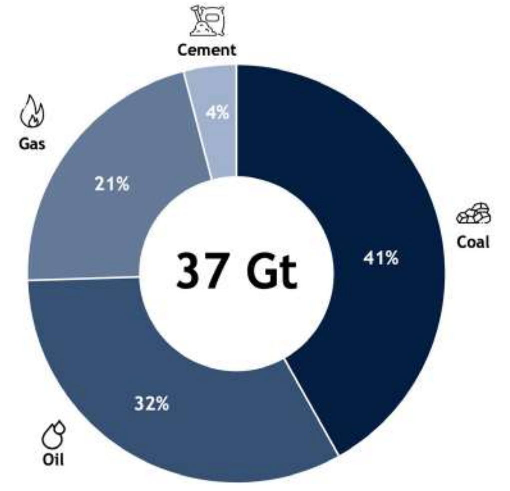
This dependency on fossil fuels directly stems from human activities' large primary energy requirements, allowing for cheap but dirty economic growth. Similarly to process industries, in terms of CO2 emissions, transport is considered "hard to abate". Although passenger transport can be decarbonised through electrification, which is more energy efficient (per unit of work) than combustion engines and can be powered by renewable sources, decarbonisation for other segments such as aviation, maritime and other heavy-duty vehicles (HDVs), whether on- or off-road, depend on technical progress.

FIG 2: GLOBAL CO2 EMISSIONS BREAKDOWN PER SECTOR AS OF 2023



*Source: Climate watch, IEA, Stifel**

FIG 3: BREAKDOWN OF GLOBAL CO2 EMISSIONS FROM FOSSIL-USE AS OF 2023



*Source: IEA, Stifel**

For example, the global transport system contributes about 17% of global CO2 emissions, more than two-thirds of which comes from road travel. There is therefore growing pressure from developed countries and emerging countries for passenger fleet electrification. However, significant challenges remain with heavy-duty vehicles (HDVs), mostly because of constraints relating to weight and energy density.

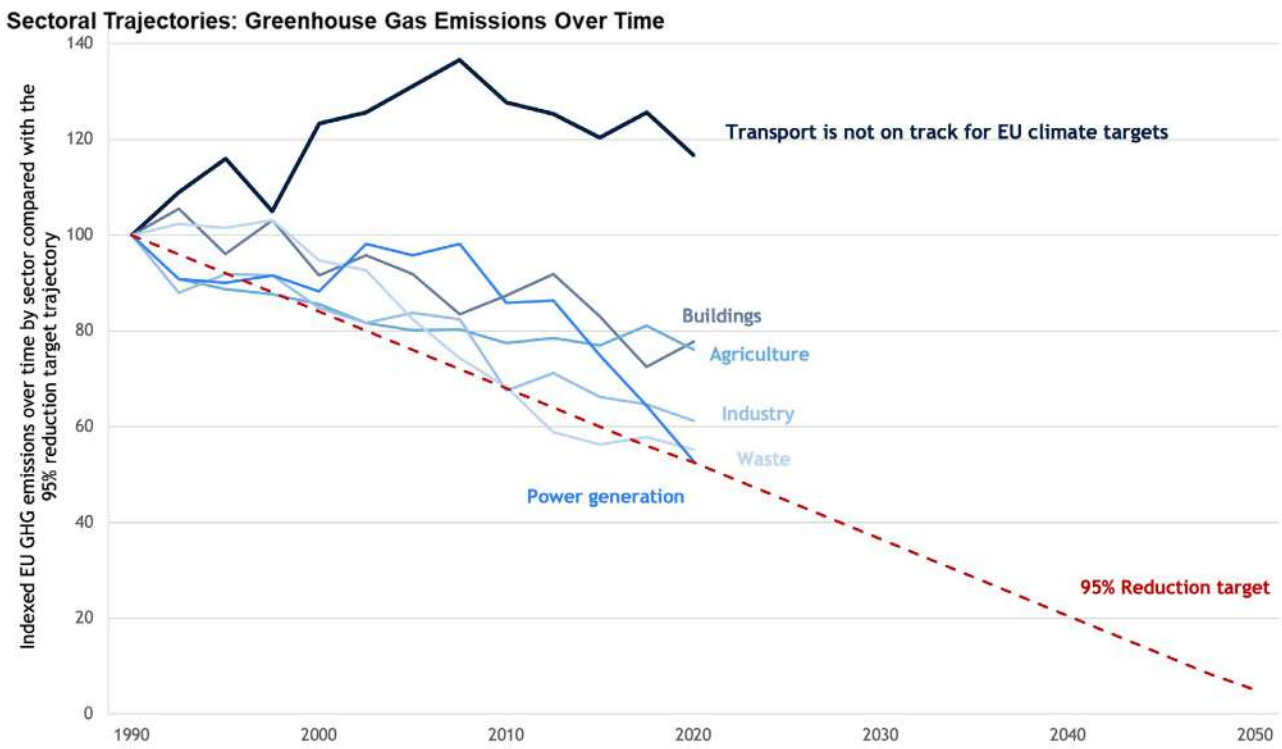
For road HDVs, which currently account for close to 40% of road transport emissions, existing technologies and the pace of improvement allow for a gradual decarbonisation of both the existing fleet and infrastructure. However, aviation and shipping, often highlighted as large emitters and respectively responsible for 11% and 13% of global transport emissions, pose different challenges. By 2050 the global vehicle fleet is expected to nearly double, also with passenger flights projected to grow by 140% above pre-pandemic levels, and cargo tonne-miles at sea anticipated to expand by 40%. To accommodate these growth levels with emissions reduction targets, wide adoption of bio- and alternative fuels, which come with better GHG emissions life cycle assessment (LCA) compared to their fossil counterparts, could be necessary to reduce emissions from existing fleets alongside their conversion, where possible, towards leaner-energy and lower-emission systems.

FIG 4: TRANSPORT-RELATED CO2 EMISSIONS BREAKDOWN AS OF 2022

*Source: Global Carbon Budget, Stifel**

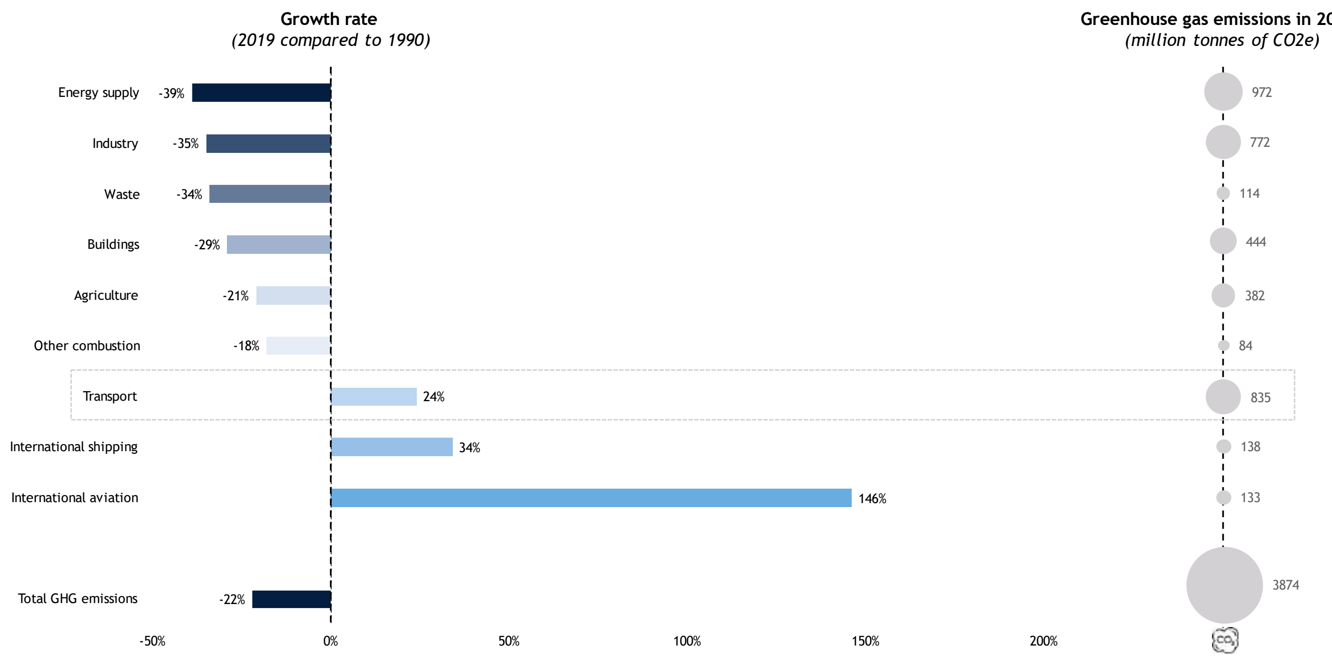
To align with the 1.5C pathway set by the Paris Agreement, every industry must undergo rapid decarbonisation but the transportation sector lags behind its targets. For example, in the EU, which is known for strict decarbonisation guidelines and diverse intermodal transportation options, the transport industry remains off-track in achieving Paris-aligned climate goals. It is the only sector to have increased its overall emissions since 1990.

FIG 5: GHG EMISSIONS TRAJECTORIES PER SECTOR IN THE EU SINCE 1990



*Source: McKinsey, Stifel**

FIG 6: GHG SAVINGS/ADDITIONS IN THE EU BY SECTOR SINCE 1990



*Source: EEA, ECA, Stifel**

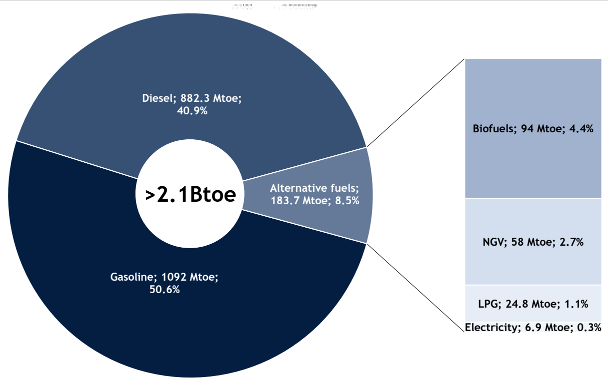
Road transport leads the switch

The road transport sector is leading the shift towards lower- and zero-emission technologies, driven by the gradual adoption of electric vehicles and ambitious targets from governments to transition existing vehicles fleets to electric systems. In that regard, the EU as been particularly aggressive, mandating that all new car sales be electric by 2035 and requiring all new urban buses to be zero-emission by 2030. Additionally, stringent emission reduction targets for other road HDVs have been set, aiming for a 45% GHG emission reduction by 2030, 65% by 2035, and 90% by 2040 compared to 2019 levels.

However, in the medium- to long-term, alternative solutions such as bio and alternative fuels are essential complement to bridge the gap until the value chain for battery electric vehicles (BEVs) becomes fully established. While the adoption of fully electrified vehicles is accelerating, at varying paces depending on the market, it will take decades before traditional internal combustion engines (ICE) are completely phased out and grid infrastructure fully ramped up. Hybrids will therefore buy slightly more time for gasoline and diesel on the passenger vehicle roadmap.

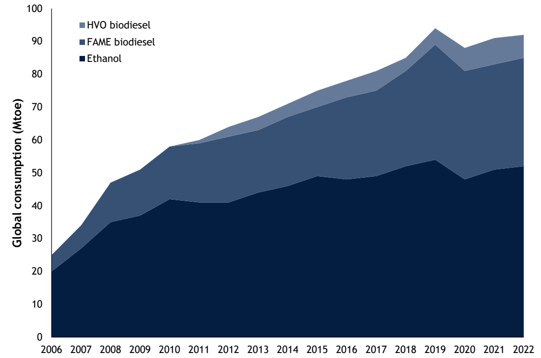
Alternative fuels (such as bio and renewable diesel/ethanol) serve as partial substitutes for traditional diesel and gasoline and are emerging as an interim solution for the road transport sector, but with wide disparities in blending mandates. Government policies and regulations therefore play a crucial role, indirectly setting the pace of growth in the market, as many countries have implemented blending mandates. In the US, for example, biofuel demand is managed through the Renewable Fuel Standard (RFS), Brazil uses the RenovaBio policy and in Europe, the implementation of RED III in each EU member's national law is expected to happen in the next 12-18 months.

FIG 7: WORLD ENERGY CONSUMPTION IN ROAD TRANSPORT IN 2022 (MTOE/YEAR)



Source: IFP Energies Nouvelles, S&P

FIG 8: GLOBAL ETHANOL, BIODIESEL & RENEWABLE DIESEL PRODUCTION FOR ROAD TRANSPORT



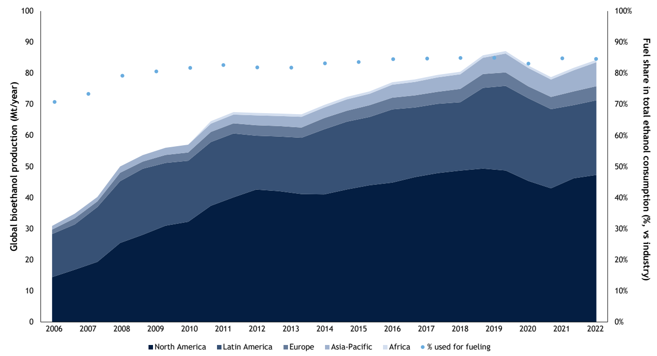
Source: IFP Energies Nouvelles, S&P, IEA

In Brazil for example, pure gasoline is no longer sold due to a mandatory ethanol blend requirement of 27%; Finland has a 18% mandate. Similarly in Indonesia and Costa Rica, 20% biodiesel blending mandates support overall demand and underlying ecosystem development. Brazil has a 10% biodiesel blending mandate. Mandates tend to be less ambitious for biodiesel than bioethanol, whether because of underlying feedstock availability or overall life cycle analysis (LCA). In 2022, those biofuels accounted for 94Mtoe, representing nearly 5% of road transport energy consumption and are expected to rise to just 7% by 2030 according to the IEA, alongside the uptake of electric vehicles. Current global bioethanol production volumes are 80-85Mt/year, while production of biodiesel, including both hydrotreated vegetable oil (HVO) and fatty acid methyl ester (FAME), stands at around 45-50Mt/year. Both fuels have seen significant volumes growth since the early 2000s.

Supportive regulatory environments in developed markets, specifically the 2005 Renewable Fuel Standard (RFS) in the US, drove significant volume growth in the biofuel industry. Transport now represents the bulk of bioethanol consumption annually, using it as a gasoline additive.

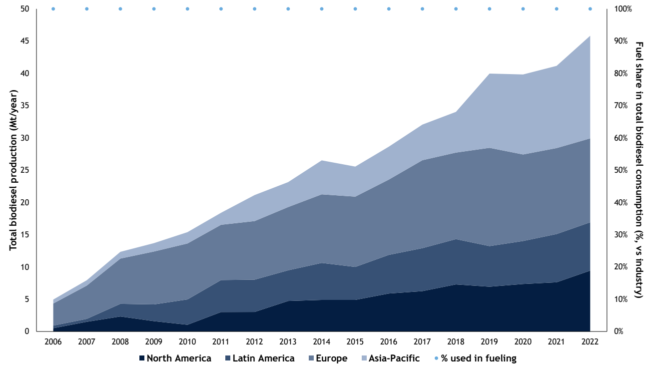
The biodiesel ecosystem has developed in a similar way but with smaller volumes than ethanol. Growing emphasis on feedstock price and availability, and competition with food crops will skew future growth in the sector towards the use of waste and residues from sustainable feedstock, with new production alternatives such as HVO emerging for renewable diesel. Although ethanol remains the most widely used biofuel globally, production growth largely depends on the pace at which the existing road fleet electrifies and new applications develop, especially in aviation for which sugars and/or ethanol could be processed into relevant feedstock or directly into kerosene (see SAF section). In contrast, biodiesel production has increased at an almost linear pace since 2000, led by ever-growing logistics needs and supportive regulatory environments in Asia, Europe and the US. However, it faces similar constraints to ethanol in the future.

FIG 9: GLOBAL BIOETHANOL PRODUCTION IN MT BY REGION (2006-2022 PERIOD)



*Source: IFP Energies Nouvelles, S&P, Stifel**

FIG 10: GLOBAL BIO AND RENEWABLE DIESEL PRODUCTION IN MT BY REGION (2006-2022 PERIOD)

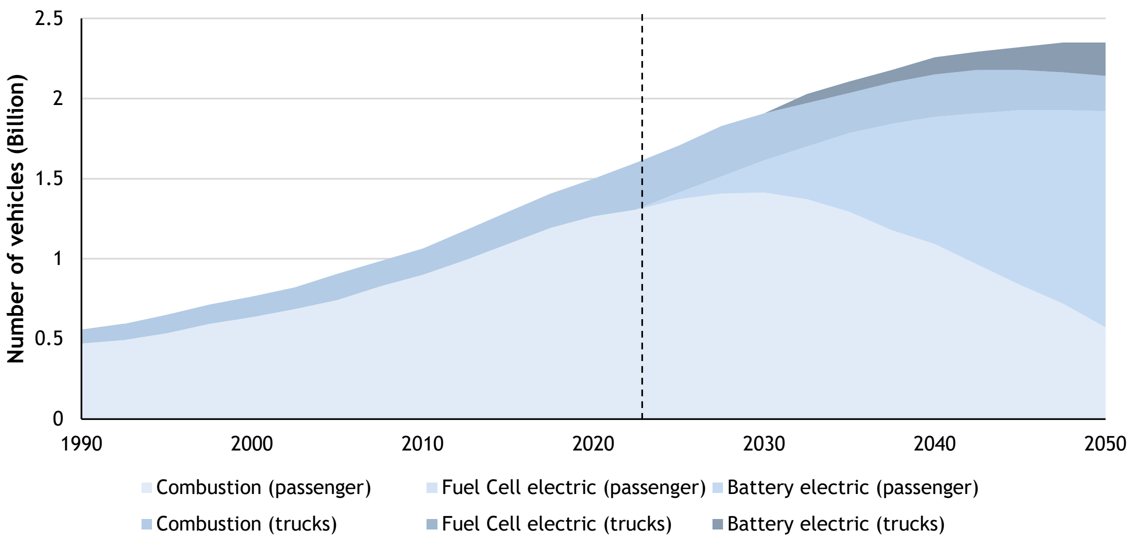


*Source: IFP Energies Nouvelles, S&P, Stifel**

With biofuels set to play an important role in decarbonising transport by providing low-carbon solutions for existing internal combustion engines technologies in the near-term and for heavy-duty trucks, ships, and aircraft in the long term, global demand is expected to continue to grow, with Asia likely to outpace other areas. However, regulators must carefully monitor the expansion of each biofuel sub-segment in the context of ensuring minimal impact on land use, food and feed prices and overall GHG emissions.

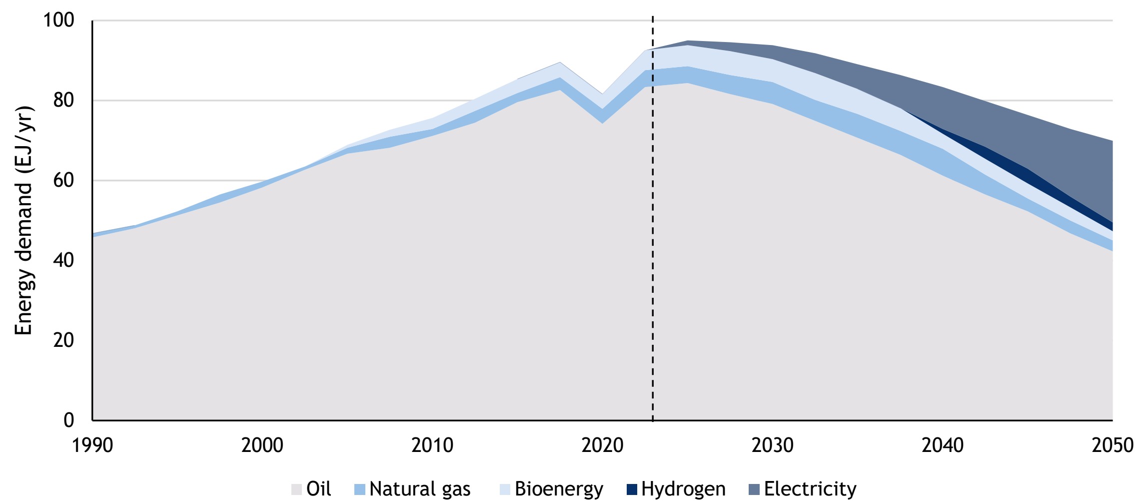
Road transport electrification is proceeding in stages, from the easiest to the hardest to abate segments – first light mobility, then shared and light commercial vehicles and ultimately HDVs. Biofuels complement this evolution. Depending on the development of charging, penetration of renewable energy and increased grid flexibility, both solutions should coexist in the coming decades, especially in light of a global fleet expected to expand from just over 1.6bn road vehicles today to 2.3bn by 2050. While the overall share of ICE vehicles in the fleet should drop from almost 100% to less than 30% over this period, with most of the decrease from passenger vehicles, the transition of ICE HDVs to electric power will gather more traction from 2030 onwards, reaching about 50% of the fleet by 2050. So, with governments acting as a "referee", biofuels will play a crucial role in supporting the decarbonisation of transport. They can provide immediate solutions to decarbonise remaining passenger or logistics fleets, with drop-in solutions for road segments where electrification is less feasible in the near term.

FIG 11: WORLDWIDE ROAD VEHICLE FLEET PER ENGINE TYPE FROM 1990 TO 2050 (IN BN VEHICLES)



*Source: DNV, Stifel**

FIG 12: GLOBAL ROAD TRANSPORT ENERGY DEMAND BY CARRIER FROM 1990 TO 2050 (EJ/YEAR)

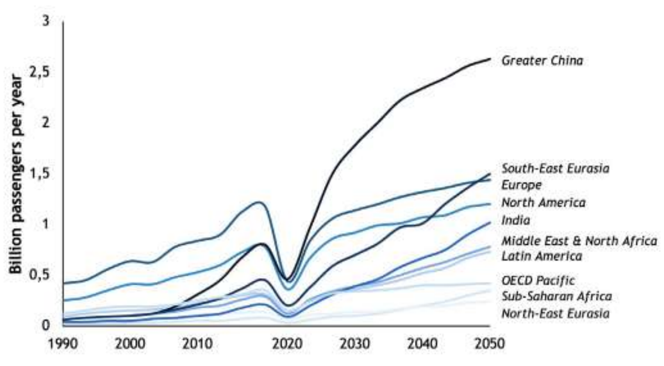


*Source: DNV, Stifel**

Growing air travel demand leaves no option for airliners

Air traffic currently accounts for 2-3% of global CO2 emissions, a relatively small share compared to road transport. However, aviation is one of the most carbon-intensive transport activities and increasing air traffic rapidly leads to a large increase in CO2 emissions. Since 1990, passenger and freight flight demand has approximately quadrupled, and despite COVID-19, the number of flights is returning to pre-pandemic levels (94% of 2019 traffic according to IATA in 2023). Looking ahead, projections from the World Economic Forum suggest that flight demand could at least double or even quintuple by 2050, while IATA estimates air travel demand could double by 2040, growing at an annual average rate of 3-4%. More than half of this growth will stem from APAC, due to favorable demographics and rising household incomes, while mature aviation markets such as North America and Europe will continue to grow a at slower pace.

FIG 13: AIR PASSENGER DEMAND DYNAMICS FROM 1990 TO 2050 (BN PASSENGER/YEAR)



*Source: ICAO, Airbus GMF, Stifel**

FIG 14: GROWTH BY MACRO REGION, DEVELOPING VS EMERGING MARKETS

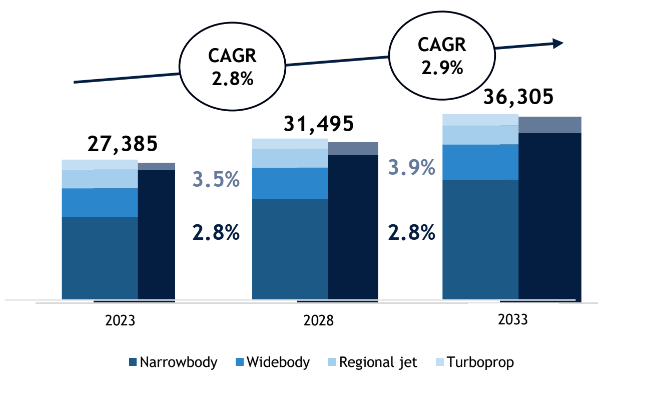
	Recovery year	CAGR (2019-2040)	Additional passengers by 2040, millions
Africa	2024	3.4%	155.7
Asia Pacific	2024	4.6%	2,554.4
Europe	2024	2.1%	665.8
Middle East	2024	3.7%	276.0
North America	2023	2.2%	565.0
Latin America & Caribbean	2023	2.9%	313.5
World	**2024**	**3.4%**	**3,940.8**

*Source: IATA, Stifel**

This growing demand is expected to drive 33% growth in the worldwide commercial aviation fleet, representing more than 36,000 aircraft by 2033 (+2.9% CAGR from 2023). This will lead to higher GHG emissions despite improving engine efficiency. Unsurprisingly, although long and medium-haul flights only constitute around 30% of the fleet, they create close to 75% of CO2 emissions due to their higher fuel consumption. With ever-growing needs for larger airplanes to limit fleet expansion and answer travel demand, as well as slightly more dynamic growth in cargo vs. passenger flights, CO2 emissions growth could surpass fleet expansion if nothing is done to mitigate jet fuel carbon intensity and consumption per plane.

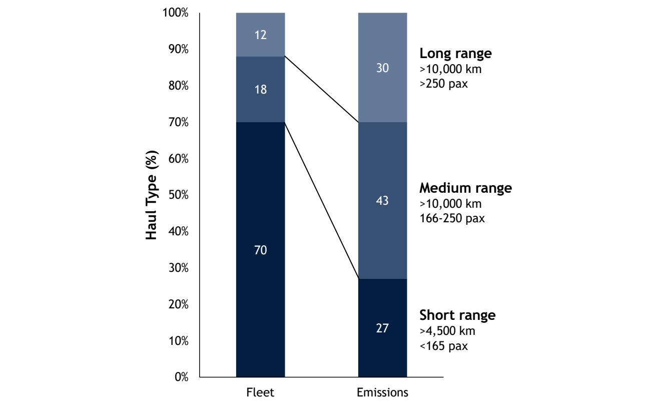
Finding a solution to aviation's carbon footprint is therefore critical. But electrification solutions that work for road transport are difficult to implement for aviation, especially for long-haul flights, based on the current energy density of batteries and high volumes required for hydrogen storage. Moreover, aeroplanes' 20 to 30-year lifespans and oligopolistic manufacturing ecosystems slow down a complete transition to new systems.

FIG 15: SUPERIOR ENGINE EFFICIENCY PREREQUISITE TO CONTINUOUS FLEET EXPANSION (# AIRCRAFT)



*Source: Oliver Wyman, Stifel**

FIG 16: MED/LONG-HAUL DRIVES MOST FUEL CONSUMPTION AND ~75% OF EMISSIONS

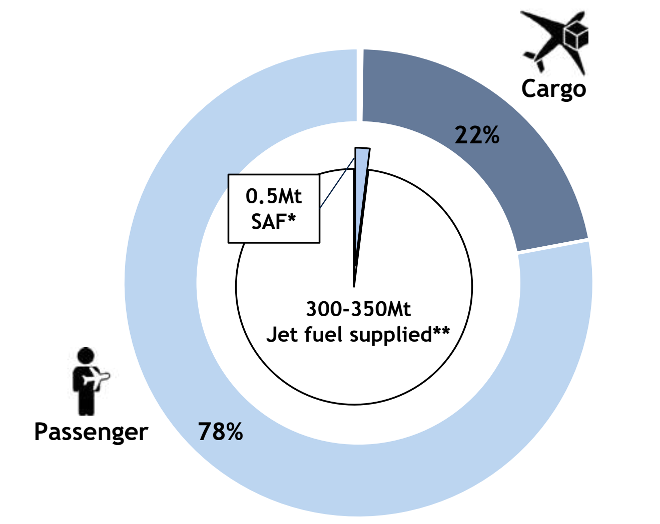


*Source: McKinsey, FCH JU, Stifel**

Given these challenges, sustainable aviation fuel (SAF) has emerged as a more immediate and impactful solution. SAF can reduce CO2 emissions by up to 75-100% compared to fossil kerosene and can be blended without requiring significant changes to existing infrastructure. Despite SAF's market readiness, it accounted for significantly less than 1% of aviation fuel in 2023, reaching close to 0.5Mt. It is now on a path towards 1.5Mt in 2024 (ie. 0.5% of total jet fuel consumption).

Expanding SAF production requires global collaboration among governments, industry, and regulators. However, there is growing competition across the bio and alternative fuels subsectors to secure relevant feedstocks. So, while the SAF ecosystem matures, it will be necessary to incorporate both biomass-based and synthetic fuels. Nonetheless, as highlighted above, SAF alone may not cover all emissions. Steady improvements in engine and system efficiency (historically around 1% per year) will also be needed to partially offset otherwise growing jet fuel demand.

FIG 17: GLOBAL JET FUEL CONSUMPTION IN MT/YEAR (2019-2023)

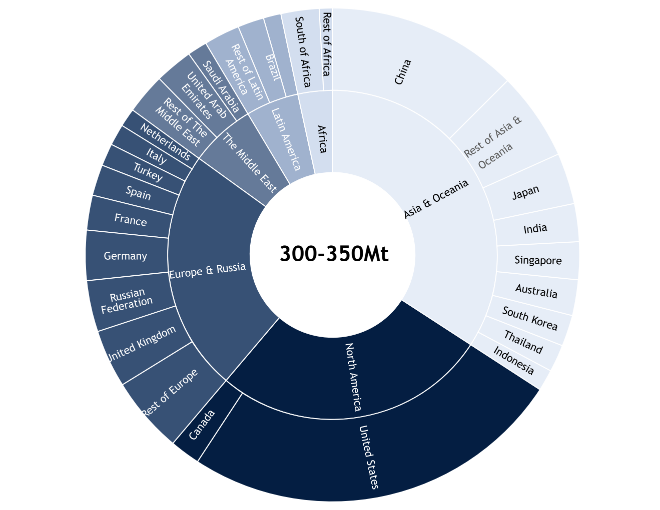


**SAF share in total jet fuel supplied*

***excluding Covid crisis with around 215Mt supplied in 2020*

*Source: Airbus, McKinsey, ICAO, Stifel**

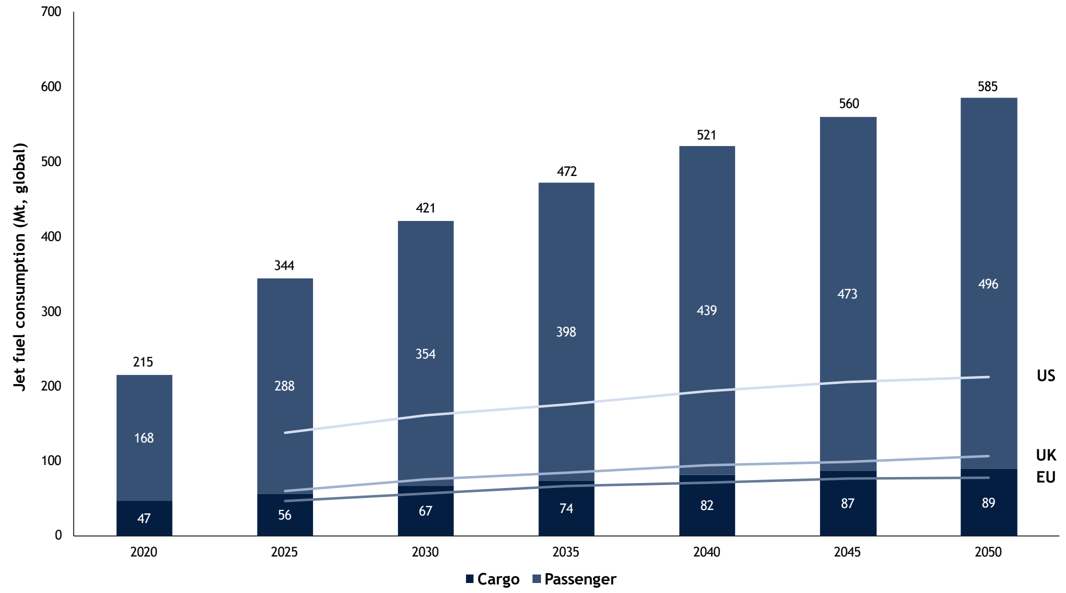
FIG 18: JET FUEL CONSUMPTION BREAKDOWN PER COUNTRY



*Source: Nature, Stifel**

FIG 19: EXPECTED JET FUEL CONSUMPTION FROM 2020 TO 2050

Equivalent global CO_2 emissions assuming 100% fossil jet (in billions of tons)	0.7	1.0	1.3	1.5	1.6	1.8	1.9



*Source: McKinsey, IATA, ICAO, Stifel**

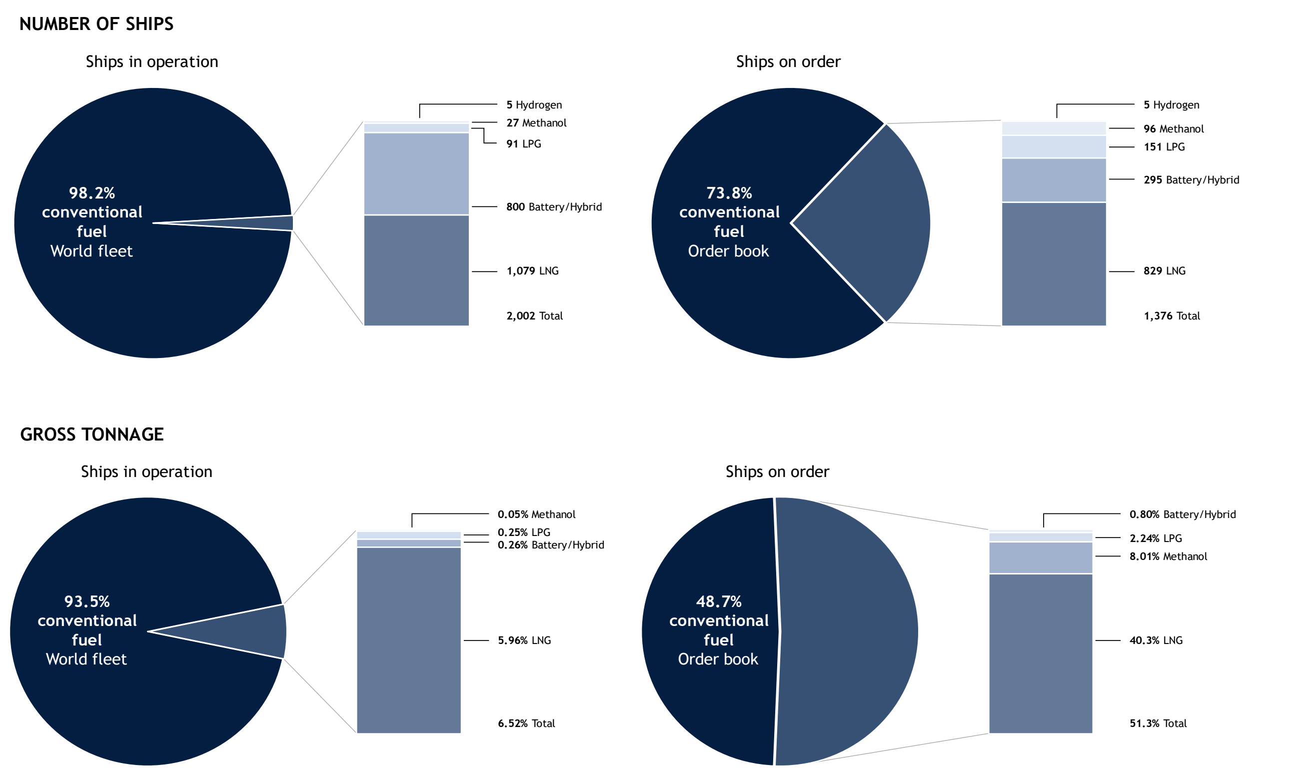
New horizons as global shipping and infrastructure gears up

Since the 1960s, heavy fuel oil (HFO), a viscous byproduct of oil refining, has dominated marine fuels. Although unsuitable for most transportation modes, HFO remains a go-to fuel for the shipping industry due to its low cost and abundance, with some marine engines specifically designed to handle its properties. Despite its economic advantages, HFO has severe environmental and health impacts, including high sulphur content, which can contribute to acid rain and respiratory diseases. Regulations have therefore been introduced to address these issues, such as the International Maritime Organisation's (IMO) global sulphur cap, which reduced allowable sulphur content in marine fuels to 0.5% as of 2020, and NOx Tiers aimed at reducing nitrogen oxide emissions. Those have resulted in a transition from HFO to low sulphur fuels and cleaner alternatives.

This shift is part of a broader regulatory trend to reduce carbon intensity of new vessels, progressively reducing CO2 emissions from the fleet, but decision and investment cycles are slow compared with road and aviation. Nonetheless, 6.5% of operational shipping tonnage can currently run on alternative fuels such as liquified natural gas (LNG), liquified petroleum gas (LPG), methanol or electricity, an increase from 5.5% in 2023. Currently, 26.2% of ships on orders awaiting delivery include alternative fuel systems. Short range and inland shipping is well positioned to move forward with electrification, with 800 fully electrified or hybrid vessels in the current fleet and 295 on order. Deepwater shipping is also transitioning, with half of the ordered tonnage equipped for LNG, LPG, or methanol dual-fuel engines, compared to one-third last year. LNG vessels have the potential to reduce GHG emissions by up to 23%, nitrogen oxides (NOx) emissions by 80%, and almost eliminate sulphur oxides (SOx), with fossil natural gas. If these ships were to adopt biomethane in the future, they could achieve over 100% emission reductions depending on upstream pathways for biomethane production.

However, as demand and cross-sector competition for biomethane increase, there will not be enough supply for a global fleet completely running on LNG. Other alternative fuels must also be considered, but their adoption is currently limited due to high costs, ongoing technology and infrastructure development. As of last year, 8% of new ship orders were for vessels designed for methanol. However, no consensus has been reached yet among shippers, with orders arriving for all solutions including LNG, methanol and ammonia. This ultimately adds new demand to high-emitting processes while at the same time giving new and low-carbon infrastructure investments a higher profile.

FIG 20: GLOBAL VESSEL FLEET BREAKDOWN AND ORDERBOOK DYNAMIC (AS OF JULY 2023)

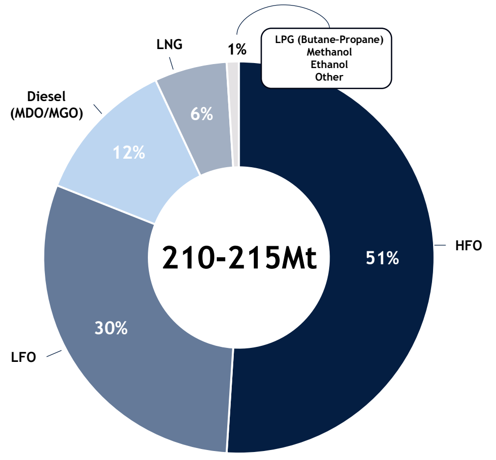


*Source: DNV, Stifel**

The industry is mostly testing available solutions and not yet fully transitioning to alternative fuels. Investments are being made in dual-fuel ships that can accommodate both fossil and non-fossil fuels, although fossil fuels remain the most commonly used. Focus areas for the industry are likely be optimising existing fleets and enhancing operational efficiencies rather than expanding the number of vessels; complying with regulatory guidelines; and making broader efforts to reduce the environmental impact of maritime transport. This shift suggests that the fleet will not significantly evolve in size but will instead be readapted alongside new bunkering and terminal infrastructure in ports.

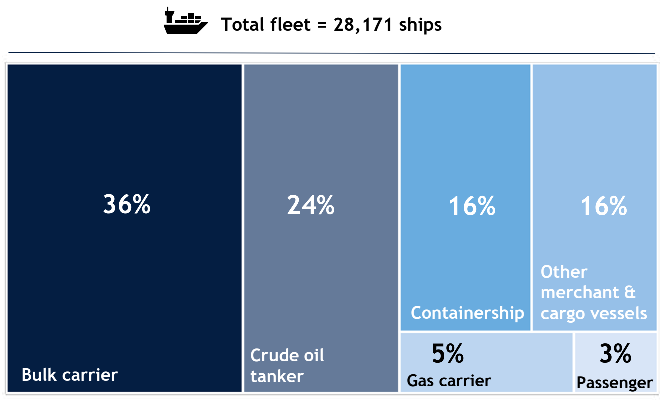
With oil demand expected to fall over the coming decades, maritime transport is poised for a material change in what it carries, with projections indicating the global fleet might reach a plateau in number of vessels by 2035-2040. This potential stabilisation also stems from advances in shipping technology, engine efficiency improvements and stricter environmental regulations.

FIG 21: GLOBAL COMMERCIAL MARINE FUEL CONSUMPTION IN MT (AS OF 2021)



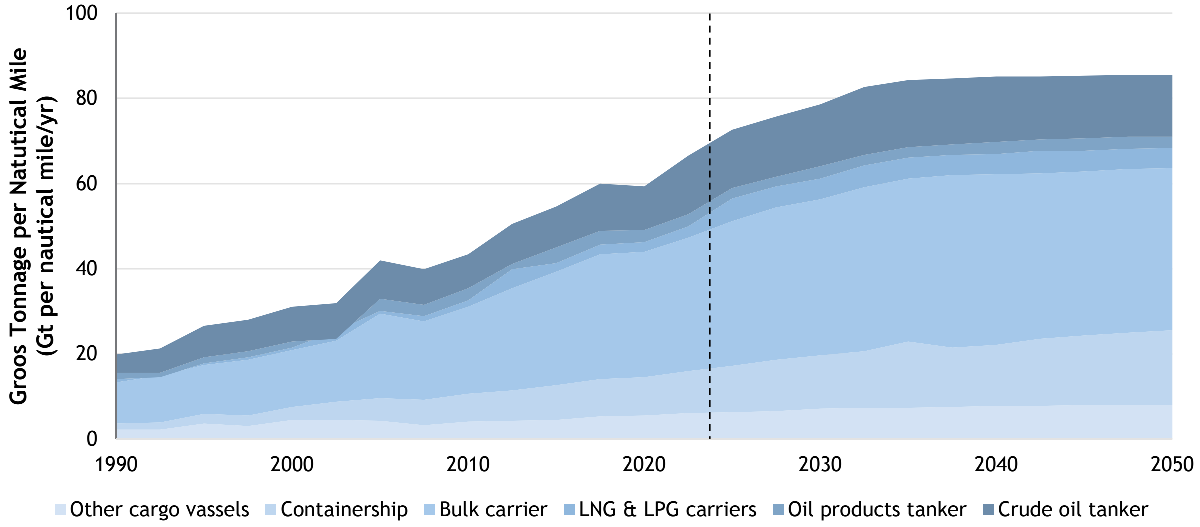
*Source: IMO, Stifel**

FIG 22: WORLD FLEET COMPOSITION (IN 2021)



*Source: IMO, Stifel**

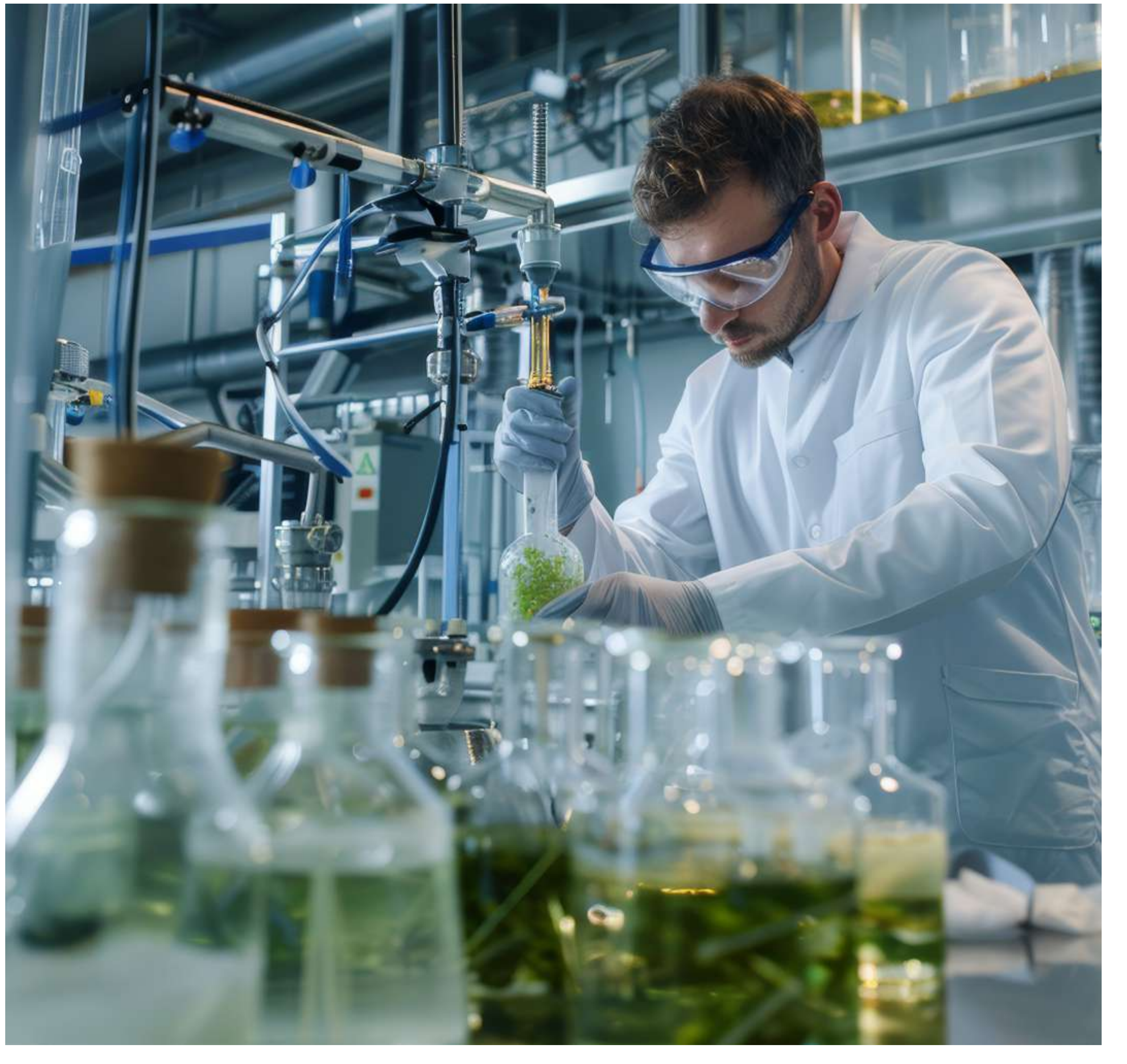
FIG 23: WORLD SEABORNE TRADE DYNAMIC IN TONNE-MILE PER VESSEL TYPE (FROM 1990 TO 2050)



*Source: Michael Barnard, IMO, Stifel**

REGULATION IS A **KEY ENABLER** FOR SUSTAINABLE FUELS

SECTION 2

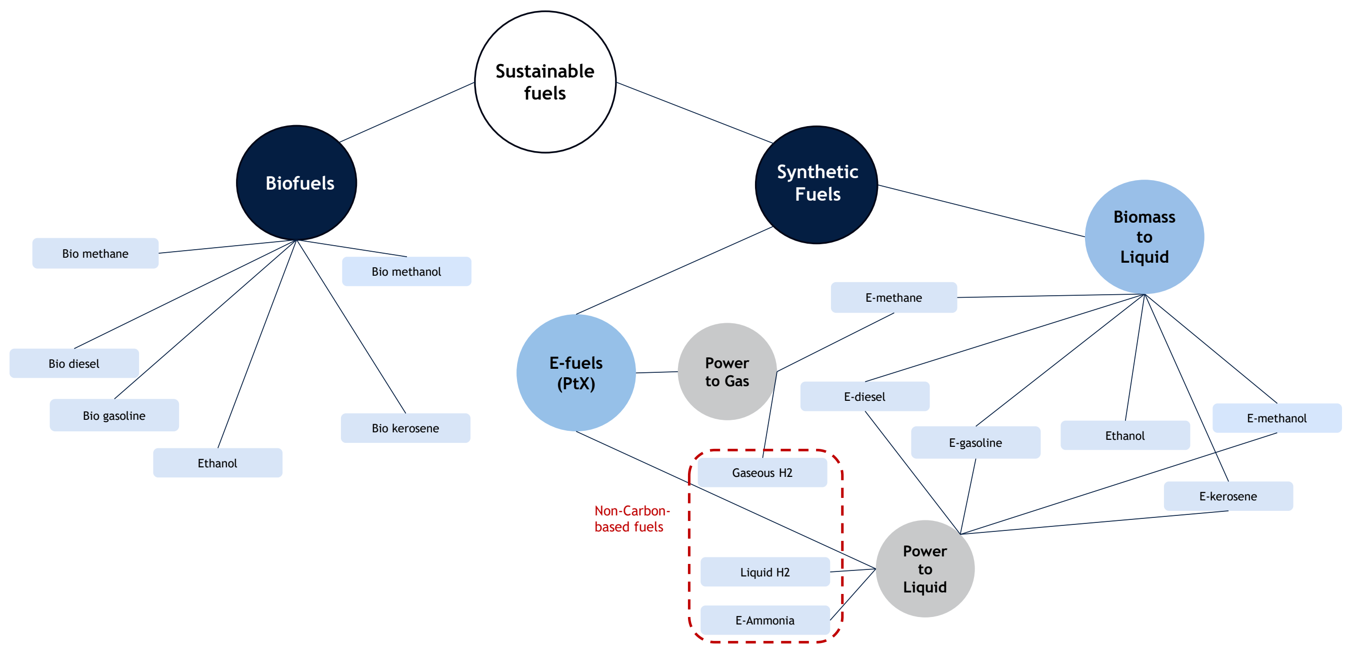


LONG-TERM CLARITY TO SCALE AN ECOSYSTEM

The alternative fuels framework

Designed to mitigate environmental impact compared to traditional fossil-based fuels, sustainable fuels are produced from renewable sources and have lower lifecycle GHG emissions. They include both biofuels and synthetic fuels, each with specific production methods and characteristics.

FIG 24: OVERVIEW OF SUSTAINABLE FUELS



*Source: Coryton, McKinsey, Stifel**

Biofuels are primarily derived from biomass and currently account for most of the volume of sustainable fuels used in the transport sector. Various biofuel generations coexist, each characterised by distinct biomass sources, as well as availability, collection and conversion challenges:

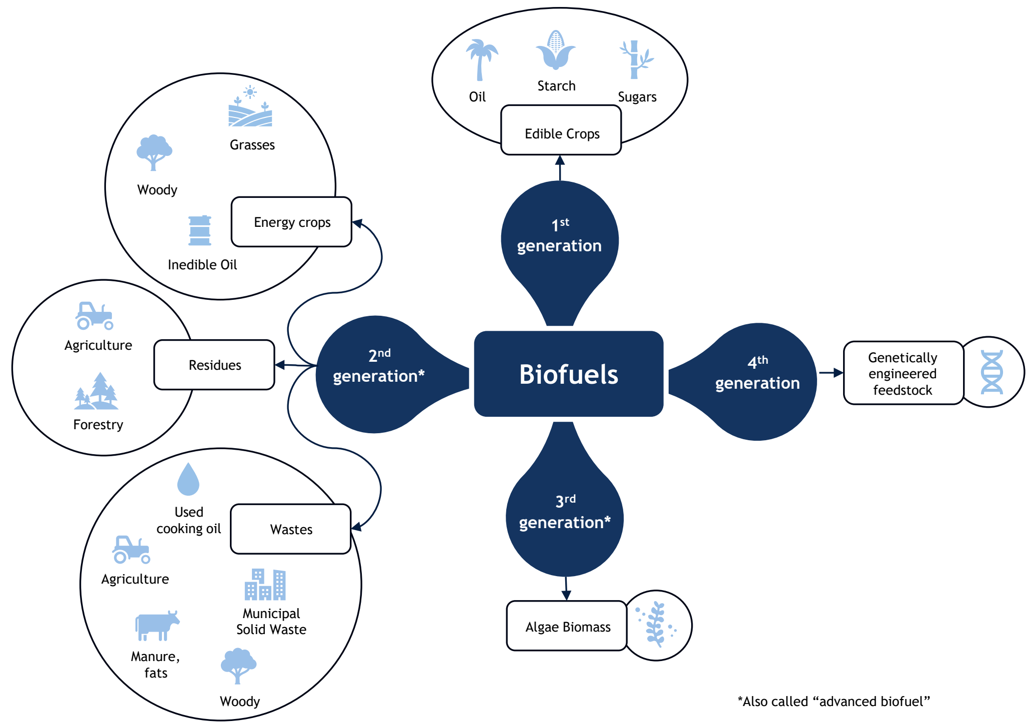
- **First-generation biofuels**, also known as conventional biofuels, are derived from agricultural food crops and vegetable oils. These fuels have faced scrutiny due to their potential competition with food production (even if they provide an alternative to agricultural production surplus, supporting global demand for soja, corn, rapeseed etc.) and concerns about land use change.

- In contrast, **second-generation biofuels**, also known as advanced biofuels, use non-food biomass sources such as energy crops, crop residues (lignocellulosic biomass) and waste oils/fats. These fuels have less impact on land use and food supply, and are seeing growth and competition between incumbents and innovators to secure access.

- **Third-generation biofuels** use byproducts from microorganism to create both oils and proteins. Algae, for example, can grow rapidly in diverse conditions, requiring minimal land and freshwater resources compared to traditional crops with high productivity and minimal environmental footprint. However, challenges remain in extracting valuable materials once crops are harvested.

- Similarly, **fourth-generation** biofuels rely on advanced biotechnological approaches, using genetically modified organisms or enhanced technology to maximise energy output while minimising environmental impacts.

FIG 25: BIOFUELS CLASSIFICATION DEPENDS ON FEEDSTOCK CONSUMPTION



*Also called "advanced biofuel"

*Source: Stifel**

The issue of food substitution (the "food for fuel debate") for first-generation biofuels, together with limitations around availability and technology for advanced biofuels, means that long-term alternatives are needed to fill the gap as energy demand continues to grow.

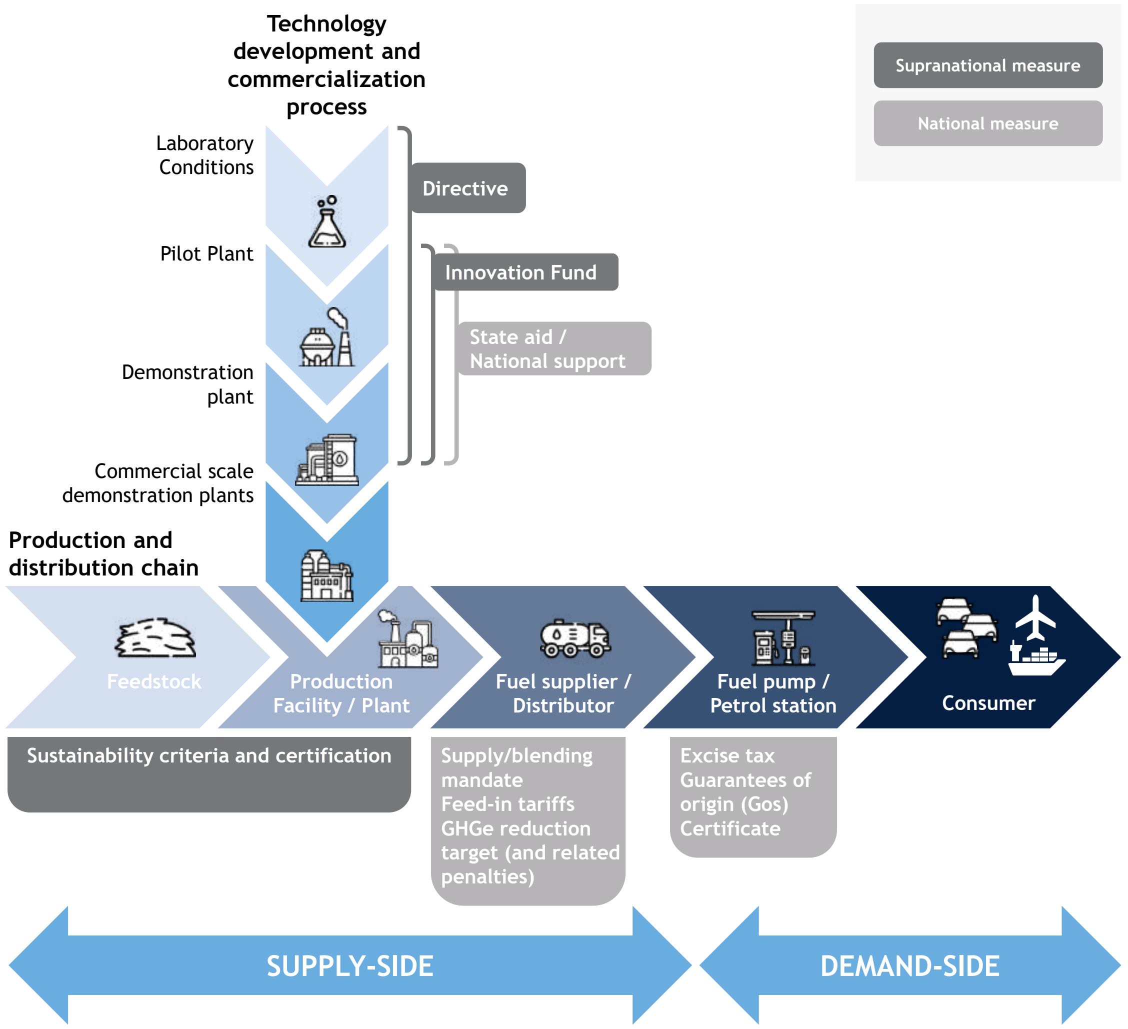
While overall ecosystem development will depend on region-specific, fuel definition and accessibility to raw materials and intermediates, mandatory adoption targets and penalty framework will prompt the transition towards alternative fuel sources, supporting the rise of synthetic fuels.

Synthetic fuels encompass biomass-to-liquid (BTL) and power-to-liquid (PTL, also known as e-fuels), each distinguished by unique production methodologies. BTL involves thermochemical conversion of biomass, typically employing processes such as gasification ahead of fuel synthesis. E-fuels use renewable or low-carbon electricity to synthesise liquid or gaseous hydrocarbons from biogenic. Synthetic fuels offer an alternative for decarbonising both transport and industrial sectors. They circumvent potential conflicts over agricultural land use but significantly increase renewable energy requirements, taking away available power from other end uses.

The development of alternative fuels needs visibility from regulators and clear decision frameworks to ensure coordinated technology development. The sector requires tight sustainability and certification criteria, strong import/export monitoring tools and clear guidelines that encourage innovation and align stakeholder interests.

Strict environmental standards, with blending mandates and GHG reduction limits from national and supranational regulators, will enable the supply side to be structured with a complete business case and outputs that are correctly priced, for example to reflect positive externalities.

FIG 26: HOW REGULATORY MEASURES IMPACT ALTERNATIVE FUELS DEVELOPMENT



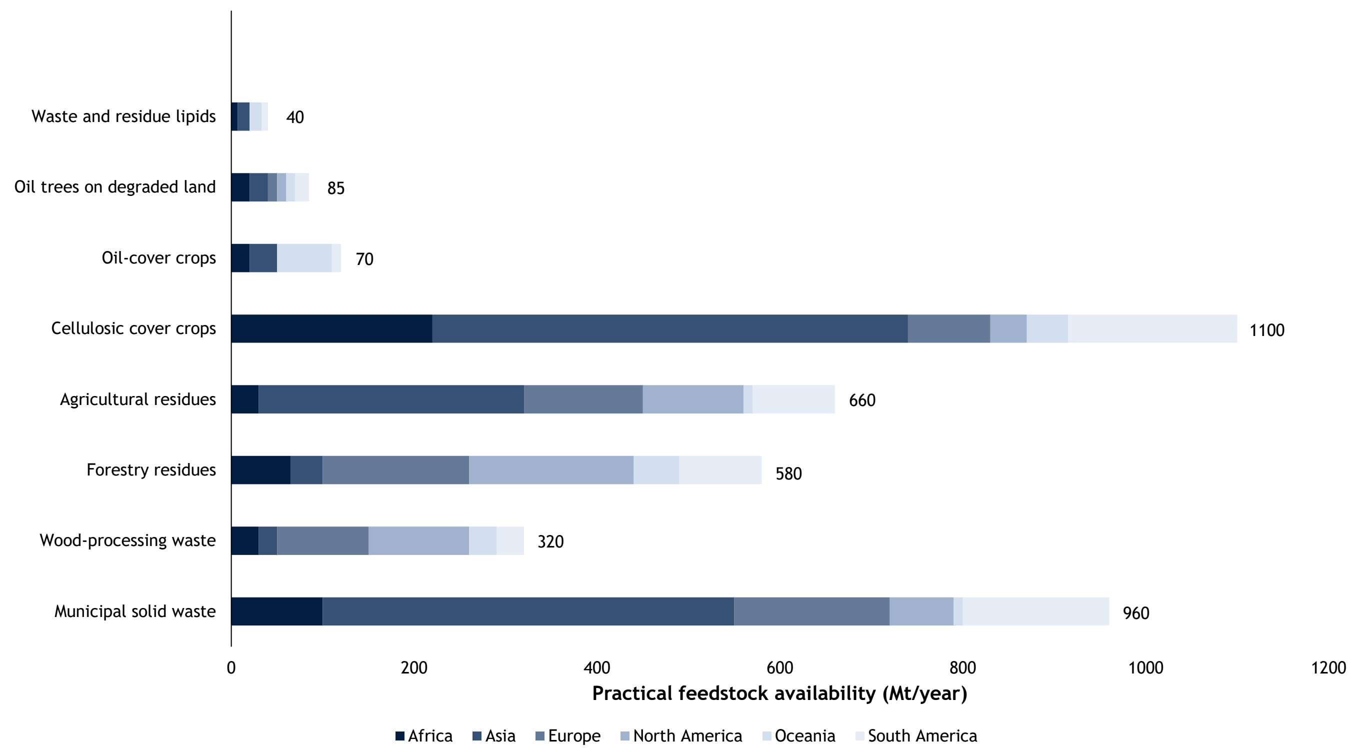
*Source: EU ECA, Stifel**

While biomass is theoretically available in large quantities, structuring the ecosystem starts with clear definition of "sustainable" biomass. From collection to processing and distribution, true industrialisation of sustainable biomass streams comes with scalability challenges. The greater the volumes produced to satisfy demand for bio- and e-fuels, the stronger the competition for waste/residue, sugars or intermediate will be. Agricultural yields, demographics, and utility networks vary widely across regions. And climate change and geopolitics can ultimately redefine resource maps and impact feedstock availability.

Measures must therefore be put in place to prevent deforestation and land degradation, ensuring that forests and natural ecosystems are not converted into agricultural land or directly fed into biofuel production, but sustainably leveraged to extract the most out of natural and already existing biomass. Additionally, food competition and land use need to be properly assessed, so production surplus can be leveraged while avoiding the conversion of land for fuel crops.

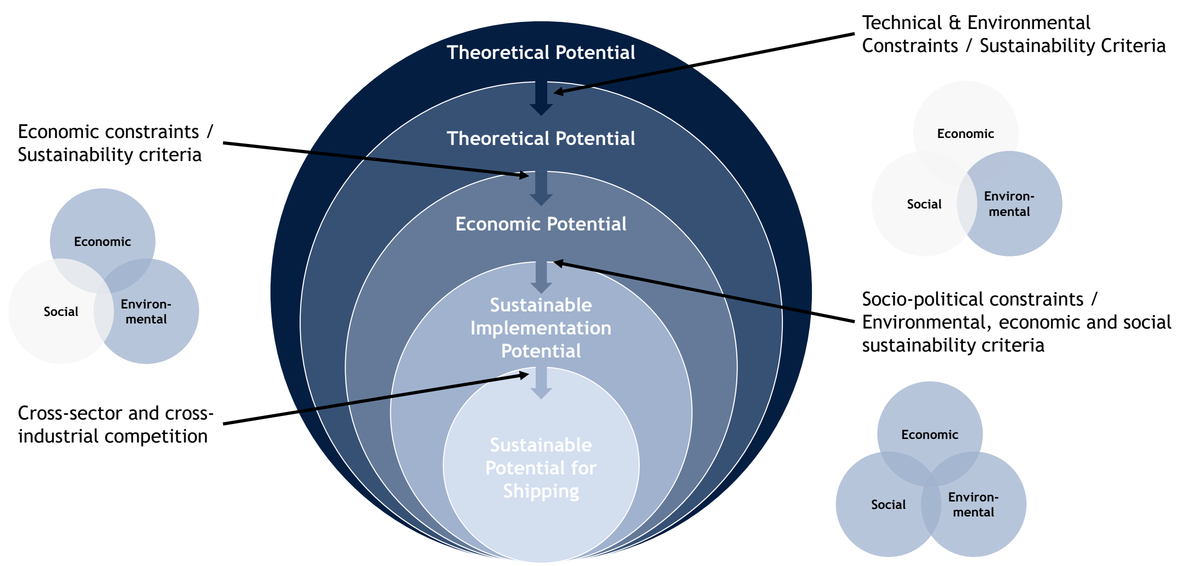
Processing infrastructure that is able to use different feedstocks is particularly relevant in this context. It reduces dependency on a single resource, and mitigates inequalities and competition across regions, especially as emerging countries begin to develop their own local infrastructure.

FIG 27: AVAILABLE ADVANCED BIOMASS FEEDSTOCK POTENTIAL (IN MT)



Source: McKinsey

FIG 28: FROM THEORETICAL POTENTIAL TO SUSTAINABLE BIOMASS FEEDSTOCK IMPLEMENTATION



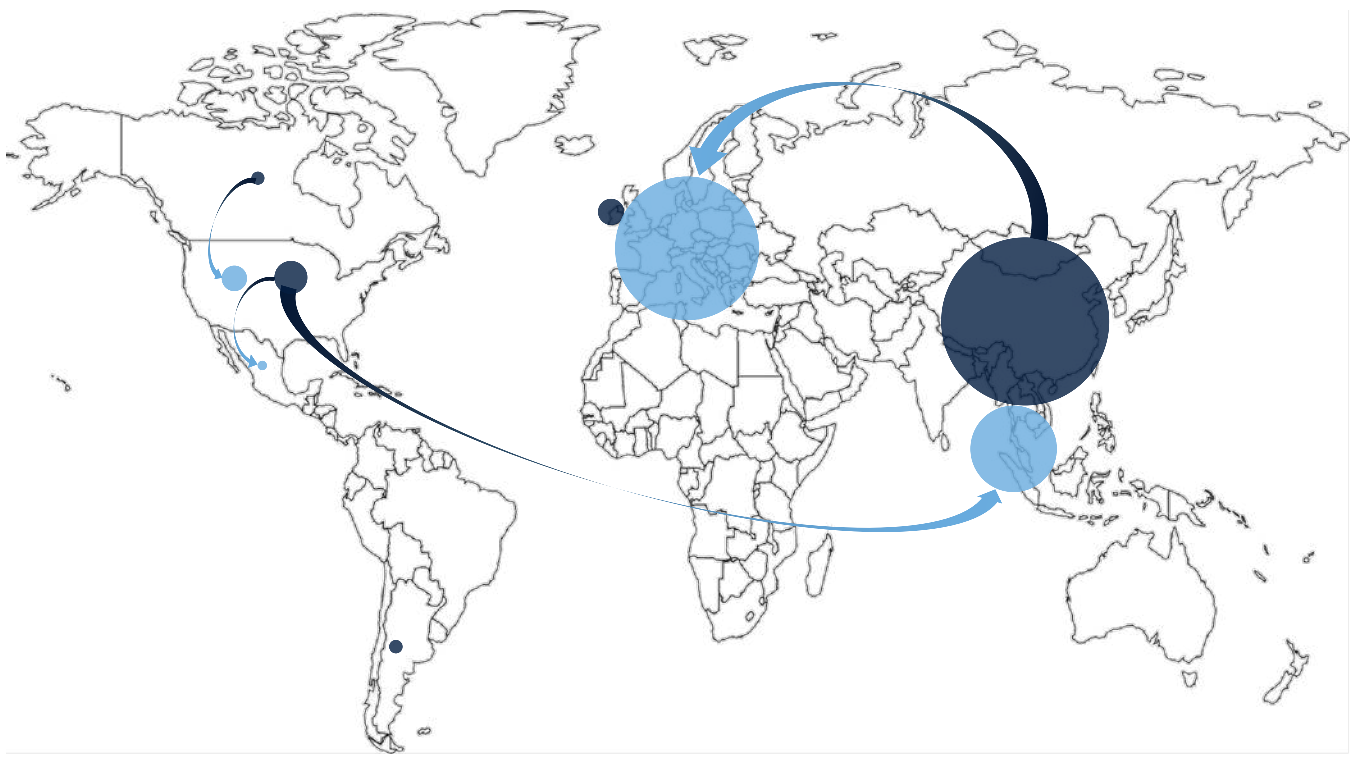
*Source: IEA, Stifel**

New producers coming to market and sovereignty considerations will highlight the scarcity of available feedstock resources. As an example, global trade in used cooking oil (UCO) reached 5.5Mt in 2022. Asia is the primary source of exports, two-thirds of which come from China. Most UCO from Asia is shipped to Europe because of the region's regulations favouring advanced biofuels.

However, there is growing interest to convert UCO for local consumption and to reshore valuable parts of the value chain. Consequently, if Asian collectors and refiners were to use local UCO supply for domestic energy (or for third parties) in the medium- to long-term rather than directly exporting waste streams, this could lead to significant downstream input shortages in developed markets. Alternative and synthetic feedstock may therefore soon be needed to make up the shortfall and allow for further infrastructure development.

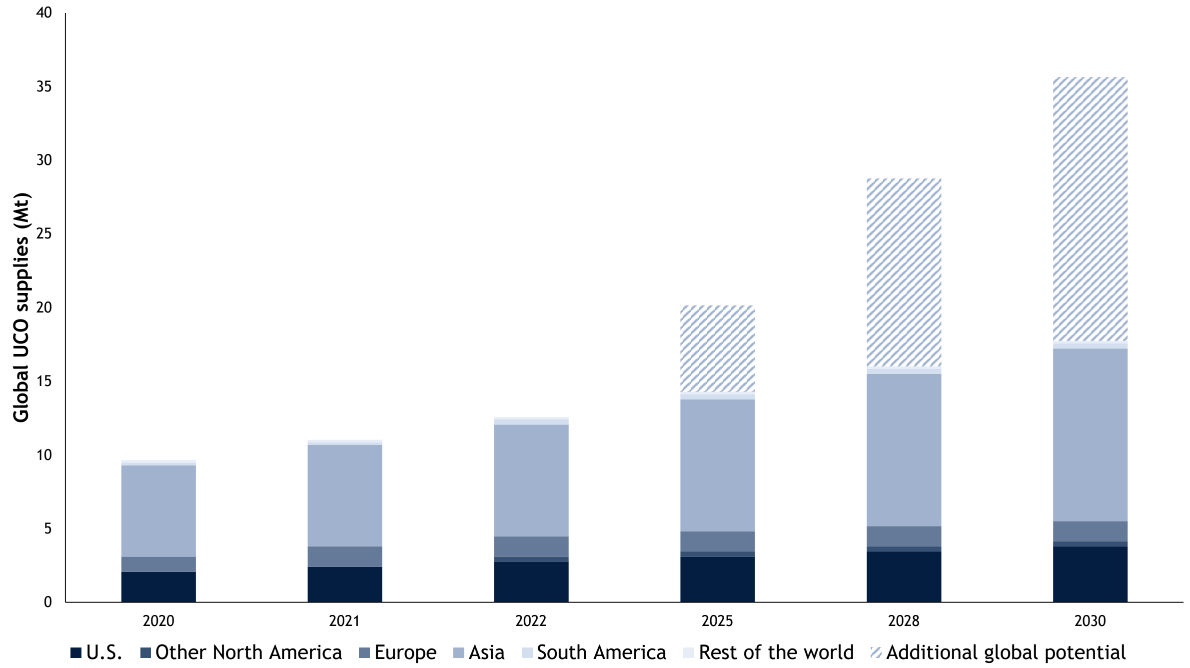
It is therefore crucial to encourage the diversification of feedstock consumption and fuel conversion technology to minimise reliance on specific regions and ensure a more local, equitable and sustainable distribution of resources.

FIG 29: ASIA IS THE WORLD'S HUB FOR WASTE FATS, OILS AND GREASES (FOG)



*Source: LMC International, Stifel**

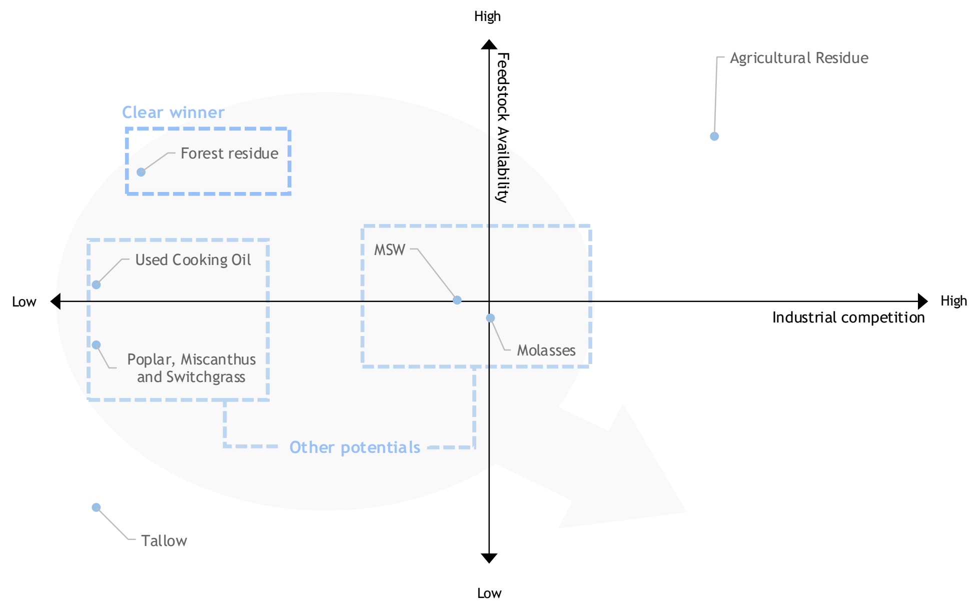
FIG 30: GLOBAL FOG DEMAND IS EXPECTED TO RISE FROM 14MT TO AT LEAST 35-40MT BY 2030



*Source: LMC International, Stifel**

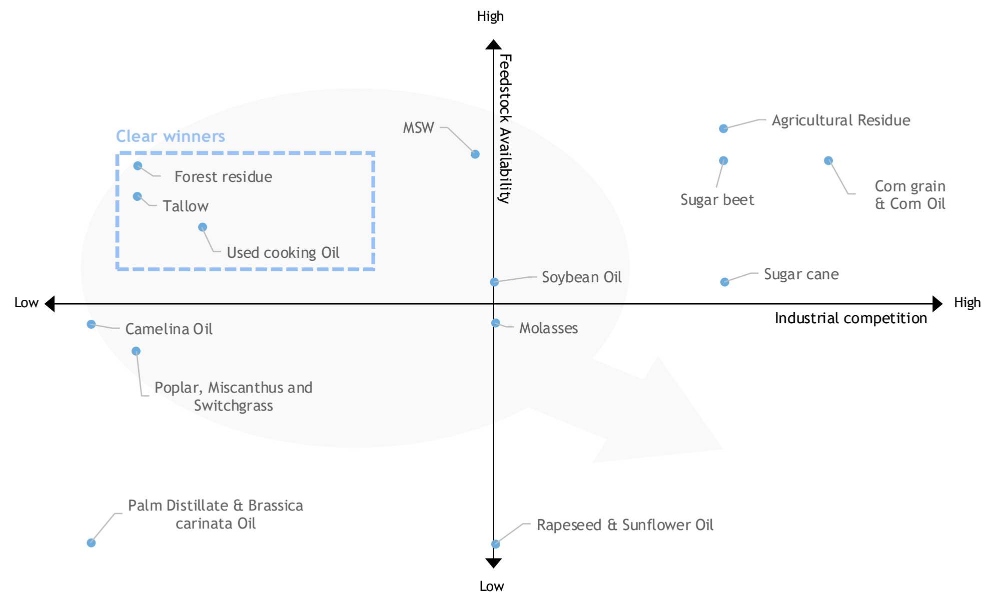
Disparities in feedstock availability will drive the dynamics of adoption and investment in alternative solutions across regions. They will favour local sourcing of bio- and synthetic feedstock together with centralised or decentralised refining set-ups that depend on the structure of available feedstock and process integration synergies. As a result, we are likely to see different technologies and infrastructure across continents, coupled with developments in feedstock options, pushing forward the waste frontier and potentially diverting today's way of consuming biomass for another, with more value and significant environmental impact at stake. These regional variations will depend on specific resources available, existing infrastructures and industrial ecosystems as well as regulatory frameworks, ultimately promoting different technologies tailored to specific local conditions. Widely used cheap, competitive feedstocks used today may no longer be cheap in the future, with distorted supply dynamics as competition increases, and growing risks of squeezed margins.

FIG 31: ILLUSTRATIVE FEEDSTOCK AVAILABILITY AND COMPETITIVENESS IN EUROPE



*Source: Capgemini, Stifel**

FIG 32: ILLUSTRATIVE FEEDSTOCK AVAILABILITY AND COMPETITIVENESS IN THE US

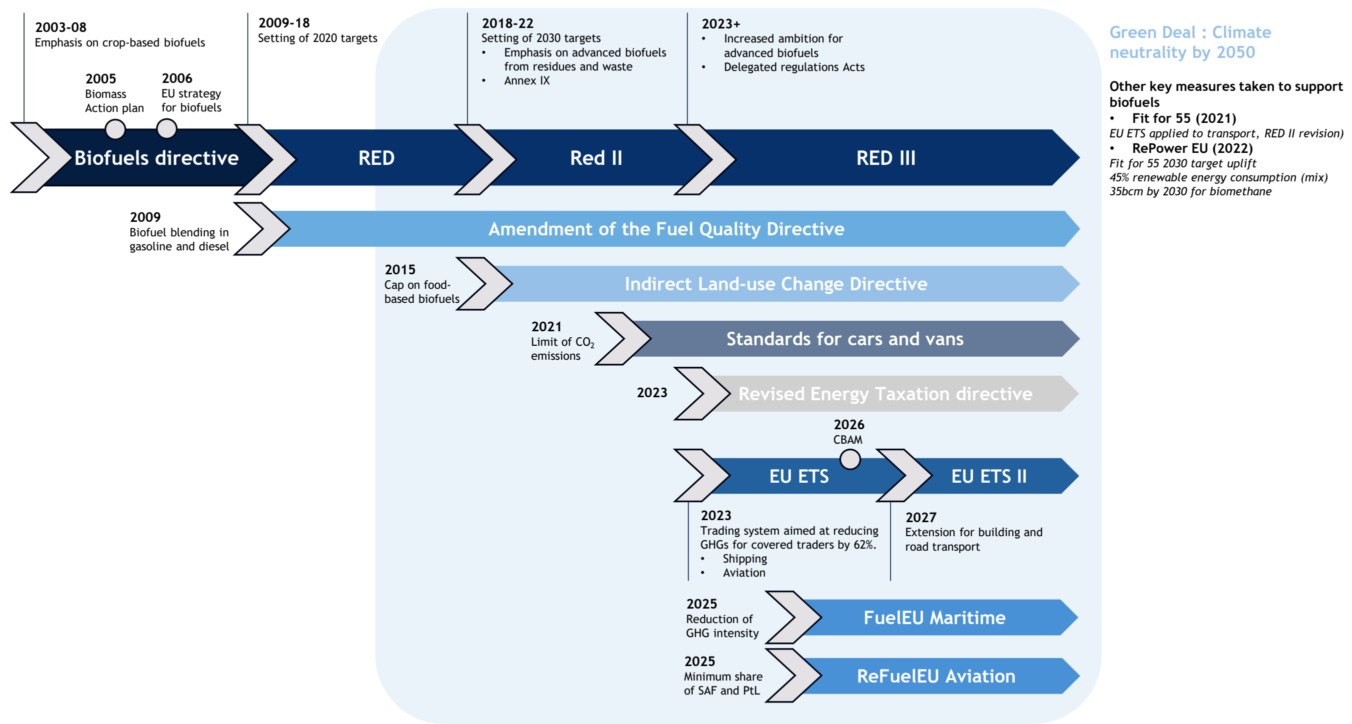


*Source: CapGemini, Stifel**

Maturing regulations drive adoption

Although, infrastructure growth requires clarity in the medium- to long-term, the regulatory landscape for alternative fuels has evolved significantly over the past 20 years. Europe has set ambitious climate goals and given the market time to adapt before adding further rules to shift away from sub-optimal standards. However, the frequent updates and modifications to regulations create a challenging environment for stakeholders, leading to uncertainty for producers.

FIG 33: KEY DEVELOPMENTS IN EU BIO- AND ALTERNATIVE FUELS POLICY



*Source: EU Commission, EU ECA, Stifel**

The Renewable Energy Directive (RED) is a good example of this. Since its initial implementation in 2009, the RED has played a key role in developing the regulatory framework to promote renewable energy across all sectors of the EU economy. It facilitates cooperation between EU member states to achieve sustainable energy objectives. Over the years, RED has played a crucial role in significantly increasing the share of renewable energy sources in the EU's energy mix from 12.5% in 2010 to 23% by 2022.

RED III has set even more ambitious targets in 2023, aiming for renewables to constitute 45% of EU energy consumption by 2030. It follows on from the 2021 Fit for 55 package, which includes the RED II revision and the application of EU ETS for transport; and the 2022 RePowerEU plan, which came with an upward revision from Fit for 55 targets for biomethane to 35bcm by 2030.

Specific RED III provisions include a mandate that 29% of energy used in transport is sourced from renewables or generates a reduction in GHG emissions of at least 14.5% compared to fossil fuels. Additionally, RED III targets 5.5% of transport energy from advanced biofuels and renewable fuels of non-biological origin (RFNBO), which encompass e-fuels and green hydrogen.

To mitigate potential ecological issues, RED is framed by two essential elements:

- Annex IX, which imposes limits on the use of crop-based biofuels and promotes biofuels produced from specified materials. This includes capping conventional crop biofuels at 7% in total energy for transport with a 1% flexibility margin. This limitation aims to prevent excessive reliance on food crops for biofuel production, mitigating concerns about competition with food production and potential land use change. Annex IX encourages the production and use of advanced biofuels, which offer higher sustainability standards compared to conventional biofuels and are now required to represent 1% of total energy use for transport by 2025, reaching 4.5% by 2030 with double counting measures (or 2.25% in real energy terms). This incentivises the development and use of biofuels derived from sources such as agricultural and forestry residues, algae, and other waste materials. Furthermore, this policy specifies minimum thresholds for RFNBOs, which include e-fuels and green hydrogen. RFNBO must contribute to at least 1% of the total renewable energy share, promoting the use of innovative technologies that produce renewable fuels without relying on biological sources.

- Delegated Acts established rules on the production of renewable transport fuels of non-biological origin (RFNBO) and recycled carbon fuels (RCF, required to be 100% biogenic CO2 from 2041 onwards in the EU), stipulating minimum thresholds and methodologies to ensure these fuels achieve greenhouse gas emissions savings of at least 70% compared to their fossil counterparts (with reference set at 94g CO2eq/MJ).

FIG 34: EU ENERGY FOR TRANSPORT TARGETS UNDER RED II AND RED III

Targets 2030	Targets in RED II (2018)	Targets in RED III (2023)
Renewable energy In transport	• At least 14% share of renewable energy in final consumption of road and rail transport	• At least 29% share of renewable energy in final consumption of all energy used in transport • Or a minimum of 14.5% reduction in greenhouse gas (GHG) compared to emissions that would have been created by fossil fuel use instead
Fossil fuel comparator (Reference value to Calculate baseline for GHG reduction target)	• 94gCO_2eq/MJ for all energy used in transport	• 183gCO_2eq/MJ for electricity used in transport • 94gCO_2eq/MJ for all other energy used in transport
Electricity used in Transport	• No sub-target • Multiplier of x4 for renewable electricity used in road vehicles and of x1.5 for renewable electricity in rail	• No sub-target • Multiplier of x4 for renewable electricity used in road vehicles and of x1.5 for renewable electricity in rail
Advanced biofuels (feedstocks listed in Annex IX, part A)	• 3.5% share of advanced biofuels in final consumption of road and rail transport • x2 multiplier	• 5.5% share of advanced biofuels and renewable fuels of non-biological origin (RFNBOs), in final consumption of all energy supplied to transport, with a 1% RFNBO minimum share • Indicative goal of at least 1.2% of energy used in maritime transport to come from RFNBOs in 2030 • x2 multiplier for advanced biofuels and RFNBOs • Additional multipliers in aviation and maritime transport: x1.2 for advanced biofuels and x1.5 for RFNBOs
RFNBOs	• No sub-target • Additional multipliers in aviation and maritime transport: x1.2	
Biofuels and Biogas From used cooking oil (UCO) or animal fats (feedstocks listed in Annex IX, part B)	• Use of biofuels and biogas from UCO and animal fats is limited to 1.7% in final consumption of energy in road and rail transport • x2 multiplier	• Use of biofuels and biogas from UCO and animal fats is limited to 1.7% in final consumption for all energy used in transport • x2 multiplier
Conventional biofuels (food- and feed-based)	• Share of conventional biofuels consumed in 2020 in road and rail transport in Member States +1%, but a maximum of 7%	• Share of conventional biofuels consumed in 2020 in the transport sector in Member States +1%, but a maximum of 7%

*Source: NOW GmbH, Stifel**

Several other major policies have emerged to reduce CO2 emissions and promote the adoption of alternative fuels:

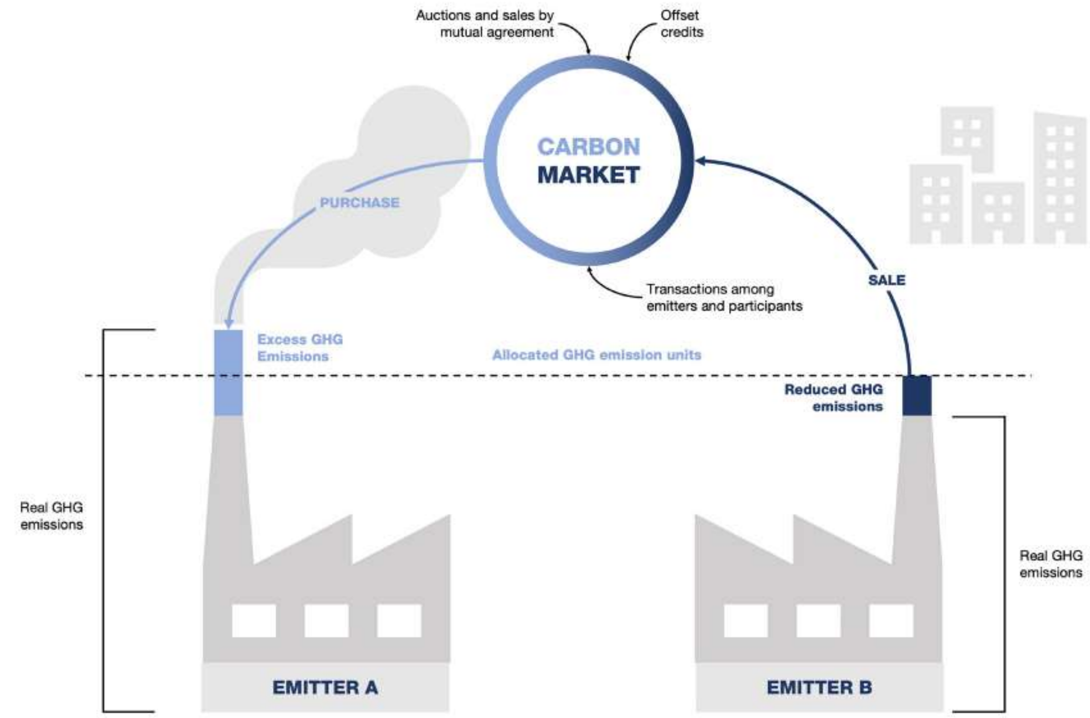
• **The Indirect Land Use Change** (ILUC) Directive introduced in 2015 aims to address the indirect impacts associated with biofuels production. This directive seeks to mitigate environmental concerns such as deforestation and land use changes induced by the cultivation of biofuel feedstocks, ensuring that biofuels used in the EU meet sustainability criteria without exacerbating ecological issues. Under this directive, fuel LCA calculations must reintegrate the estimated impact of dedicated agriculture for fuel activities.

• **The 2021 CO2 emissions standards for cars and vans** represent a crucial milestone in the EU's efforts to decarbonise transportation. These standards mandate a phased reduction in CO2 emissions for new vehicles, with stringent targets set to achieve full decarbonisation by 2035. For cars, the emissions limits represent 95g CO2/km from 2021-2024, followed by a 15% reduction from 2025-2029, and a 55% reduction from 2030-2034, culminating in zero emissions by 2035. Similarly, vans face reduction targets starting from 147 g of CO2/km in 2021-2024, progressing to full decarbonisation by 2035.

• **The 2023 Revised Energy Taxation Directive** (ETD) establishes a comprehensive framework for the taxation of energy products within the EU. This directive includes minimum tax rates based on the energy content and environmental impact of fuels, aiming to incentivise the use of sustainable energy sources while phasing out support for conventional fossil fuels and non-sustainable biofuels. Since its revision, the ETD has limited member states' ability to exempt or reduce taxes, ensuring consistent pricing incentives for decarbonisation across various sectors.

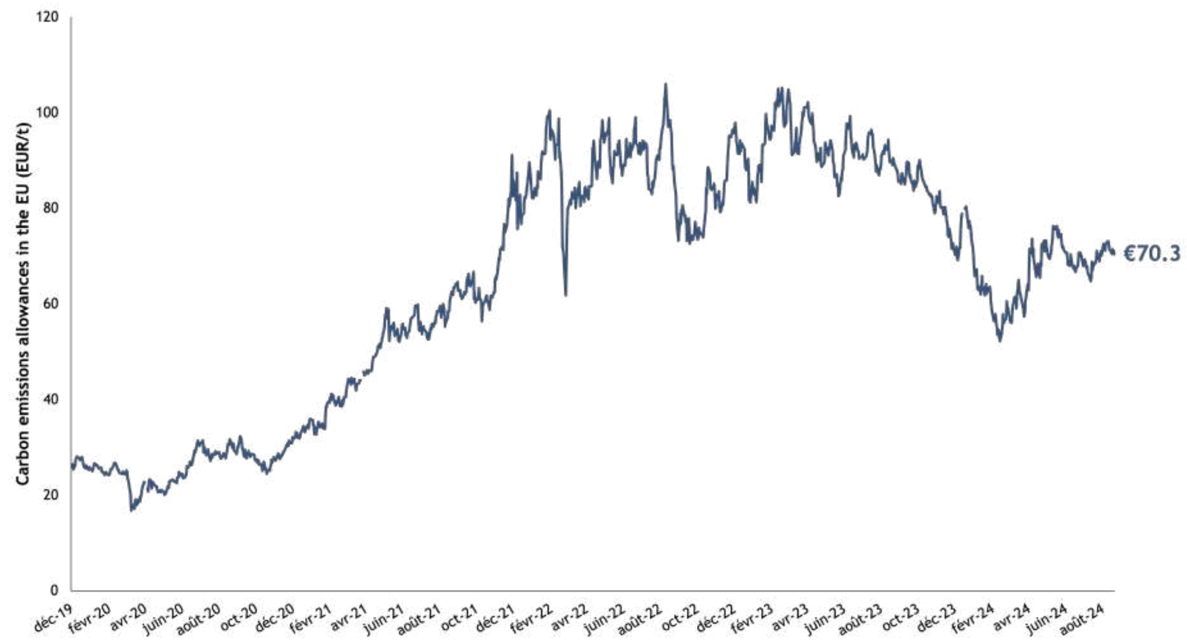
• Finally, **the EU Emissions Trading System** (EU ETS), scheduled for revision in 2026-2027, specifically targets transport emissions from aviation and shipping to achieve a 62% reduction in GHG emissions by 2030 compared to 2005 levels. This cap-and-trade system involves the issuance of emission allowances (EUAs), which can be traded to regulate emissions effectively. The system includes provisions such as a declining cap on emissions allowances, with reductions set at 4.3% per year from 2024-2027 and 4.4% per year from 2028-2030. Furthermore, free allocation of allowances is provided to sectors at risk of carbon leakage, with reductions beginning in 2026 and continuing until 2034. The Carbon Border Adjustment Mechanism (CBAM) complements the EU ETS by imposing a carbon price on imported goods based on their carbon content, thereby promoting local consumption when possible.

FIG 35: CAP AND TRADE SYSTEM IN EU



*Source: Ministère de l'Environnement et de la Lutte contre les changements climatiques – Gouvernement du Québec, Stifel**

FIG 36: IMPLIED PRICE OF CARBON UNDER THE EU ETS SINCE 2012



*Source: Reuters, Stifel**

While the EU has established the Climate Social Fund to support individuals and businesses impacted by the EU ETS, it's important to note that the European system primarily functions as a regulatory framework that penalises entities exceeding CO2 emission limits. Europe relies heavily on market self-regulation, which contrasts sharply with US/UK systems that emphasise short- and medium-term incentives to reward producers and seed alternative fuel initiatives.

In the UK, the Renewable Transport Fuel Obligation (RTFO) mandates fuel suppliers to demonstrate that a given portion of the fuel they distribute comes from renewable and sustainable sources. Since 2021, suppliers are therefore required to comply with blending mandates, with percentages gradually increasing to 14.6% by 2032. The obligation applies to suppliers handling more than 450,000 litres of fuel annually, with biofuel producer certificates guaranteeing traceability.

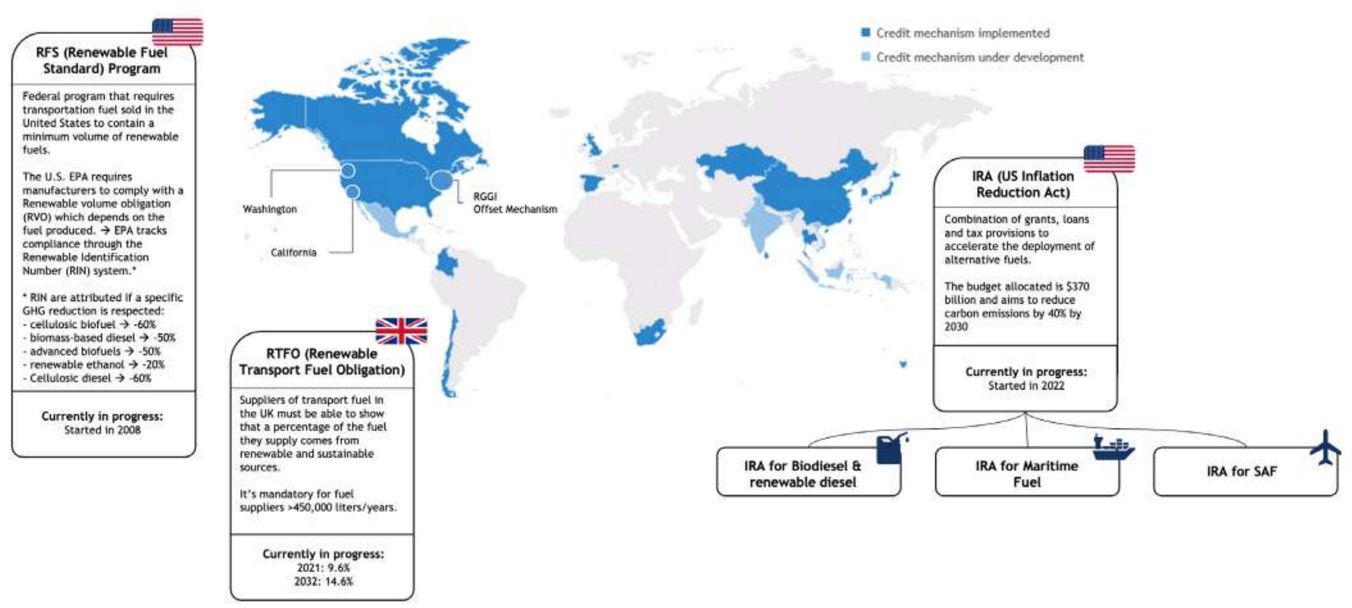
Suppliers have several options available under the RTFO's compliance system. Firstly, they can choose to directly supply the necessary volume of biofuels to the UK market, ensuring they meet the mandated renewable fuel percentage, directly retiring Renewable Transport Fuel Certificates (RTFCs). Alternatively, suppliers may opt for a buy-out option, where they pay a fixed fee per litre of non-compliant fuel supplied, compensating for their renewable fuel obligations. Additionally, suppliers can purchase RTFCs from accredited renewable fuel producers and importers. Each RTFC certifies that a specific volume of renewable fuel has been supplied and meets the sustainability criteria outlined by the RTFO.

In the US, the Renewable Fuel Standard (RFS) programme, a federal policy aimed at increasing the use of renewable fuels and reducing reliance on petroleum-based transportation fuels, has been implemented. Under the RFS, the Environmental Protection Agency sets Renewable Volume Obligations (RVOs), thereby mandating the supply of specified volumes of biofuels into the US road fuels distribution system for a given period (this can be set retrospectively).

The RVO is calculated by multiplying the mandated percentage for each biofuel category by the volume of road fuels projected to be sold in the coming year. This calculation considers various Renewable Identification Numbers (RINs), unique codes assigned to batches of biofuels to track their compliance with the program's GHG reduction requirements. For instance, D3 RINs are assigned to cellulosic biofuels and require a 60% reduction in greenhouse gas emissions compared to petroleum-based fuels, while D6 RINs, assigned to renewable ethanol, necessitate a 20% reduction.

The RIN market facilitates compliance with the RFS blending obligations. Companies falling short of their mandated biofuel usage can therefore purchase RINs from others who exceeded their obligations. This market-based approach allows flexibility for fuel producers and importers to meet their obligations under the RFS while encouraging the adoption of renewable fuels across the US transportation sector, i.e. boosting producers' initiatives to secure RIN credit incentives, whether directly engaging into greenfield projects, hedging through consolidation or supporting innovative players.

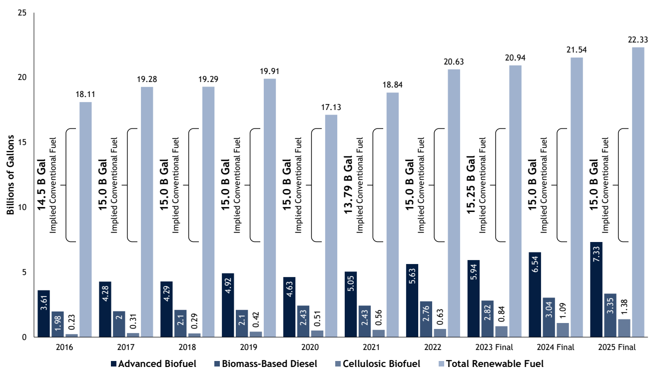
FIG 37: THE UK/US PARADIGM FAVOURS PRODUCERS AND BLENDING TAX CREDIT



*Source: US EPA, UK Parliament, Stifel**

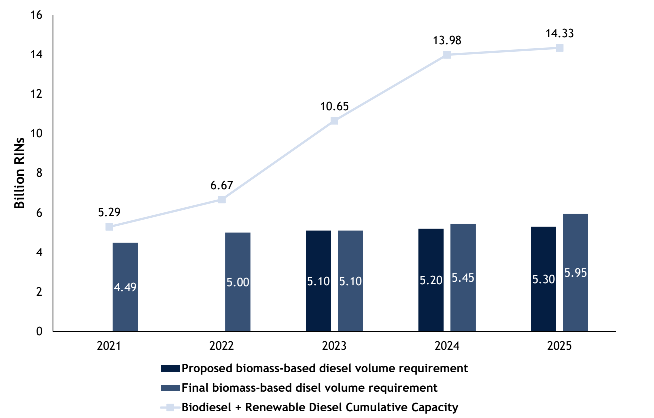
Historically, production quotas in the US have been consistently adjusted and revised, which has stimulated growth in the biofuels industry, fostered technological innovation and aligned with long-term environmental objectives. These quotas motivate producers to expand their biofuel production capacity and ultimately enhance the diversity of energy sources used in the transportation sector, such as ethanol, diesel and methane. However, while quotas, which are regularly revised upward, have supported the rise of the bioethanol and biodiesel industry in the US, they are temporary and only designed to back industry growth until maturity. As such, support for first-generation bioethanol production topped 15bn gallons since 2015 (vs close to 18bn gallons, i.e. >53Mt total capacities as of 2023 in the country), limiting capacity growth by reducing marginal profits in the sector. Recently, a rather similar decision was made on D4 RVOs (bio- and renewable diesel) for the 2023-2025 period, printing significantly below announced biodiesel and renewable diesel capacities. This is therefore questioning the place of diesel in the envisaged US transport energy mix, especially for HDVs, but also impacting European suppliers at a time where German production cannot rely on Swedish demand (where the diesel blending mandate was cut from 30% to 6% late in 2023 to fight inflation) and will not be able to leverage US imports.

FIG 38: EPA RFS BIOFUEL VOLUME REQUIREMENT OUTLOOK FOR 2023-2025



*Source: Argus, EPA, Stifel**

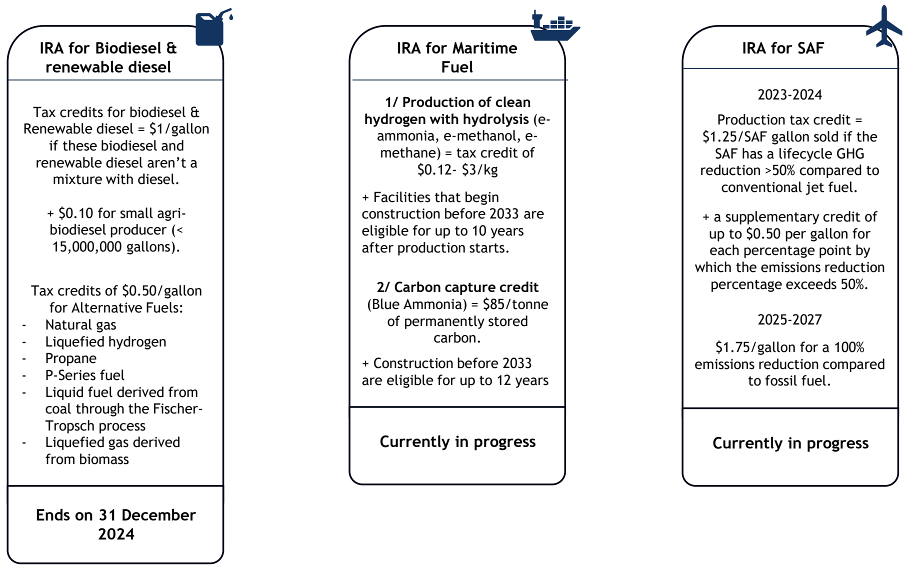
FIG 39: PROPOSED VS FINAL D4 RIN RENEWABLE VOLUME OBLIGATION FOR 2023-2025



*Source: Argus, EPA, Stifel**

The US incentive system in the USA has been further advanced since 2022 by the Inflation Reduction Act (IRA), with grants, loans and provisions to the tune of $ 370 billion to accelerate the deployment of clean energy and reduce carbon emissions by 40%. The IRA runs to 2030 and supports both low- and zero-carbon fuels.

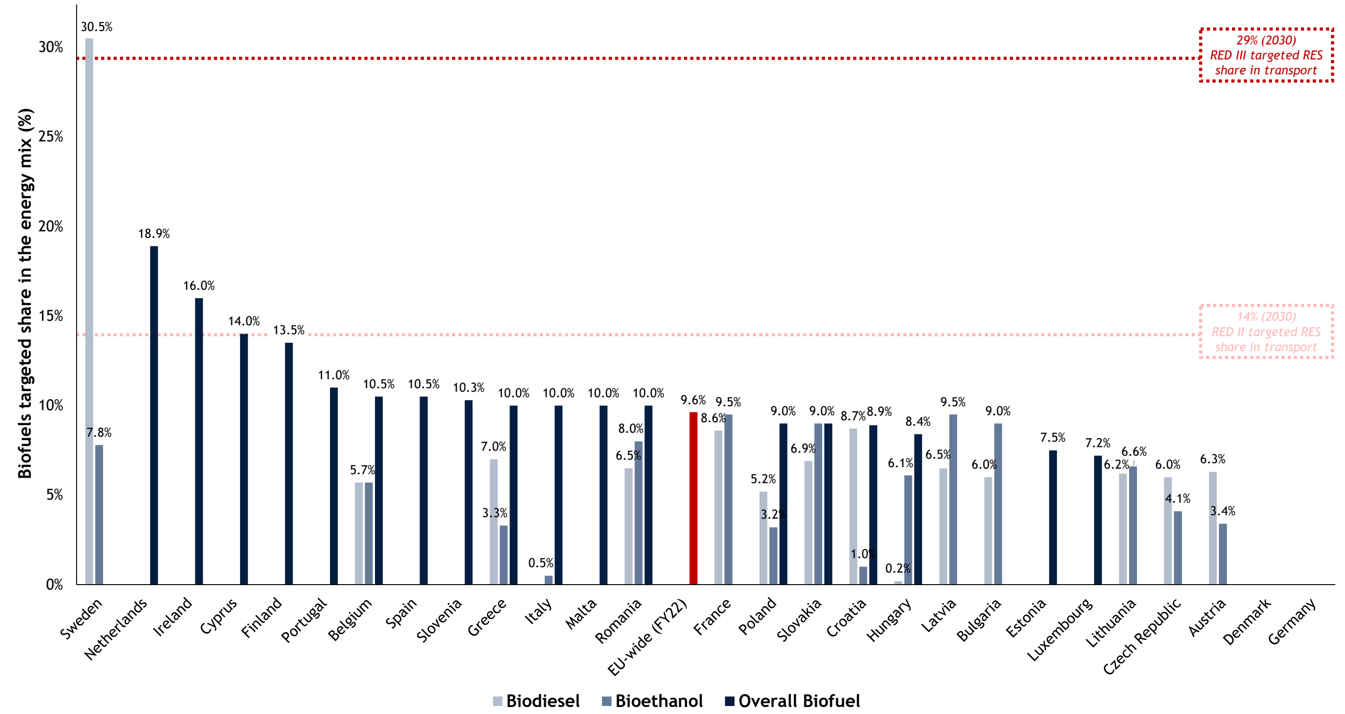
FIG 40: US INFLATION REDUCTION ACT TARGETS HDV AND INDUSTRY DEVELOPMENTS



*Source: US EPA, UK Parliament, Stifel**

The incentive-based approach boosts industries by encouraging producers to increase their capacity for biofuel production, even when the economics are challenging and technologies less mature. However, some producers may maximise fuel production to accumulate credits for future resale, betting on higher credit prices. In contrast, restrictive systems such as the EU ETS impose emission limits, forcing producers to modify their existing production processes and products. The advantage of this system lies in the flexibility it offers for states in achieving these targets, all pointing in the same direction but with different focus areas.

FIG 41: TARGETED BIOFUELS SHARE IN OVERALL TRANSPORT ENERGY MIX ON A PER COUNTRY BASIS



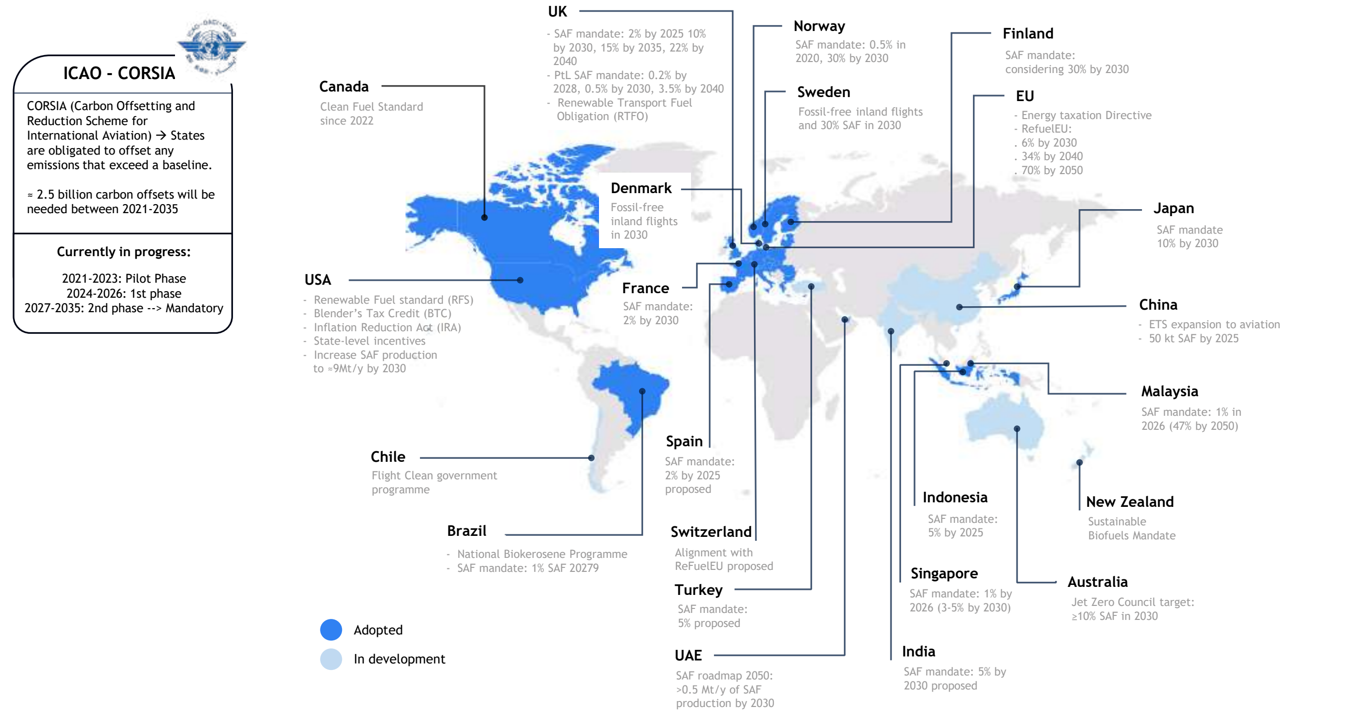
*Source: European Biodiesel Board, Stifel**

For aviation, the International Civil Aviation Organization (ICAO) plays a pivotal role in establishing long-term objectives and measures for the industry, notably through the CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation) system. Under CORSIA, airlines are required to offset any emissions that exceed a specific baseline level. As such, approximately 2.5bn carbon offsets are anticipated to be needed between 2021 and 2035 for airlines to comply with CORSIA.

CORSIA is structured into three phases: pilot, 2021-2023; 1st phase, 2024-2026; 2nd phase, 2027-2035; designed to gradually integrate and enforce emissions reduction measures within the aviation sector. Mandatory compliance starts from 2027 onwards. The baselines under CORSIA are differentiated between voluntary and mandatory compliance: 329 million metric tons of CO_2 equivalent for voluntary participants and 475 million metric tons CO_2e for mandatory participants. CORSIA aims to develop a thorough, cross-referenced international fuel reporting/monitoring tool, ultimately resulting in an international tax framework to boost efforts from airline and states to mitigate air traffic's environmental footprint.

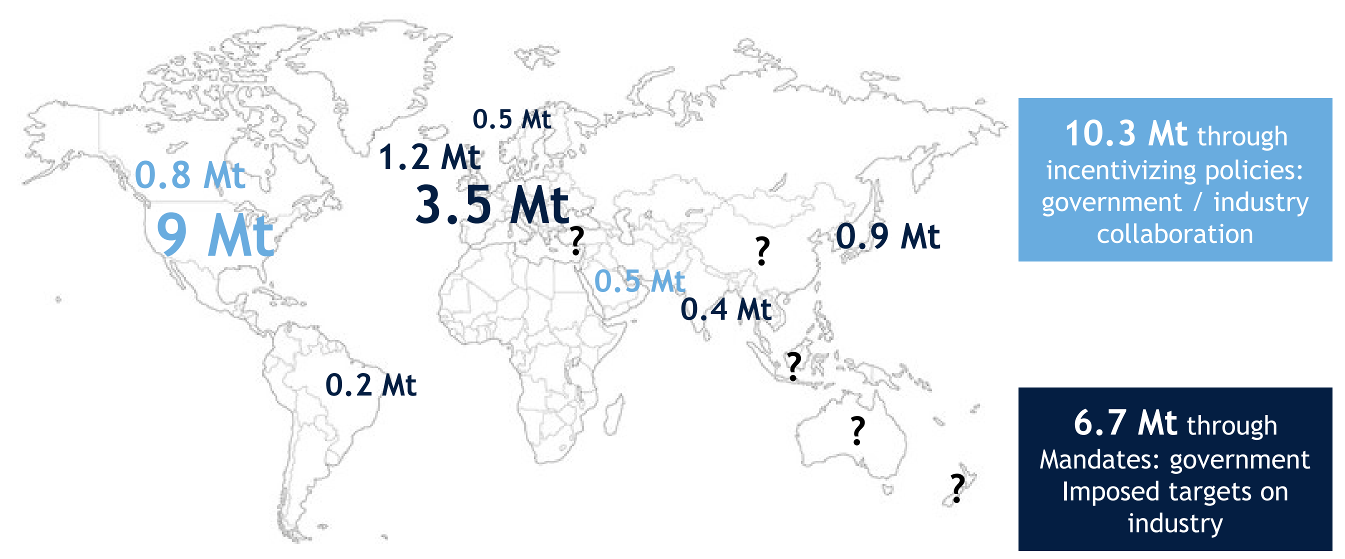
Following ICAO directives, individual countries must adapt and implement measures, often incentives and mandates for the use of sustainable aviation fuel (SAF). Currently, these are expected to result in approximately 17-18Mt of SAF mandates by 2030. However, only around 13Mt of SAF production capacities are planned by 2030, falling short of ICAO's minimum 2030 target of 14Mt.

FIG 42: AVIATION DECARBONISATION AND SAF INITIATIVES AROUND THE WORLD



*Source: World Economic Forum, Stifel**

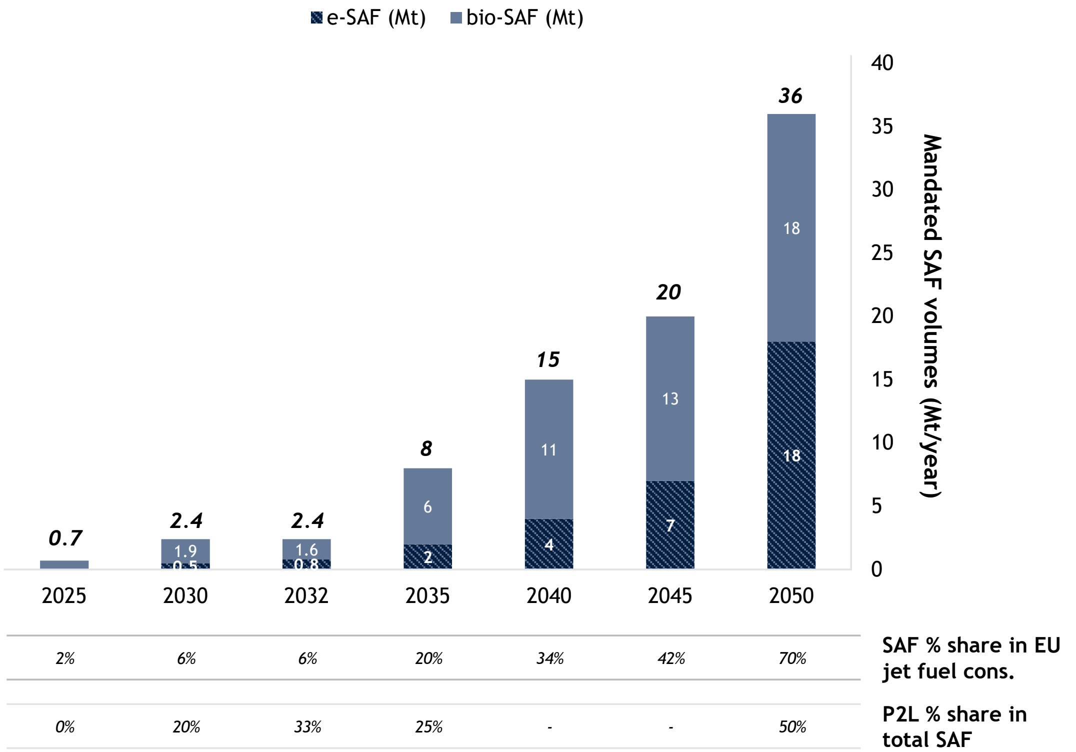
FIG 43: STATE-MANDATED SAF PRODUCTION BY 2030 AS OF DECEMBER 2023



*Source: ICF, Stifel**

However, Europe has been the first to implement a robust aviation policy, with the introduction of RefuelEU from 2025 onwards. RefuelEU mandates blending quotas for SAF and requires a minimum share of synthetic fuels within total SAF supplied. Additionally, it regulates refuelling practices at EU airports to prevent emissions from overfuelling, and ensures that customers are informed about ecological flight options.

FIG 44: EXPECTED SAF VOLUMES UNDER REFUELEU



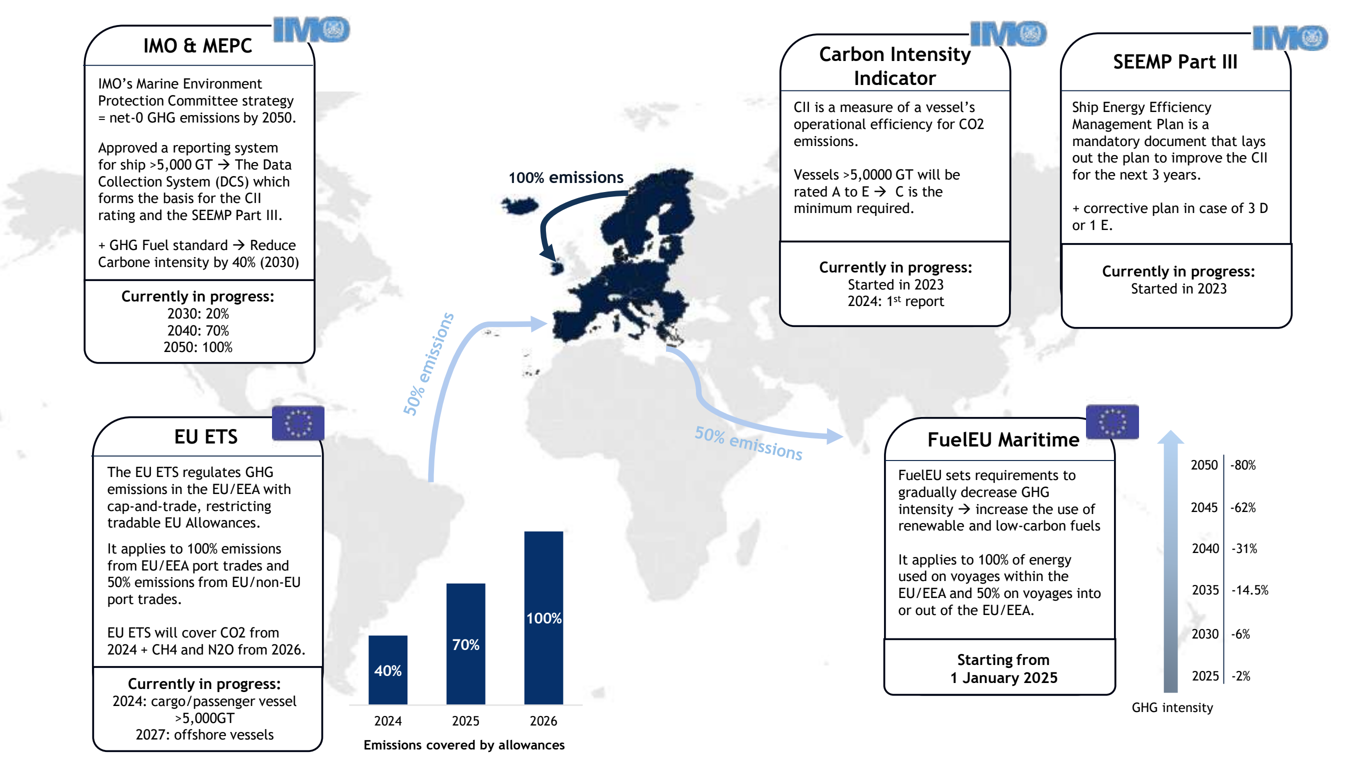
This is based on a scenario where EU jet fuel consumption increases from 30-35Mt in 2023-2025 to 40Mt and more than 50Mt respectively by 2030 and 2050.

*Source: EU Commission, Stifel**

For the maritime sector, the International Maritime Organisation (IMO) sets international targets to reduce GHG emissions from international shipping, aiming for 20% reduction by 2030, 70% by 2040, and net-zero emissions by 2050 compared to 2008 levels. Two main measures have been introduced by IMO to verify compliance with these objectives: the Carbon Intensity Indicator (CII) and the Ship Energy Efficiency Management Plan Part III.

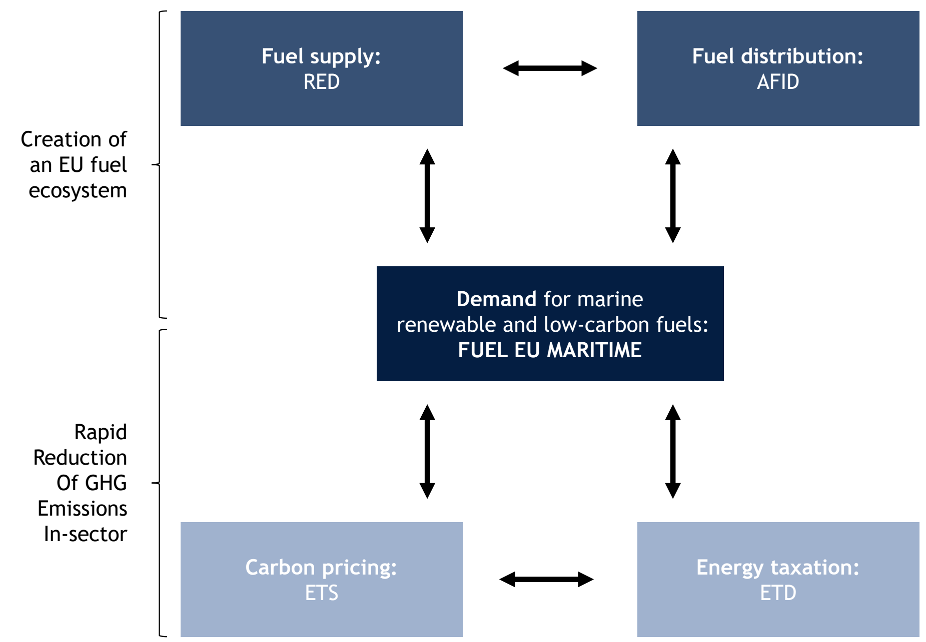
Europe has again taken the lead on maritime emissions, using the FuelEU Maritime, regulation to increase the share of renewable and low-carbon fuels. FuelEU applies to ships over 5,000 gross tonnage, which represent 55% of the fleet but account for about 90% of CO2 emissions. It mandates the reduction of GHG intensity with progressive targets, however without providing specific guidance on one fuel or another to reduce emissions – still asking for 2% RFNBO in total maritime energy consumption by 2034. This leaves the door open for fleet optimisation and hybrids as a first step.

FIG 45: MARITIME INITIATIVES AROUND THE WORLD



*Source: World Economic Forum, Stifel**

FIG 46: FUELEU MARITIME AIMS TO CREATE A COMPLETE ECOSYSTEM



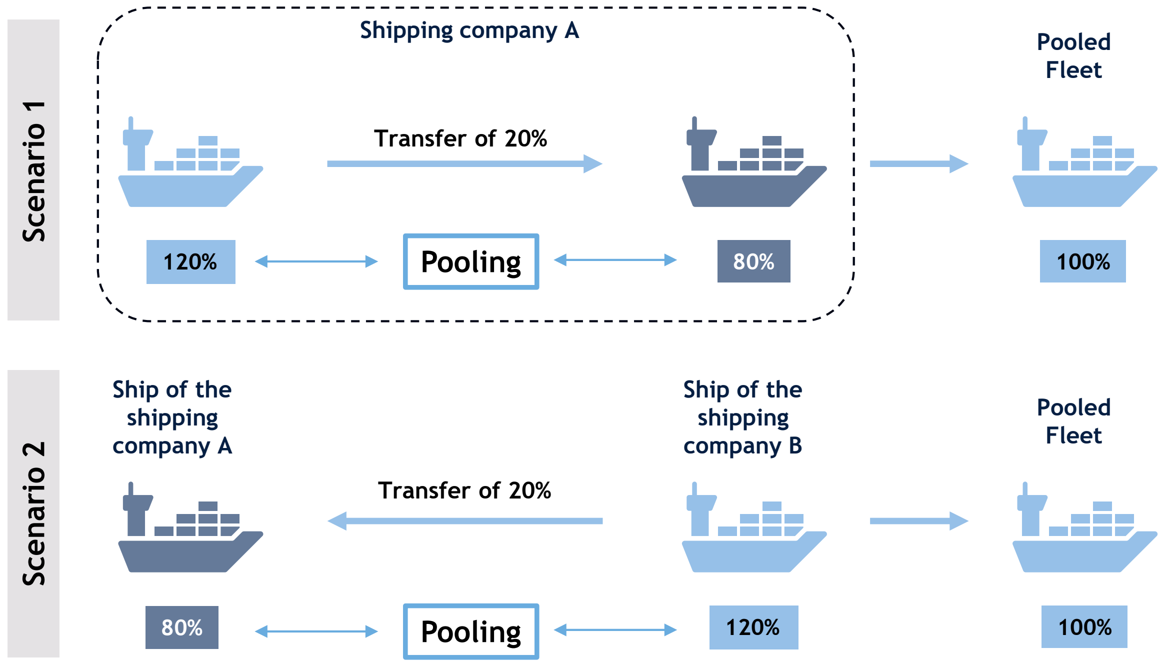
*Source: NOW GmbH, Stifel**

Europe has also introduced comprehensive penalty systems under the RefuelEU and FuelEU initiatives, setting the region apart in its implementation of strict regulatory measures for both the aviation and the maritime sectors.

The European Commission has established clear criteria and non-compliance penalties to enforce SAF blending and obligations. This regulatory framework targets both fuel suppliers and airlines with fines. Fuel suppliers face penalties calculated as at least double the difference between the yearly average price of fossil jet fuel and bio/e-SAF, multiplied by the amount of SAF that would have been required to meet the target. Specific penalties apply for shortfalls in the advanced biofuels and synthetic fuel mandates. According to SAF supplier SkyNRG, these penalties could range between €1k and €6k per tonne of fuel for advanced biofuels and synthetic fuel mandates, respectively. Airlines, meanwhile, would incur penalties representing at least twice the annual average price of conventional jet fuel, multiplied by the quantity of SAF not uplifted. With an average market price of $800 per ton of jet fuel, airlines would therefore risk penalties of at least €1.6k per ton of non-tanked SAF.

For the maritime sector, penalties are based on deviations from the GHG compliance balance of ships as well as the quantity and cost of RFNBO that ships should have used under the related 2% sub-target by 2034. Therefore, ships with higher GHG intensity than the threshold must pay a remedial penalty proportional to their compliance deficit. This deficit is the difference between the reference GHG target and the actual GHG intensity, multiplied by a penalty of €2.4k per tonne of VLSFO energy equivalent, ie. approximately €0.058/MJ of non-compliant energy. These penalties are not imposed on each ship within a fleet but are attributed to each maritime company through a pooling system, in which double-counted initiatives can hedge against older and carbon-intensive ships. As ships have a lifespan of 20-30 years, this system allows time for fleet renewal, where one ship contributes to decarbonisation and offsets emissions from older polluting vessels within the same or another company, in exchange for monetary compensation.

FIG 47: PENALTIES FOR NON-COMPLIANCE WITH FUELEU MARITIME



*Source: Bureau Veritas, Stifel**

WAITING FOR **TRUE CARBON** ACCOUNTANCY TOOLS

GHG emissions basics: defining, monitoring and regulating

The first step in reducing GHG emissions is to classify them and set a target. The Greenhouse Gas Protocol has a framework with emissions divided into three categories, Scopes 1, 2 and 3:

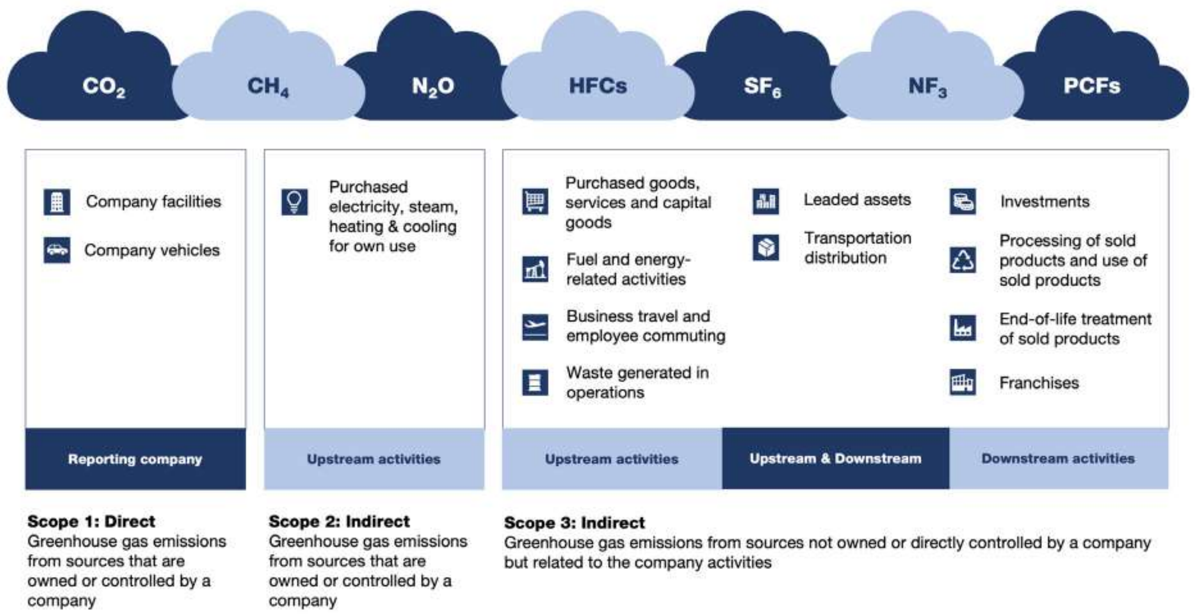
- Scope 1 - Emissions that are generated directly by the organisation, for example running boilers or furnaces

- Scope 2 – Indirect emissions created through electricity or heat purchased to run the business

- Scope 3 – Indirect emissions generated up and down an organisation's value chain

Scope 1 and 2 emissions are relatively easy to measure and mitigate, as they are under an organisation's control. However, it can be very difficult to measure Scope 3 data and reduce related emissions. For many businesses, Scope 3 emissions account for more than 70% of their carbon footprint, meaning that access to data is an important factor.

FIG 48: DEFINITION OF SCOPE 1, 2 AND 3 EMISSIONS FOR CARBON ACCOUNTING



*Source: Carbone4, Stifel**

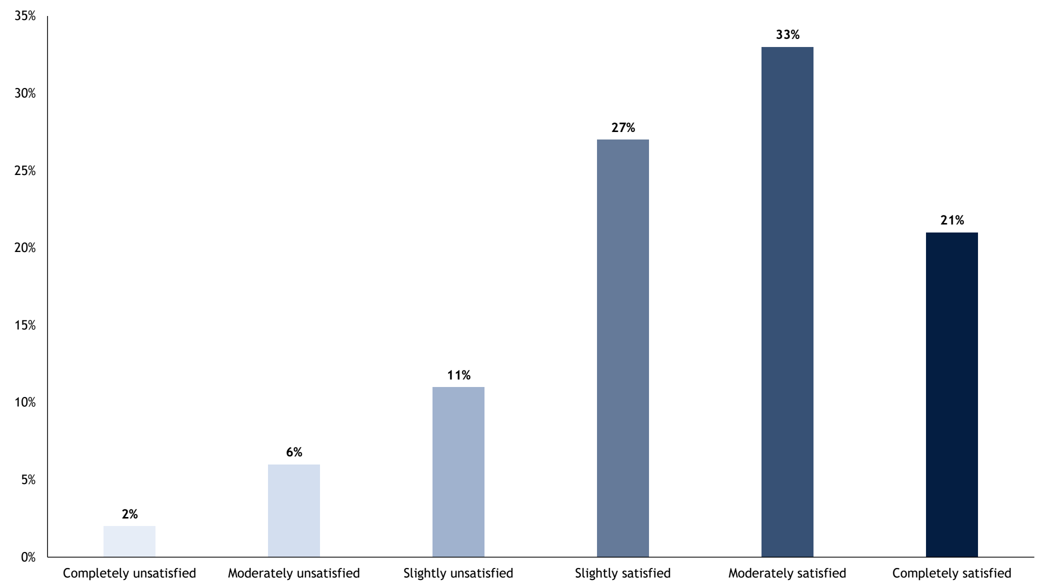
The next step in reducing emissions is to understand where they come from, how to measure and classify them, and then to establish a baseline. A range of software solutions has been developed to make sense of all the data being collected. We have identified two categories of solutions:

- **Sustainability platforms.** These aggregate operational data from companies, estimate their impact from an ESG standpoint and help set targets for the future. This category includes companies such as Vaayu, whose platform connects to shops' point-of-sale systems and calculates the carbon footprint of all daily transactions using the company's database of more than 600,000+ data points. Vaayu's platform offers retailers emissions benchmarking against their peers and details the carbon footprint of individual items.

- **Data analytics technologies.** These collect a huge array of data and apply proprietary algorithms to extract actionable insights. In this field, companies operating in an area known as asset observation are emerging. Their solutions fuse data from a large array of sources such as Earth observation satellites, with a focus on GHG-intensive assets such as oil and gas wells and pipelines, refineries, coal mines, landfills, or any other industrial facilities.

Software is important for data transparency and actionability, both of which are crucial for organisations aiming to improve their sustainability. However, the World Economic Forum reports that only 9% of companies are actively using software that supports data collection, analysis and reporting on their ESG activities. According to a SAP Insights survey, only 21% of business executives said they were completely satisfied with the quality and availability of data collected for sustainability.

FIG 49: DATA QUALITY IS STILL A CHALLENGE FOR ENVIRONMENTAL SUSTAINABILITY



Source: SAP

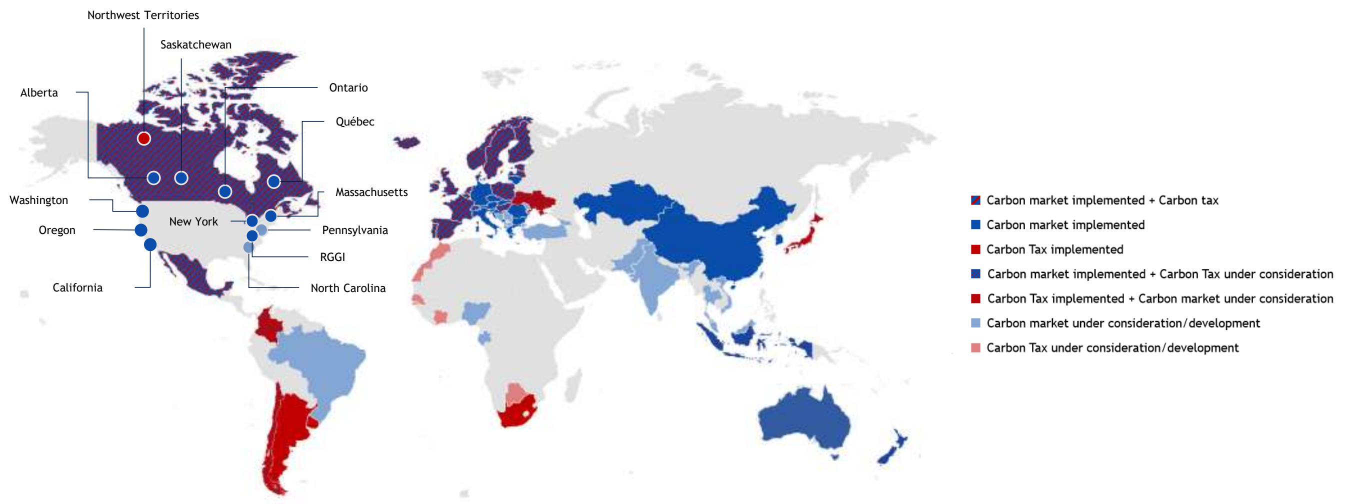
Based on accurate measurement and reporting of emissions, it is essential for regulators to incentivise emissions mitigation, carbon removals and remediation efforts. Two primary systems are used, either separately or together:

- **Carbon taxes** directly set a price on carbon by defining a tax rate on greenhouse gas emissions or the carbon content of fossil fuels. This approach makes it more expensive to emit carbon, thus providing an economic incentive for emitters to reduce their emissions and switch to cleaner energy sources. The revenue generated from the tax can be used to fund renewable energy projects, energy efficiency programs, or be returned to the public through rebates.

- **Carbon markets** allow countries or companies to buy and sell carbon emission allowances or credits. This market-based approach sets a cap on total emissions and enables entities that reduce their emissions below their allowances to sell the surplus to those who exceed their limits. This system incentivises the reduction of emissions by putting a price on carbon and encouraging cost-effective emission reductions. The EU ETS, RFS and RTFO systems are good examples of carbon markets.

According to the World Bank, there are 75 carbon pricing mechanisms worldwide, implemented either as carbon taxes (39) or emission trading systems (36). These mechanisms operate at various scales: 31 at the local/regional level, 44 at the national level, and one at the inter-state level. The regions covered by carbon pricing mechanisms account for 54% of global GDP in 2023 and 50% of global greenhouse gas emissions.

FIG 50: MAP OF CARBON TAXES AND ETS SCHEMES IN 2023

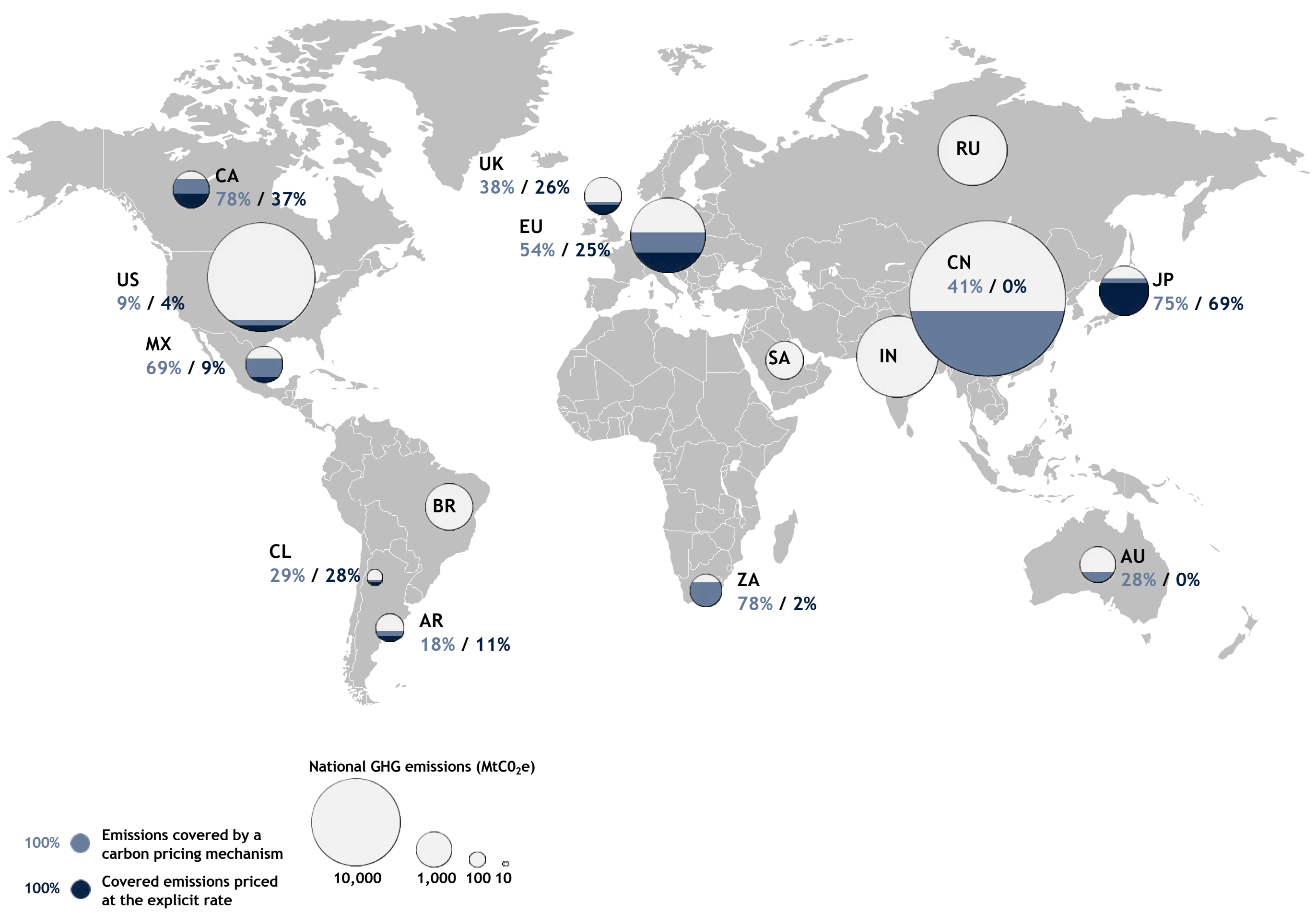


*Source: World Bank Carbon Pricing, Stifel**

Existing carbon frameworks fall short

Indeed, only 24% of global greenhouse gas emissions are currently covered by at least one carbon pricing mechanism. This coverage is highly uneven across countries. In some, there is no carbon pricing mechanism at all, while in Norway, coverage is as high as 89%. Additionally, there are significant disparities in the volume of emissions taxed at the explicit price. For instance, Japan has minimal exemptions, with 69% of its emissions taxed at the explicit rate. In contrast, although China's Emissions Trading System covers 41% of its emissions, the extensive distribution of free quotas results in almost negligible explicit pricing coverage.

FIG 51: GLOBAL COVERAGE OF CARBON EMISSIONS VS CARBON TAX SCHEMES

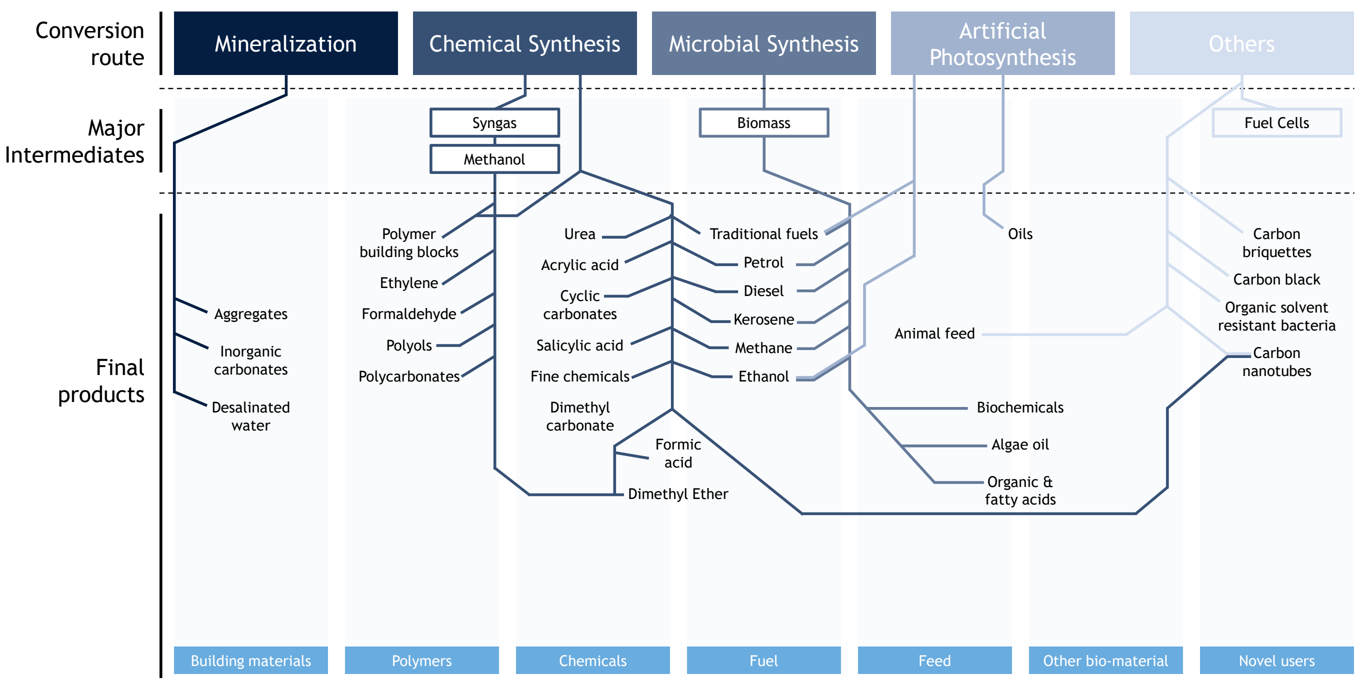


Source: Institute for Climate Economics

The range of explicit carbon prices remains broad and is often too low to be effective. In 2023, these prices varied from as little as $0.01 per tonne of CO2e in California and Mexico, to $154 per tonne of CO2e in Uruguay. More than 70% of the emissions covered are priced below $20 per tonne of CO2e. Nevertheless, the 2017 Stern-Stiglitz report on carbon pricing estimated that the full incentive effect of these mechanisms would be achieved with systematic provision and prices between $40 and $80 per tonne of CO2e starting in 2020, up to between $50 and $100 per tonne of CO2e from 2030 onwards. This highlights the need for a harmonised system, with stronger pricing that reflects the negative externalities associated with carbon emissions and penalties to effectively drive emissions reductions.

Nonetheless, most low-carbon end-products rely on proper carbon prices to reflect a “green premium” in improving carbon footprints compared to fossil alternatives. Although accompanied by more challenging economics, carbon schemes could allow for quicker infrastructure and technology roll-out, from chemical compounds to fuels, metals and renewable energy. However, scalability, replicability and price inflation are all issues to watch out for.

FIG 52: A WIDE RANGE OF LOWER-CARBON END PRODUCTS RELY ON CO2-ROUTES AND CARBON CAPTURE, USAGE AND STORAGE (CCUS)



*Source: BCG, Stifel**

BREAKING INTO TOMORROW’S **REFINING WORLD**

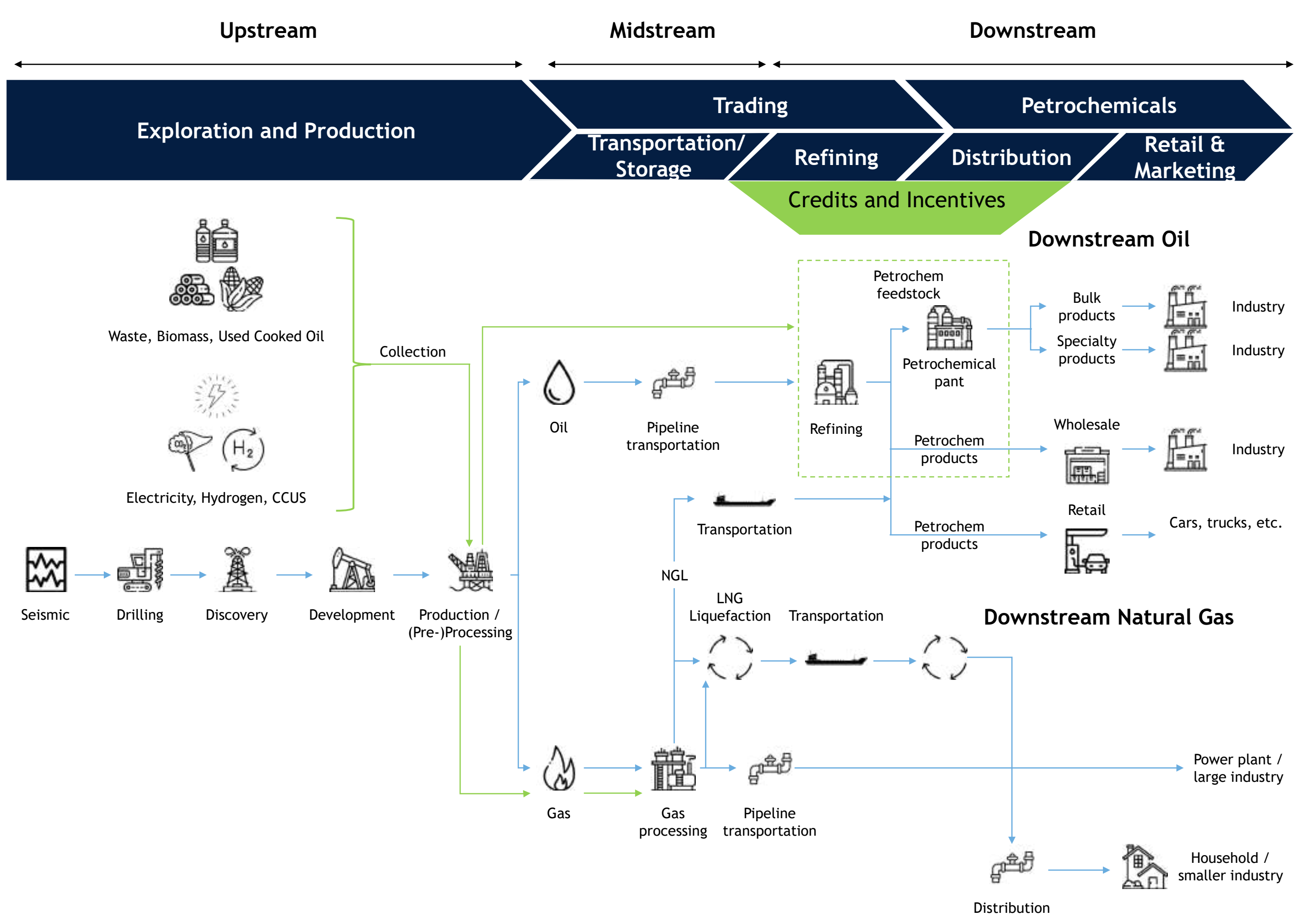
SECTION 3

REFINING THE **VALUE CHAIN**

Centralised vs decentralised?

While low-carbon fuel technology is still in its early stages, a significant market for transportation fuels is about to develop. It is, however based on an evolving landscape, with some fuels serving crucial short-term needs and others emerging as dominant long-term solutions. As the appetite grows, global production hubs are likely to emerge in countries with abundant biomass/land availability as well as renewable energy potential, with market participants exploring bio- and e-pathways. Deriving low-carbon fuels from plant materials, waste and residues will also mean a shift in paradigm for traditional fossil players, who are accustomed to managing depletion rates from oil and gas fields rather than using replenishable feedstocks. The value chain will therefore undergo significant transformation led by upstream and downstream requirements.

FIG 53: THE OIL AND GAS VALUE CHAIN AND HOW IT WILL CHANGE



*Source: BCG, Stifel**

The upstream production of low-carbon fuels can rely on entirely new feed and feedstocks compared to traditional fossil fuels. Integrated oil and gas companies and refineries can therefore partner with renewable power producers, technology providers and biomass-based business to develop production hubs. The scarcity of sustainable biomass and overall land/power availability, means that there will be a growing number of collection and the pre-processing players looking to supply sustainable alternative feedstocks. Different production set-ups could coexist in the future. Modularised small/medium-scale systems could address isolated biomass hotspots, while tailored refining sites could be adapted to local agri-hub biomass volumes. Traditional centralised refineries could be less scalable in the future, more based on access to feedstock rather than technology constraints such as availability, maturity, process economics. For example, new biofuel producers are working closely with farmers and municipalities for waste management, restaurants for used cooking oil, and polluting industries for carbon capture to secure diverse and sustainable feedstock sources.

Similarly, growth in low-carbon fuels will most probably depend more on midstream transportation and storage, either because refineries are centralised, or because of stable load requirements and challenges from renewables intermittency and biogenic carbon flows.

Founded in 2021 in the Netherlands, this bio- and e-technology provider emerged as a collaborative venture between Coval Energy and Microfuel Innovations to solve one of the main issues in the SAF industry – access to competitive and high-volume feedstock.

To solve feedstock bottlenecks and accelerate the ramp-up of HEFA SAF infrastructure, GAFT has developed two unique technological approaches for the production of FOG alternatives: (i) the fermentation of glycerin and/or 1G/2G sugars to produce a bio-feedstock and (ii) a patented high-pressure CO2 electrolyser using renewable electricity tto convert (biogenic) CO2 and water into a liquid energy carrier, subsequently used by microorganisms to produce fatty acids by fermentation. GAFT's process is all based on natural processes used for centuries to produce foods and beverages but results in high-purity fatty acids with a higher value than traditional and scarce FOGs available around the world.

With both lab and small demo testing capabilities, GAFT garnered support from the EIC and is currently in the process of setting a pilot plant together with partners. This is a key milestone in the context of its licensing go-to-market efforts, demonstrating that its process economics work at an industrial scale.

Based in the Netherlands, Vertoro emerged in 2017 as a spin-off from a collaborative initiative involving Brightlands Chemelot Campus, DSM, Chemelot InSciTe, Maastricht University and Eindhoven University of Technology. Leveraging a patented thermochemical process, Vertoro specialises in converting sustainably sourced wood and agricultural residues (such as sawdust) into liquid lignin. At the heart of Vertoro's approach lies a patented thermal solvolysis process, capable of transforming lignocellulosic biomass, particularly lignin, into a versatile product called Goldilocks®. This pioneering process involves the mixing of lignin with a solvent and subsequent heating, all achieved without the need for catalysts, resulting in a platform product with multifaceted applications. Combining solvolysis, hydrolysis and fermentation could ultimately allow Vertoro to deliver renewable fuels to the marine industry before moving ahead with AtJ and PtoL partnerships to address aviation needs.

Vertoro is a Maersk-backed company since October 2021, counting as one of Vertoro's main investors with a binding offtake agreement on first plant(s) output. Additionally, Vertoro is collaborating with several fuel producers/providers, leveraging a partnership with Quadrise since September 2022 to integrate its crude sugar oil on a Focus Motor Yachts, and having signed in August 2024 a major JDA with Raizen, eyeing to secure commercial-scale offtake agreements based on Vertoro's technology integration into Raizen's 2G ethanol facilities.

Universal Fuel Technologies (UFT) specialises in advanced renewable fuel production technologies, focusing on transforming various feedstocks into sustainable aviation fuel (SAF), gasoline and other valuable chemicals through innovative processes. The company provides its "Flexiforming" technology to renewable fuel project developers based on licensing. The technology relies on a versatile single-stage all-gas-phase reaction using a zeolite catalyst at moderate conditions (10 atm, 400°C) and has been extensively tested with over 50 different feedstocks in 500+ pilots.

Responding to feedstock constraints in the renewable fuel industry Flexiforming can convert fuel-grade ethanol, methanol, and other alcohols into AtJ SAF, BTX (benzene, toluene, xylene), or gasoline, upgrade renewable naphtha and LPG into SAF or gasoline and also co-process fossil naphtha with renewable alcohols or convert light olefins into gasoline and jet fuel.

Highly flexible, UFT's technology could allow to transform a wide range of lower value by-products from general waste and the oil & gas and renewable fuel industries, responding to local feedstock constraints while adapting to longer-term by-product challenges.

Founded in 2019 as a spin-off from Atmostat, a subsidiary of the French industrial group ALCEN, Khimod is a climate-tech company dedicated to the decarbonisation of hard-to-abate sectors, harnessing the potential of flow chemistry by focusing on continuous hydrogenation. Leveraging Alcen's extensive technological base and innovative drive, Khimod's field-proven technology is centred around its disruptive Heat Exchanger-Reactor (HER), produced thanks to diffusion bonding, a breakthrough technique initially introduced in the context of the ITER project and developed over the last 20 years by Atmostat. Based on its HER, allowing for high energy efficiency, higher yield and selectivity while relying on very low catalyst requirements, Khimod designs and manufactures turnkey autonomous and modular, small- to medium-scale systems from a few Kt/year to hundreds Kt/year. Those systems can address a wide range of chemical reactions, from Sabatier-based methane/methanol synthesis, to reforming, (reverse) water gas shift, Fisher Tropsch or Haber Bosch synthesis, thereby producing liquid fuels and/or key starting materials for industrial chemistry.

With several methanation pilots already operational in Europe (for example with Jupiter 1000, Methycentre), Khimod continues to capitalise on industrial partnerships, as with the Avebio pilot project for the production of e-kerosene, launched together with Elyse Energy in March 2023.

Dioxycle

Founded in 2020 in France, Dioxycle is a technology provider specialising in carbon dioxide conversion, aiming to capture and convert CO2 into valuable chemical products. The company's innovative electrolyser technology disassembles carbon emissions and reassembles them into energy-rich and useful molecules, such as ethylene, which is crucial for producing fabrics, plastics, and construction materials or ethanol, either used as a chemical in industries or as a fuel, for example for use in AtJ SAF. This process paves the way for 100% sustainable fuels and everyday chemicals without further CO2 accumulation in the atmosphere. Dioxycle aims to recycle over 600 megatonnes of CO2 annually.

The company recently won the «Best CO2 Utilisation 2024» award at the 12th edition of the CO2-based Fuels and Chemicals Conference. Its last raise took place in July 2023, with Dioxycle raising €17m to build its first on-site demonstration project and an industrial prototype.

Aker Carbon Capture

Founded in 2005 in Norway, Aker Carbon Capture is a publicly traded company specialising in carbon capture technology. The company's innovative process uses a mixture of water and organic amine solvents to absorb CO2 and is applicable to emissions from various sources including gas, coal, cement, refineries, waste-to-energy, hydrogen, and other process industries. Aker Carbon Capture offers three mobile and modular capture plants with capacities ranging from 40Kt to over 400Kt of CO2 annually, catering to both mid-range and large-scale emitters and including an offshore version.

The company has completed several test programmes, has around 20 ongoing projects at different maturity stages, and is already constructing three CCUS plants that will collectively capture 1Mt of CO2. More recently, in March 2024, the American oilfield services provider SLB announced plans to merge its carbon capture activities with Aker Carbon Capture. SLB now holds 80% of the combined operations.

Carbon Centric

Carbon Centric is a Norwegian project developer backed by Ostfold Energi, Obligo and Vardar, focused on developing CCS and CCUS projects. Based on Shell Catalyst's carbon capture technology, the company is offering carbon capture as a service. Carbon Centric owns and operates carbon capture plants for small and medium-sized waste and biomass incineration facilities, allowing asset owners to reduce emissions without substantial investment, while managing everything from FEED to installation, operation and offtakes. Carbon Centric also supplies sustainable food-grade CO2 and offers carbon removal as a service for companies aiming to incorporate negative emissions into their sustainability strategies.

The company leverages a first 10Kt/year project in Norway, which was FIDed in late 2023 and is expected to be operational in 2025. It also has three additional projects in Norway and Iceland, which will produce 180Kt/year by 2027/2028. Depending on the location of those sites, Carbon Centric could supply nearby PtoL projects in the medium- to long-term.

again

Founded in 2021 as a spin-off from the Technical University of Denmark, Stanford University and MIT, Again Bio is a bioengineering platform commercialising biosolutions for the capture and the conversion (CCUS) of industrial CO2 emissions into valuable products. Based on a one-step gas fermentation process, bacteria growing at elevated temperatures ferment CO2 and hydrogen into carbon-negative acetate and acetic. Those two are important base chemicals used for example in adhesives, solvents, plastics, textiles or cosmetics manufacturing.

While Again Bio leverages a 65-foot-tall pilot in Copenhagen (able to capture and convert up to 1 ton of CO2 per day), its technology is producing at commercially viable yields and the company has signed a partnership with Helm in 2024 to sell 50Kt/year of CO2-derived acetic acid from its production facilities.

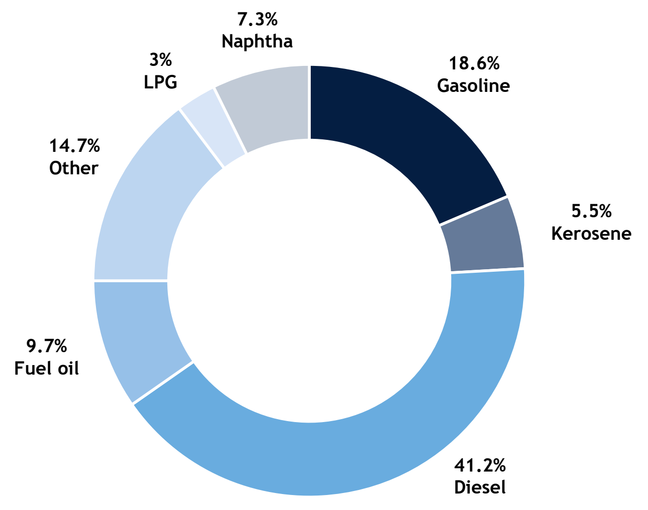
The company has raised more than USD53m to date with the support of Google Ventures, HV Capital, ACME, and Atlantic Labs, expecting a first commercial plant in operation by the end of 2025 or early 2026. Those private capital investments complement a USD47m EU grant dedicated to the PyroCO$_2$ project, eyeing carbon-negative acetone production around Again Bio's technology. This is providing enough resources to manage Again Bio's work-package, bio-process development, and the upscaling of its proprietary bacterial process.

The introduction of alternative fuels is profoundly transforming the downstream segment, with higher specific output yields from bio- and low-carbon fuel production technologies. While they are looking to adapt/convert their facilities to use waste and residues, not all refineries can make these adjustments easily. Access to feedstocks with reliable economics is crucial to avoid stranded assets, which puts more pressure on the infrastructure conversion process.

Higher specific yields also limit the potential for integration into existing processes at a time when it has become a strategic imperative. Process integration allows refiners to maximise return across the entire hydrocarbon value chain, unlocking synergies, reducing costs and increasing efficiencies.

This is typically reflected in average refinery output, with oil and gas processing mostly addressing transport energy demand, but also producing large volumes or co-products downstream for industries such as plastics, textiles and cosmetics. As a result, while low- carbon fuel production complements electrification to reduce economic reliance on fossil energy, it could also reduce overall refinery output for downstream subsegments. It therefore requires strong waste collection and recycling ecosystems to at least partially close the material cycle.

FIG 54: AVERAGE REFINERY OUTPUT IN EUROPE



*Source: IEA, Stifel**

BIOFUELS' **MULTIFACETED APPROACH** TO CLEAN ENERGY

Complementary but transitory road fuels

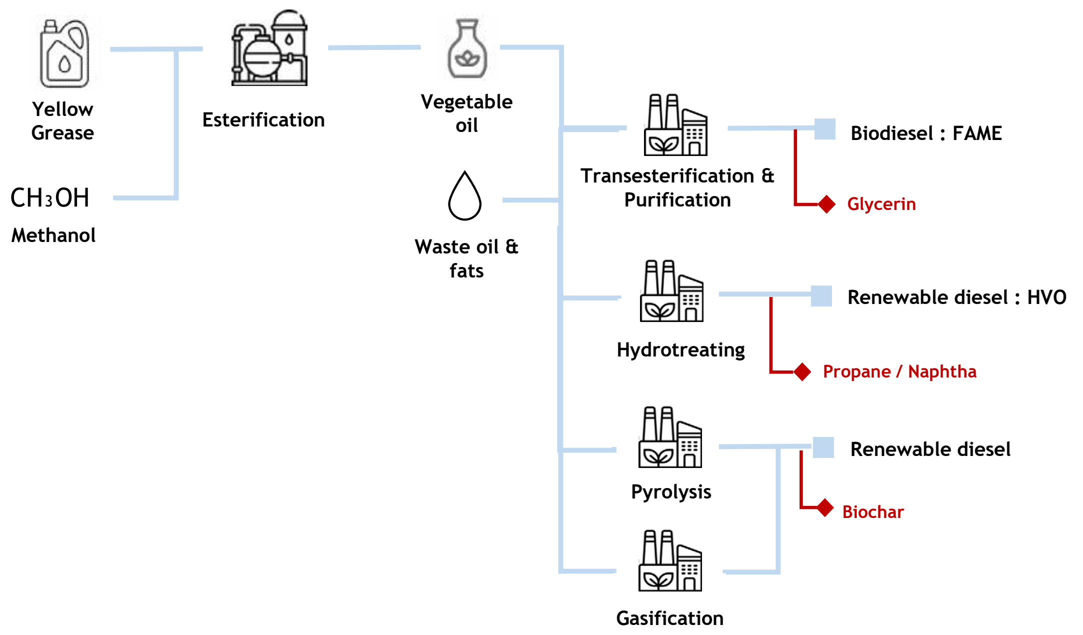
To be a viable fossil fuel substitute, alternative fuels need to offer superior environmental benefits, be economically competitive and be producible in quantities that make an impact on final energy demand. They also provide need to provide net energy gain over the energy sources used upstream. Ethanol is estimated to yield about 1.2-1.3x the energy invested in its production; biodiesel yields 1.9-2.0x. With the current push in favour of road transport electrification facing potential delays in the 2035 ZEV framework in Europe and short- to medium-term electricity grid congestion, there is a need for complementary solutions. Biodiesel and bioethanol are the most mature and widely available biofuels:

- **FAME** (fatty acid methyl ester) **biodiesel** is a mono-alkyl ester produced via (trans)esterification. Biodiesel meets both the biomass-based diesel and overall advanced biofuel requirements: it is produced from vegetable oils, yellow grease, used cooking oils or animal fats, mixed with methanol and either sodium hydroxide or potassium hydroxide. This transesterification process converts fats and oils into biodiesel (90%) and glycerin (10%), the latter being a valuable co-product for the pharmaceutical industry. Nonetheless, the rise of FAME has created a surplus of glycerine, which can however also be used in anaerobic digesters to produce biomethane or fermented in biolipids to produce biodiesel and SAF. Due to the hygroscopic nature of FAME as well as its biological content and the presence of oxygen in the fuel, bacteria tend to grow at the interface between FAME and free water, potentially clogging filters. As a result, 7% is an established standard for FAME blending with fossil diesel.

- **HVO** (Hydrotreated Vegetable Oil) **diesel** is often referred as **renewable diesel** because it can be produced from the same fats, vegetable oils and greases than FAME, but is of a similar quality to fossil and biomass-to-liquid (BTL) fuel. Hydrotreatment allows for the removal of oxygen with hydrogen after a first gasification step, using a Fischer-Tropsch (FT)-like method to create a liquid. Unlike FAME, HVO can be used pure as well as being blended.

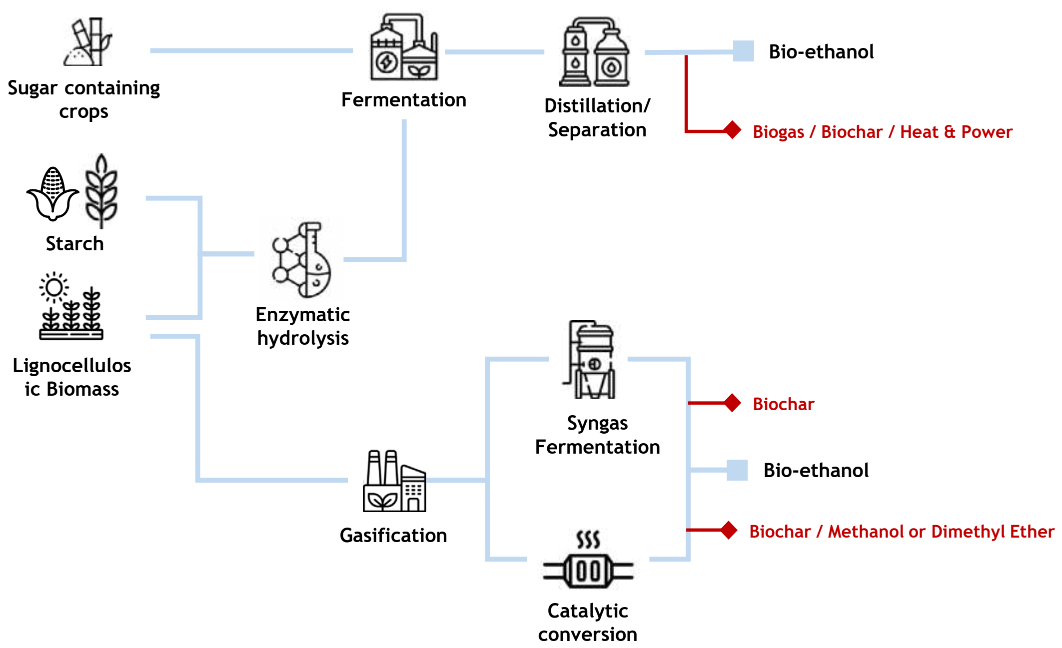
- **Bioethanol** can be produced through the fermentation of biomass-derived sugars. It is a well-established and widely used method, with first-generation extraction the least challenging. The typical process involves breaking down biomass materials such as corn, wheat or sugarcane into fermentable sugars, which are then converted into ethanol by microorganisms. Bioethanol can also be produced using lignocellulosic feedstocks, which are more complex and harder to break down. This can be achieved through gasification, considered one of the most suitable thermal treatments due to its ability to convert most of the biomass into useful carbon compounds.

FIG 55: BIODIESEL PRODUCTION PATHWAYS



Source: Stifel*

FIG 56: BIOETHANOL PRODUCTION PATHWAYS



Source: Stifel*

FIG 57: MAIN BIODIESEL PLAYERS

Source: Stifel*

FIG 58: MAIN BIOETHANOL PLAYERS

Source: Stifel*

Borregaard

Founded in 1889, Borregaard is a Norwegian-listed and globally leading biorefinery company specialised in the conversion of sustainable woody raw materials (lignocellulosic biomass) to advanced and eco-friendly biochemicals and biomaterials. Traditionally engaged in pulp and paper processing, Borregaard focuses on extracting the most out of the three primary wood components, i.e. fibers, lignins and sugars, leveraging a cutting-edge portfolio of technologies to efficiently use 94% of woody feedstock.

As well as its biorefinery in Sarpsborg (Finland), from where Borregaard supplies high-purity speciality cellulose, the company has five production sites outside Norway dedicated to the production of lignin-based products (biopolymers, wood-based vanillin). In that context, Borregaard produces advanced (2G) bioethanol, successively (i) cooking spruce chips with acidic calcium bisulfite cooking liquor, (ii) hydrolysing hemicellulose into various sugars during the cooking process, (iii) concentrating spent sulphite liquor and (iv) fermenting sugars and distilling ethanol.

With less than 16Kt/year (50kg/ton of processed wood) of bioethanol production capacities, Borregaard supplies advanced bioethanol to Statoil (among others), a leading retail chain for petrol and diesel, however most volumes are sold for use in higher-value chemical products or as solvents.

austrocel hallein

Austrocel is a private Austrian company created in 1890 and acquired by TowerBrook in 2017. It is a leading manufacturer of dissolving pulp, which is primarily used in the textile industry for the production of viscose fibers, as well as a bioenergy producer, making bioethanol, biogas and bioelectricity. Austrocel's core strategy relies on its process integration expertise, where it adds and integrates new process technology blocks to unleash wood's full potential (under a "cascadic material use of wood").

High-purity cellulose is derived from residual spruce and fir wood from sustainably managed forests, unlike competition that tends to require higher quality wood input. Austrocel envisages Mt/year fiber technology potential capacity worldwide.

Additionally, the company boasts the world's largest wood-based bioethanol plant, producing up to 23Kt/year of 2G bioethanol, equivalent to almost 1% of total Austrian gasoline consumption. AustroCel also uses an innovative fermentation process to generate biogas from pulp factory filtrates, subsequently providing 100GWh/year of green electricity and district heating based on a CHP plant.

Looking forward, the company aims to further enhance its operations while testing additional integration plans, ranging from the conversion of its own biogas and biogenic CO2 into biomethanol, to the ongoing AgroBiogel developments (lignin-based water absorbent that could significantly increase agricultural yields).

ENVIEN INTERNATIONAL

Established in 2007, Envien is a private Slovakian consortium of companies across Central and Eastern Europe, spanning across 8 countries. The company is the 9th largest biodiesel producer and 10th largest bioethanol producer within the EU, currently leveraging close to 250Kt/year of bioethanol production capacity and 470Kt/year of biodiesel production capacity, mostly derived from corn sugar and rapeseed oil.

Envien's growth strategy revolves around strategic acquisitions within the biofuels sector, integrating vegetable oil production in Poland, its key feedstock supplier, on top of biorefinery assets in Slovakia, Czech Republic, Hungary and Croatia for fuel production. In 2023, the company ventured into the Indian biofuels market with an investment project aimed at establishing a bioethanol production unit using broken rice for feedstock. Envien also focuses on raw material and residuals preparation for co-processing to reuse materials or recover biomethane, as well as on waste-to-liquid pathways, especially around the conversion of municipal solid waste into biomethanol.

Verbio
Biofuel and Technology

Verbio is a German-listed company established in 2006 specialising in the production and distribution of biofuels, with a product lineup including biodiesel, bioethanol, biomethane, bioglycerine, phytosterol, and fertiliser derived from biomass. What distinguishes Verbio is its integrated and sustainable production approach, focused on maximising raw material utilisation and minimising waste. While Verbio's biodiesel process is similar to FAME competitors, in the medium to long term it plans to add another process block, using chemical ethenolysis to produce specialised bio-based chemicals. Verbio's bioethanol technology claims to offer 50% higher energy vs conventional bioethanol using flexible biomass inputs (wheat, cereals, slop, maize, and straw) instead of high-protein only, and recovering various raw materials and by-products either for industrial applications or for further processing into biomethane.

Verbio operates four bioethanol and biodiesel production facilities throughout Europe, predominantly in Germany, along with two bioethanol plants in North America and a biodiesel plant in Canada. Additionally, the company has several renewable natural gas (RNG) units located in Germany and India. In total, Verbio has 710Kt/year biodiesel (FAME, o/w ~100Kt waste-based) and 800Kt/year bioethanol production capacity, complemented by near 2GWHeq/year biomethane production capacity.

ARGENT ENERGY

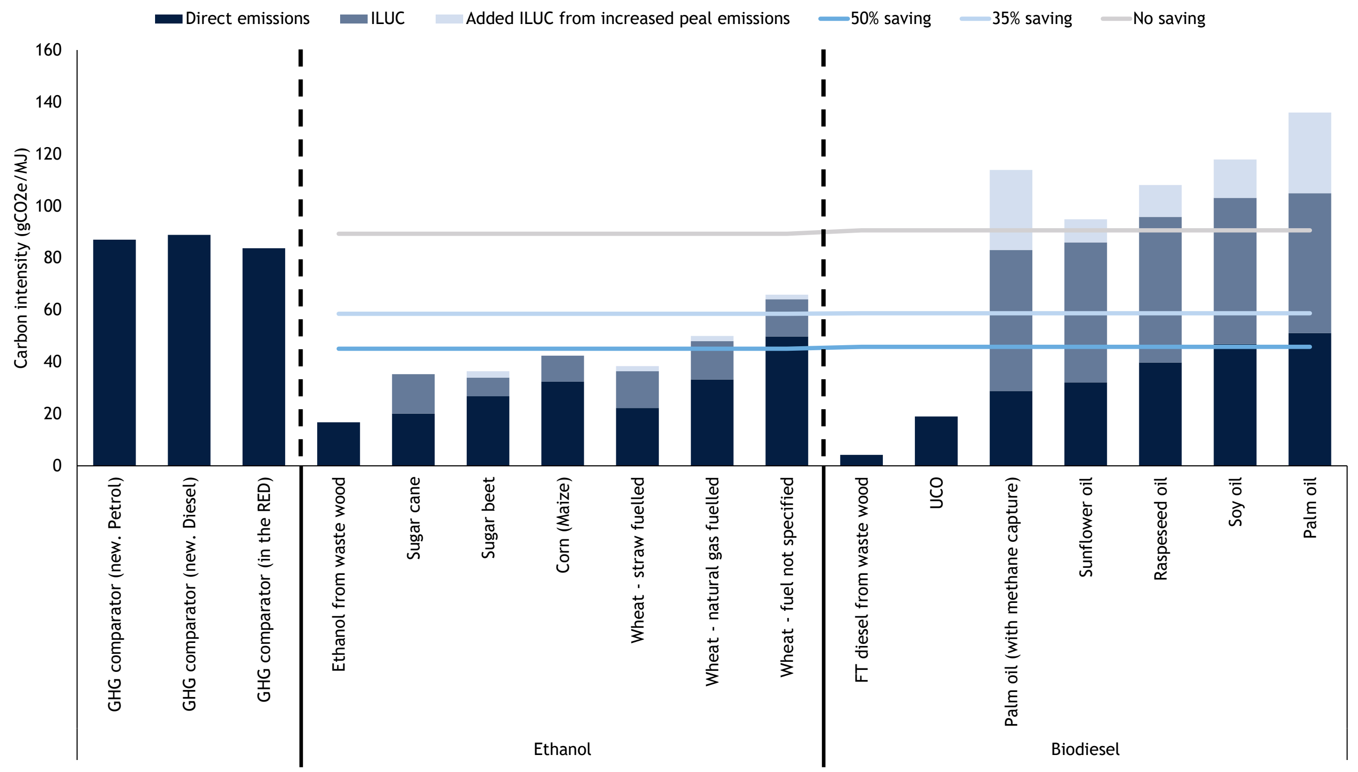
Established in 2001, Argent Energy, is a prominent player in the UK renewable energy landscape and was acquired by John Swire & Sons in 2013. Specialising in the production of second-generation biodiesel derived from waste fats and oils, the company leverages annual production capacity of 195Kt/year from two sites (Stanlow and Amsterdam). Its initial Motherwell site (45Kt/year) closed at the end of May 2024, facing competition from Chinese and US imports as well as difficulties with importing tallow oil.

With plans to increase biodiesel production in Amsterdam more than five-fold to 540Kt/year, Argent Energy aims to improve the value of its biodiesel byproducts. Boosting glycerin output began by constructing a glycerin refinery in Amsterdam (50Kt/year at scale), with a view to expanding its product portfolio in the chemical market, including antifreeze agents, plasticisers for polymers, components for epoxy resins, and the potential integration of new fuels.

Collaborating closely with the marine sector, Argent Energy aims to customise Biofuel-Oils (BFO) to contribute to the decarbonisation of sea transport. This resulted in 100% FAME fuel test phase used in a successful trial between FincoEnergies and VT Group, a Dutch maritime logistics company, potentially unlocking barriers to biodiesel adoption for the inland shipping sector.

The risk with those first-generation biofuels is that their production can result in substantial increases in indirect GHG emissions from the soil and removed vegetation. This is because production can indirectly cause additional deforestation and land conversion if existing agricultural land is turned over to biofuel production, or if agriculture has to expand at the expense of forests, grasslands or other carbon-rich ecosystems. Standalone biodiesel from vegetable oil surplus releases less agricultural nitrogen, phosphorus, and pesticide pollutants when compared to bioethanol, per net energy gain.

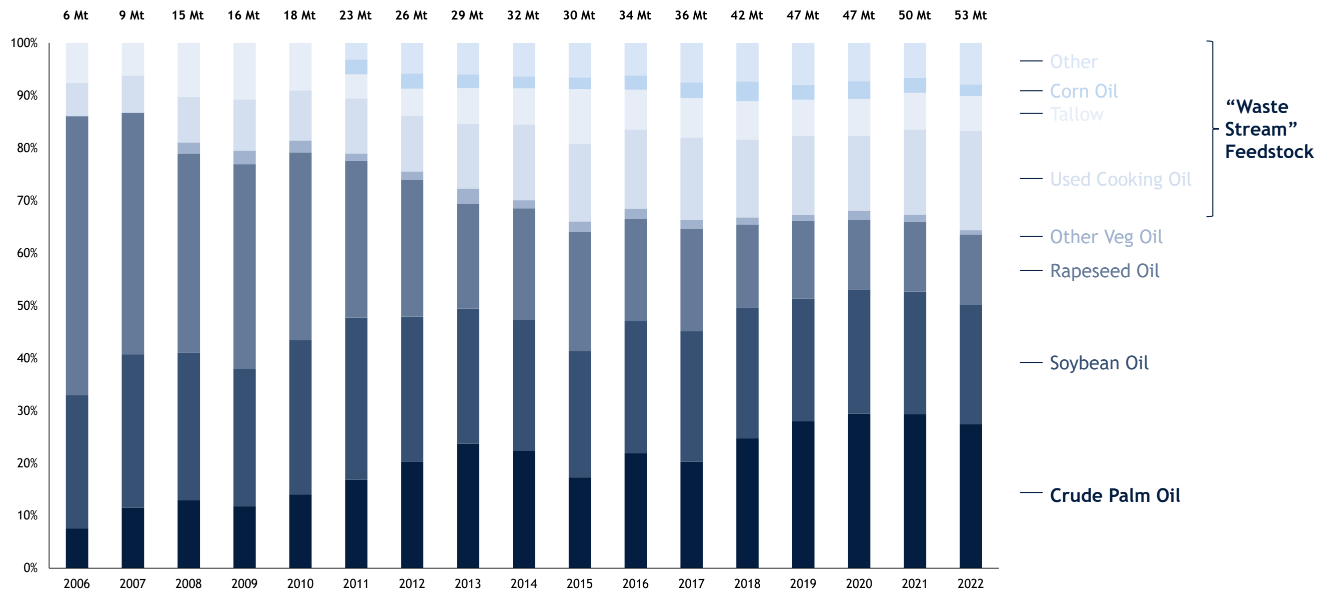
FIG 59: GHG EMISSIONS REDUCTION PROFILE OF BIOFUELS INCLUDING INDIRECT LAND USE CHANGE (ILUC) FACTORS



*Source: Szabo, Zoltan. "Reviewing the GHG Savings of Ethanol", Ethanol Europe, Stifel**

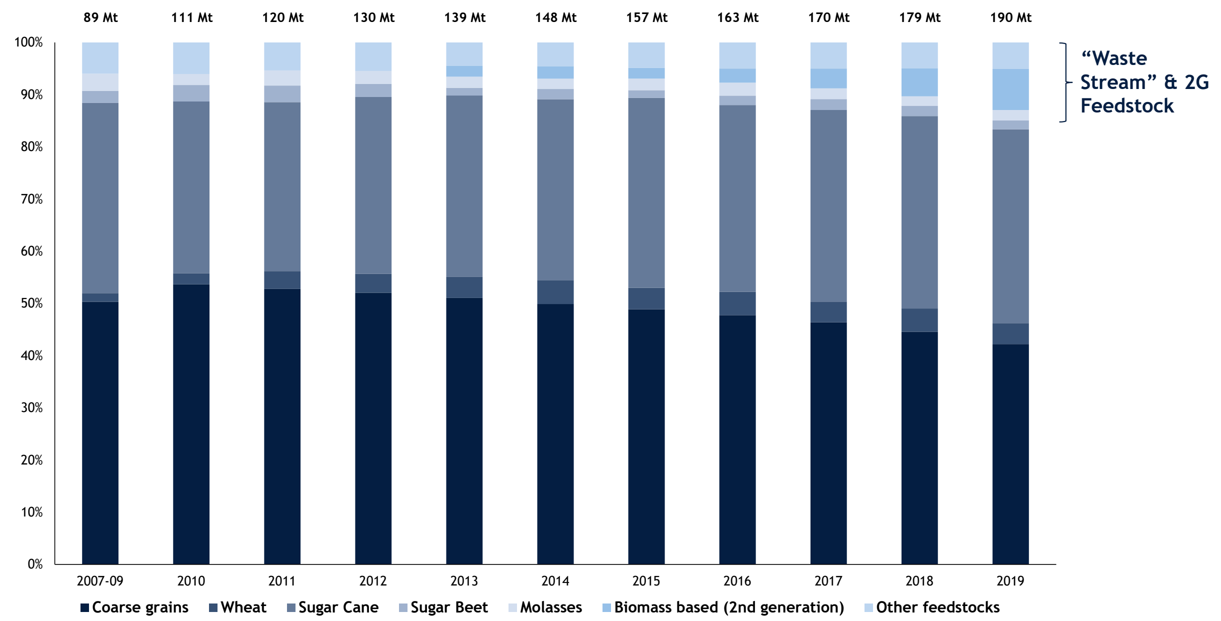
As such, whereas current bioethanol and biodiesel production ecosystems mostly rely on crop-based sugars and oils, there is growing interest in lignocellulosic ethanol and renewable diesel, both coming with their own scalability challenges. While second-generation ethanol is a perfect illustration of the extractable value from in-depth process integration with the upstream pulp and wood residues industries, such industrial complex and biorefinery replicability remain challenging. HVO on the other hand relies on rather cheap but scarce feedstock such as used cooking oil and oil residues, for which growing competition should arise from HEFA SAF facilities going forward, increase feedstock scarcity and geographic dependencies, ultimately with strong feedstock cost inflation. This could harm bio- and renewable diesel producers margins considering the pressure brought by SAF mandates and the resulting willingness to pay for expensive jet-fuel solutions, potentially displacing available feedstock in the market.

FIG 60: GLOBAL FEEDSTOCK USED IN PRODUCTION OF FAME AND HVO OVER 2006-2022



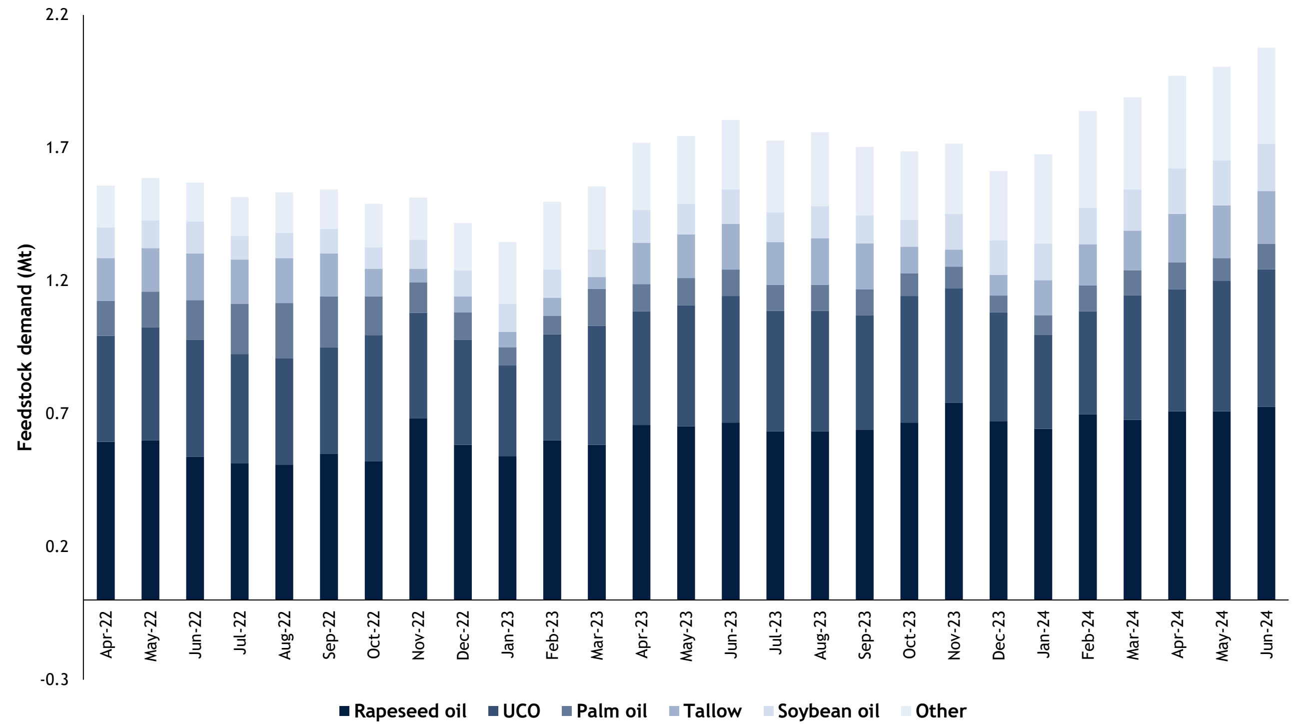
*Source: US DoE, IEA, US DA, FAS Posts, Stifel**

FIG 61: GLOBAL FEEDSTOCK USED IN PRODUCTION OF BIOETHANOL OVER 2006-2019



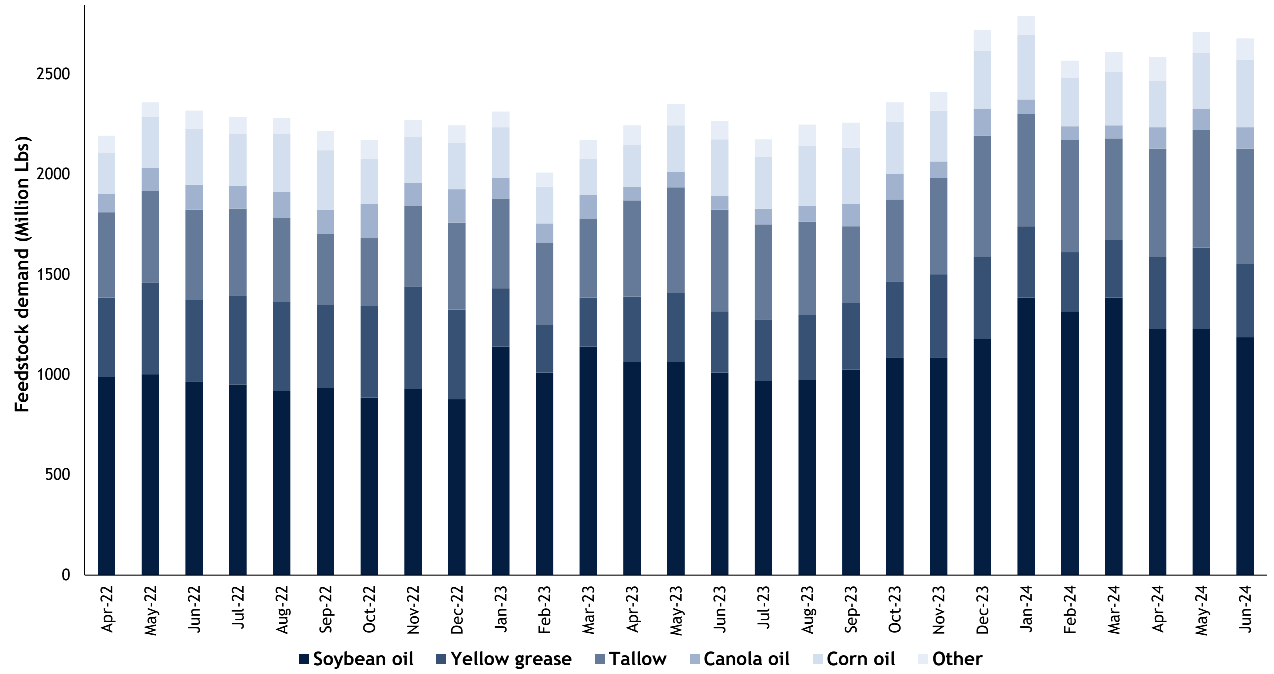
*Source: The Crop Site, Stifel**

FIG 62: EUROPEAN BIODIESEL AND HVO FEEDSTOCK DEMAND FROM Q1 22 TO Q1 24



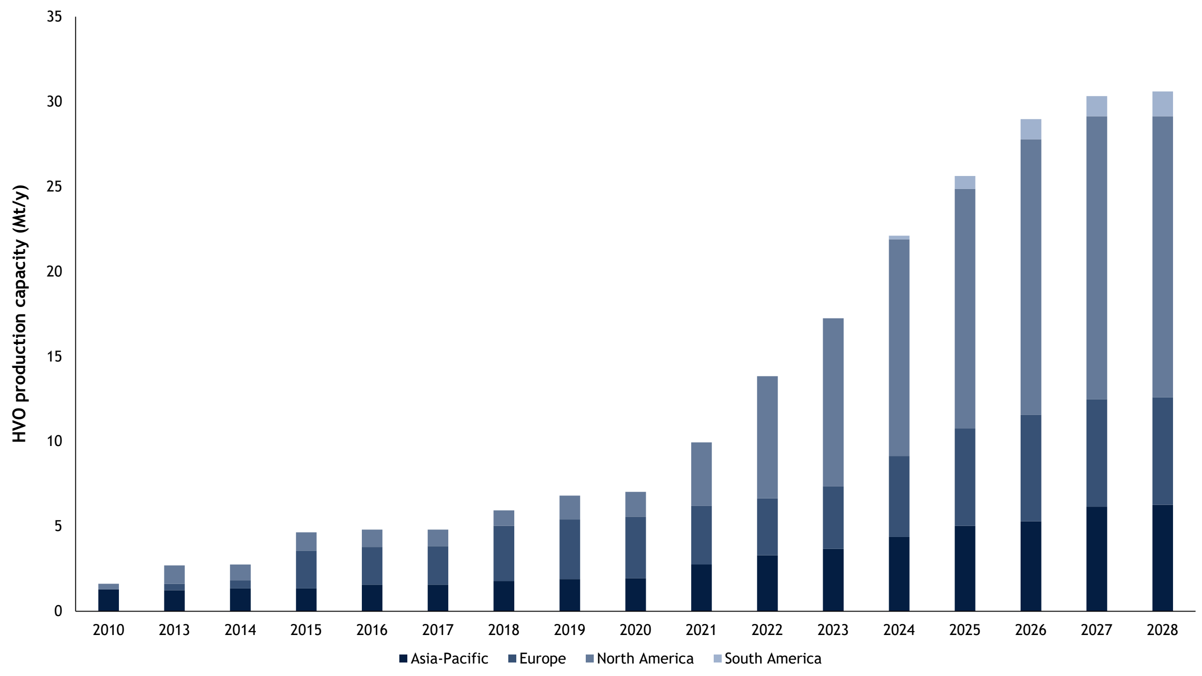
*Source: Argus, Stifel**

FIG 63: US BIODIESEL AND HVO FEEDSTOCK DEMAND FROM Q1 22 TO Q1 24



*Source: Argus, Stifel**

FIG 64: PLANNED BIODIESEL CAPACITY EXPANSION IS MOSTLY DRIVEN BY HVO

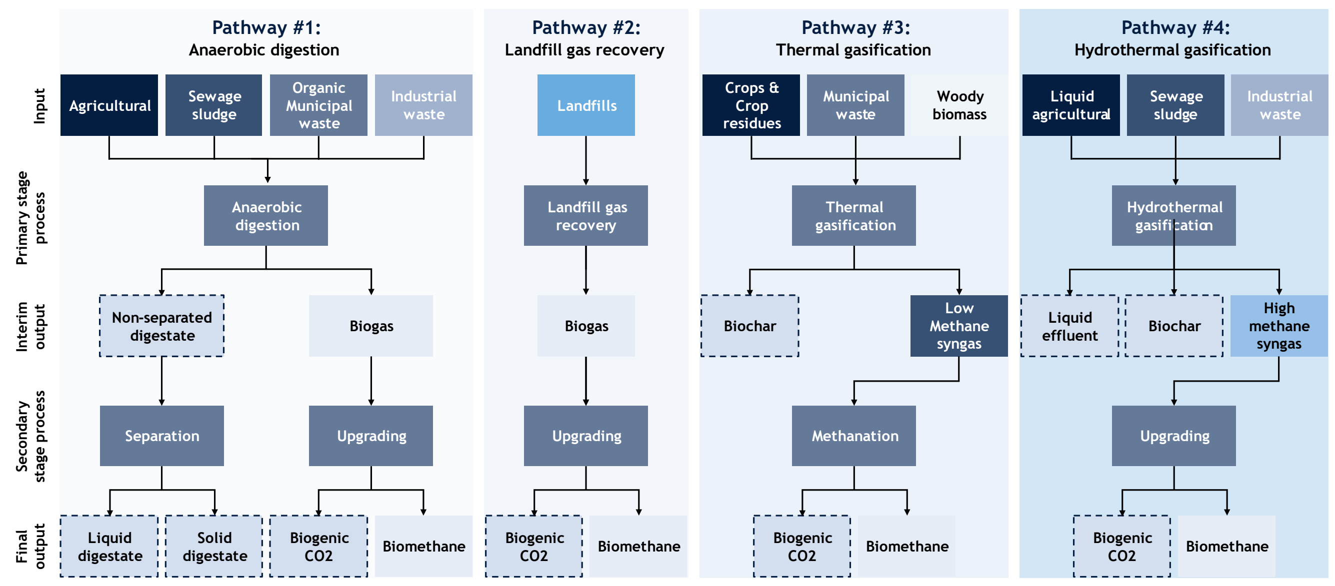


*Source: Argus, Stifel**

In the same way that bioethanol and biodiesel are drop-in fuels for existing ICE vehicles, switching to methane/biomethane could be of interest depending on the maturity of electricity grids and the pace at which they can absorb rising EV charging needs (requiring grid extension or grid updates). Indeed, taking the UK as a reference, where the gas grid is very ramified and can handle significant flow, one temporary alternative can arise for medium- and heavy-duty vehicles in switching to CNG, waiting for technologies and infrastructure to mature. While this could be done on fossil natural gas and reduce up to 20% GHG emissions compared to diesel, this would have an even higher impact relying on biomethane production. Unsurprisingly, the biomethane ecosystem is on the rise, growing as per local regulation (RTFO in the UK), with the EU being the world's largest producer (boosted by RePowerEU scheme).

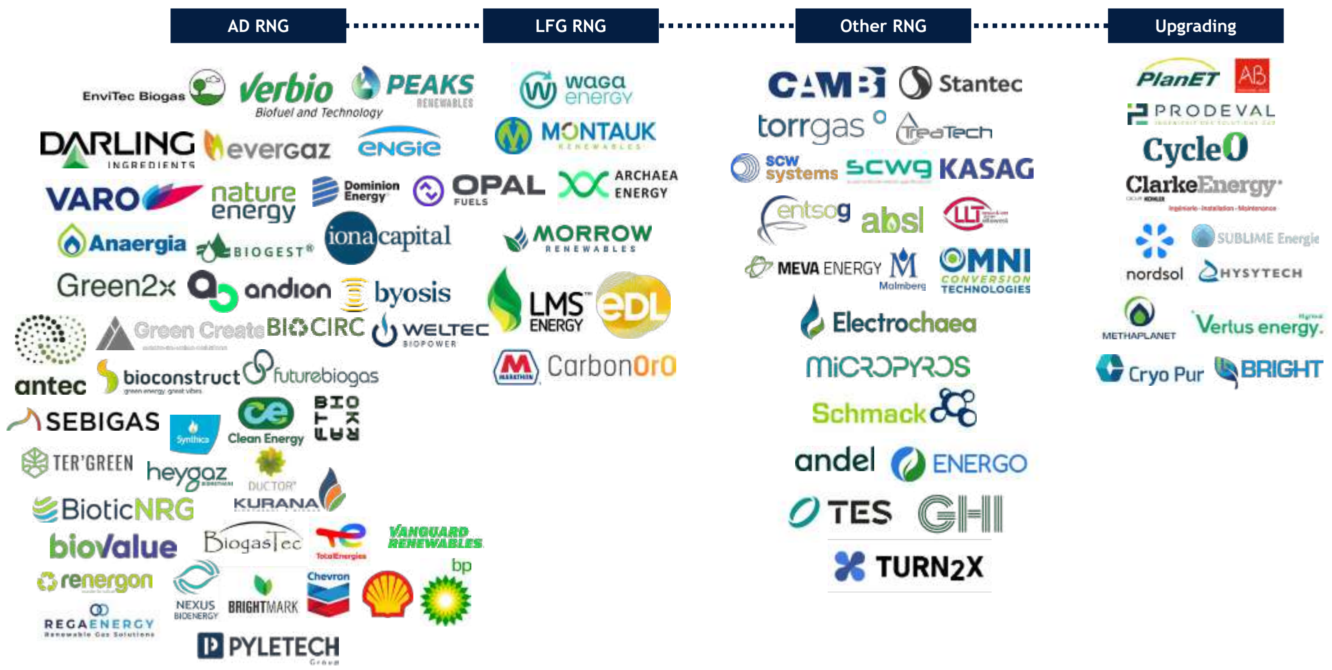
Biomethane can be generated from various feedstocks, including food crops and plant residues, sewage sludge, and different types of waste. While the production process is generally consistent across the four available technology pathways, different feedstocks require specific technology, generally involving the conversion of feedstock into an intermediate gas with 45%-60% methane content ahead of purification into grid-compliant methane with 98% purity. Nonetheless, to prevent misuse of food crops, avoid controversial land use and favour waste recovery, first-generation and advanced biomethane from sources such as residues, manure and wastewater needs to be differentiated. It is important to bear in mind that ultimately biomethane can only be a temporary tool to impact transport emissions compared to overall natural gas consumption, as it is a scarce but important molecule for process industries.

FIG 65: BIOMETHANE PRODUCTION PATHWAYS



*Source: Arthur D. Little, Stifel**

FIG 66: MAIN BIOMETHANE PLAYERS



*Source: Stifel**

Waga Energy is a French listed company specialising in the production of renewable natural gas (RNG) from landfill gas. Established in 2015, the company combines a globally unique and cutting-edge technology with environmental stewardship to transform waste into a valuable energy resource. Waga Energy installs standardised, modular and easily scalable WAGABOX® units, which are advanced purification systems able to convert landfill gas from any type of landfill into high-quality RNG. These units combine both membrane filtration and cryogenic distillation to efficiently separate methane from other gases, allowing for ~90% RNG recovery while always ensuring grid-compliant output (>98% purity).

Currently holding a dominant position in France and in Europe, Waga Energy is gradually gaining solid ground in North America, steadily delivering both in terms of pipeline investments and project execution with high-calibre partners. On top of its 35 contracts secured to date, totalling >1.7TWh/year of installed capacity (>2.3TWh/year with third-party owned-assets), Waga Energy has a pipeline of 11.7TWh/year. In 2024, the company raised €52m fresh equity on top of a €60m credit line with Eiffel Investment and a €100m green syndicated loan, all dedicated to improving project seed capabilities and accelerating roll-outs. Waga Energy is aiming for €200m revenue and 4TWheq of installed capacity by 2026.

Initially founded in 2009, Ductor is a Finnish biotechnology company that has developed an innovative 2-step process able to separate and capture nitrogen from organic waste streams, addressing the long-standing issue of ammonia inhibition in traditional anaerobic digestion (AD) processes. This technology stabilizes and optimises biogas production from high nitrogen feedstocks such as poultry manure, significantly enhancing the economics of biogas facilities by adding inexpensive feedstock and new revenue streams. Microorganism-based, with low heat, low energy and low pressure requirements, the process liquefies RNG digestate into a biofertilizer that is uncoloured and 100% matching agro-industry standards. This involves a fermentation step prior to the classic AD process, converting excess nitrogen into ammonia/ammonium, which is then captured and recycled. The process also creates valuable byproducts such as pure nitrogen fertiliser and high-phosphorus soil improvers.

Ductor owns a pilot site in Tuorla (Finland), which can process 1.4Kt/year of poultry manure and produce 266,000Nm3 of RNG. TotalEnergies acquired a 20% stake in May 2023, following the acquisition of Fonroche Biogaz and the opening of Biobéarn in 2024, which is the largest AD site in France, with an ouput of 160GWheq/year. Future plans for Ductor include commercial projects in North America and Mexico, strategically focusing on a first industrial-scale project in Ohio.

TreaTech, a Swiss start-up spun off from EPFL in 2015, has developed a unique and proprietary hydrothermal gasification process that converts otherwise incinerated waste streams into valuable resources, including methane-rich renewable gas, clean water and minerals. This technology transforms liquid industrial waste and municipal wastewater into methane, first pressurising waste to 230 bars and heating it to 40°C and causing the water to precipitate minerals such as phosphorus and potassium, which can be used as fertilizers. The remaining water and organic matter are then processed in a catalytic reactor that primarily produces methane, (along with some hydrogen and CO2) that can be used as an onsite energy solution or injected into the grid network. This method is significantly faster than traditional biomethanation, reducing processing time from 20-30 days to about 30 minutes, and creating a gas nearly ready for grid-injection, bypassing the synthetic methanation step required by some competitors.

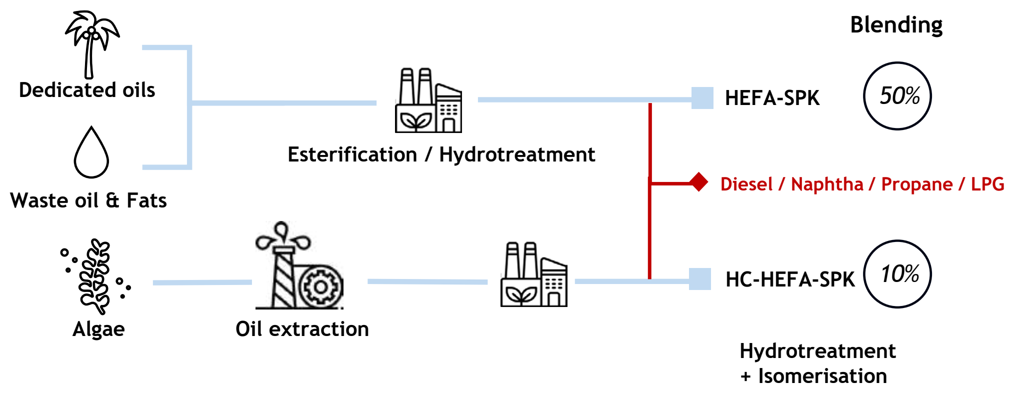
Currently at a pilot scale, TreaTech aims to deploy modules capable of processing 3-4 tons of waste per hour by 2025. The company raised CHF9m in June 2023 in a funding round led by Engie New Venture and Montrose Environmental Group, alongside notable support from the EIC Fund, Sipchem Europe, CMA CGM Fund for Energies, and Holdigaz.

Growing SAF market demand shakes up existing feedstock equilibriums

Sustainable aviation fuel (SAF) is the only viable and scalable alternative to jet fuel. One of the main differences between pure SAF and jet fuel is the absence of aromatics, which can cause issues with sealing and lubrication in aircraft engines. These issues are currently addressed by blending pure SAF (bio- or e-kerosene) with conventional jet fuel (fossil kerosene and aromatics). In 2023, the American Society of Testing and Materials (ASTM) approved several SAF production pathways, all recognised by the ICAO. Additionally, 11 other processes are under evaluation. These pathways differ in terms of feedstock requirements, output co-products and GHG emission reduction potential. ASTM also sets maximum SAF blend ratios with conventional jet fuel, currently capped at 50%, to ensure safe aircraft and engine operation. Promising SAF production pathways include:

- **Hydroprocessed esters and fatty acids (HEFA):** This widely used method converts waste oils and lipids such as used cooking oil into SAF through hydrogenation. It involves removing oxygen through hydrodeoxygenation and then cracking and isomerizing molecules to achieve the necessary jet fuel chain length. HEFA allows for a maximum blend ratio of 50%.

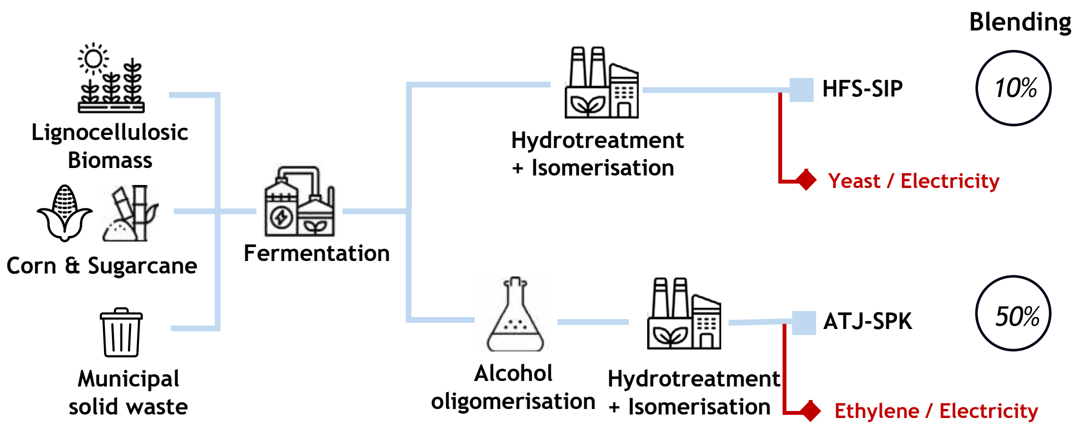
FIG 67: HEFA SAF PRODUCTION PATHWAY



*Source: Stifel**

- **Alcohol-to-Jet (AtJ):** With the first commercial-scale plants now appearing, this pathway, processes any feedstock that can be converted to alcohols (such as ethanol, iso-butanol and methanolc) and then into SAF with a high specific yield. AtJ removes oxygen from alcohols and links the molecules to achieve the desired carbon chain length through oligomerisation. Currently, ethanol and iso-butanol are the approved feedstocks for AtJ technology, relying on upstream pathways for relevant sustainable intermediates and resulting in a maximum blending ratio of 50%.
- **Sugar-to-Jet (Synthesised Iso-Paraffins or SIP):** This method uses microbes to convert sugars into farnesene, which can then be processed into SAF with hydrogen. The maximum blending ratio for SIP is 10%.

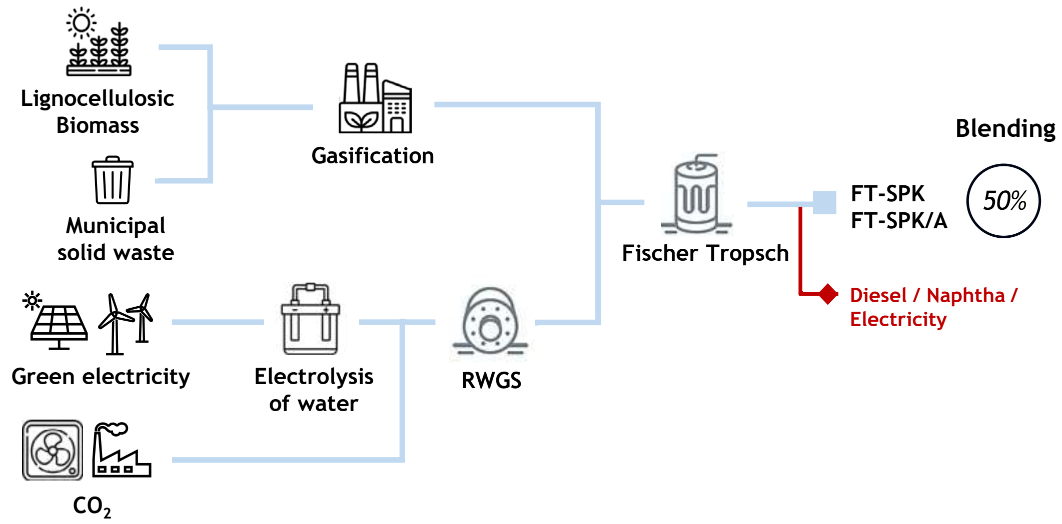
FIG 68: ATJ & SIP SAF PRODUCTION PATHWAYS



*Source: Stifel**

- **Fischer-Tropsch (FT):** FT reactors are mature oil and gas technologies that require a syngas intermediate. When based on biomass or waste gasification, the aim is to produce a mix of hydrogen and carbon monoxide, which is then converted into SAF in an FT reactor. The FT process can break down any carbon-containing material into gaseous building blocks, which are then synthesised into SAF and other fuels. For the power-to-liquid (PtoL) approach, renewable electricity is used to produce hydrogen via electrolysis, which is then combined with captured biogenic CO2 using a reverse water-gas shift (RWGS) reaction to create a synthetic gas mixture of hydrogen and carbon monoxide, processed by a FT reactor into SAF. Because a FT reactor runs on a stable load, the e-FT system requires significant onsite storage capabilities, either on the CO2 side or for renewable hydrogen.

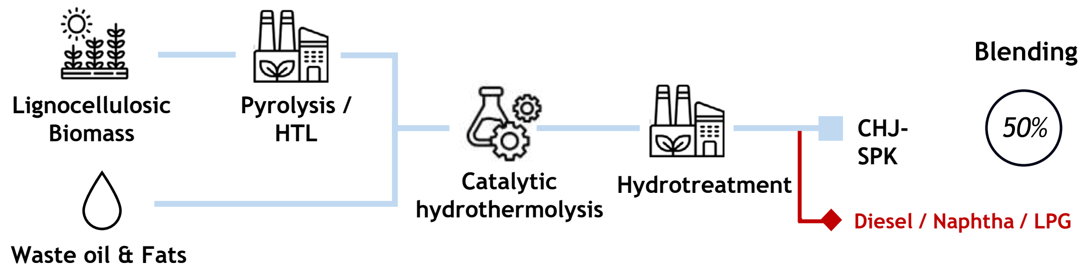
FIG 69: FISCHER TROPSCH SAF PRODUCTION PATHWAYS



*Source: Stifel**

- **Catalytic Hydrothermolysis (CHJ) / Biocrude Hydrotreatment** converts fatty acid esters and free fatty acids into SAF via catalytic hydrothermolysis followed by hydrotreatment, hydrocracking, or hydroisomerisation and fractionation. The maximum blend ratio for CHJ SAF is 50%.

FIG 70: CHJ SAF PRODUCTION PATHWAY



*Source: Stifel**

The efficiency and sustainability of SAF production processes rely heavily on underlying feedstock sourcing/traceability as well as yields and output selectivity. Each SAF production pathway offers varying levels of efficiency and generates different types and amounts of co-products.

The HEFA method, which is the cheapest and most mature alternative to date, stands out due to its high conversion rate of roughly 90%, with at least 50% of the processed input resulting in SAF. According to McKinsey, around 46% of the total output is SAF, with most of the remainder being renewable diesel that can be used for road or marine applications. Less than 10% generally consists of "light ends" such as LPG and naphtha. In theory, SAF selectivity could be as high as 75% according to Neste and is continuously being improved. High yield and lower feedstock volume requirements make HEFA a preferred choice among producers, driving much interest in HEFA projects, which also appears to be the most cost-effective option. However, HEFA relies on waste fats and residue lipids, meaning constrained growth potential in the long term if no alternate/synthetic grease production method is developed. Additionally, whereas HEFA is today the most competitive option, increasing competition for UCO or reshoring could result in significant volume shortages and/or feedstock price spikes, harming HEFA's competitiveness in the medium to long term.

In contrast, the ATJ pathway is less efficient in terms of feedstock utilisation, with a conversion rate (from biomass to process output) estimated at around 13%, however with 77% SAF selectivity when optimised for jet fuel production, alongside a small share of renewable diesel. If the process is not optimised for jet fuel production, SAF yield drops significantly to around 25%, with potentially poor economics. The challenge with ATJ also comes from feedstock availability. In a market such as the US with significant first-generation sugar or alcohol, agricultural surplus could make ATJ an attractive option for decarbonising aviation when road biofuel demand begins to plateau. However in Europe, the use of second-generation sugars is a prerequisite, and second generation bioethanol conversion is challenging to scale as it requires integration into other processes. Here, the ATJ growth path would likely be more challenging.

Finally, the Fischer-Tropsch method, which for bioSAF involves biomass gasification, assumes a feedstock conversion rate of 20% to total output. (Feedstocks can be lignocellulosic, MSW, tyres/plastic etc). When optimised for jet fuel, SAF selectivity can go up to around 60%, with the remainder used for renewable diesel or naphtha. According to industry contacts, there is potential for technological improvements to increase the SAF selectivity to 70%. Specifically, industrial waste gas can bypass the gasification step and be fed directly into the process after optimising the hydrogen-to-carbon monoxide ratio, which could enhance overall efficiency and reduce feedstock requirements.

NESTE

Established in 1948 and headquartered in Finland, Neste is a publicly traded company renowned for its leadership in renewable diesel (HVO) and HEFA-SAF production. As a producer and a technology provider, Neste leverages its proprietary NEXBTL technology, a unique platform enabling the conversion of various renewable fats and oils into premium-quality renewable products, including fuels and feedstock for polymers and chemical production. With this technology, Neste produces high-quality renewable diesel exclusively from 100% renewable raw materials.

Neste is currently expanding its renewable fuel capacities, planning to invest €2.5bn in the conversion of its Porvoo crude oil refinery into a biofuels production facility over the long term, with half of Porvoo's planned renewables capacity, 1.5Mt/year, dedicated to HEFA-SAF production.

Neste already produces SAF in Porvoo, however mostly from its Singapore (1Mt/year capacity) and Rotterdam (0.5Mt/year capacity) refineries. Rotterdam began production early in 2024 and serves over 70 direct customers and more than 25 airports worldwide. Neste is continuously strengthening its position in the market, developing numerous strategic partnerships, including collaborations with industry leaders such as Airbus and investing to explore alternative methods for converting low-quality raw materials into high-quality solutions (EUR94m R&D in 2023 alone). Neste has studied over 2,000 raw materials in the past decade.

ecoceres

Incubated by Towngas with first initiatives in 2008, Ecoceres is a Hong Kong-based advanced biorefinery platform, with a proprietary technology portfolio enabling the production of a wide spectrum of biofuels, biochemicals and biomaterials from 100% waste-based biomass. Underpinned by continuous technological innovation, Ecoceres excels in decomposing agricultural waste into basic components for renewable product production as well as in biomass gasification for syngas generation. It is one of the few players that has production capacity for hydrotreated vegetable oils (HVO) for diesel, sustainable aviation fuel (HEFA-SAF) for jet fuel, and cellulosic ethanol for gasoline substitutes.

Ecoceres has a significant presence in China, with the world's first ISCC-CORSIA Plus facility in Jiangsu, boasting commercially available production combined HVO/SAF capacities of 300Kt/year and is currently constructing a new facility in Malaysia, expected to start in H2 2025, with a design capacity of 350Kt/year (>60% SAF). Used cooking oil and waste from palm oil mills will be among the main raw materials for this new plant, which is located in the Johor region of Malaysia.

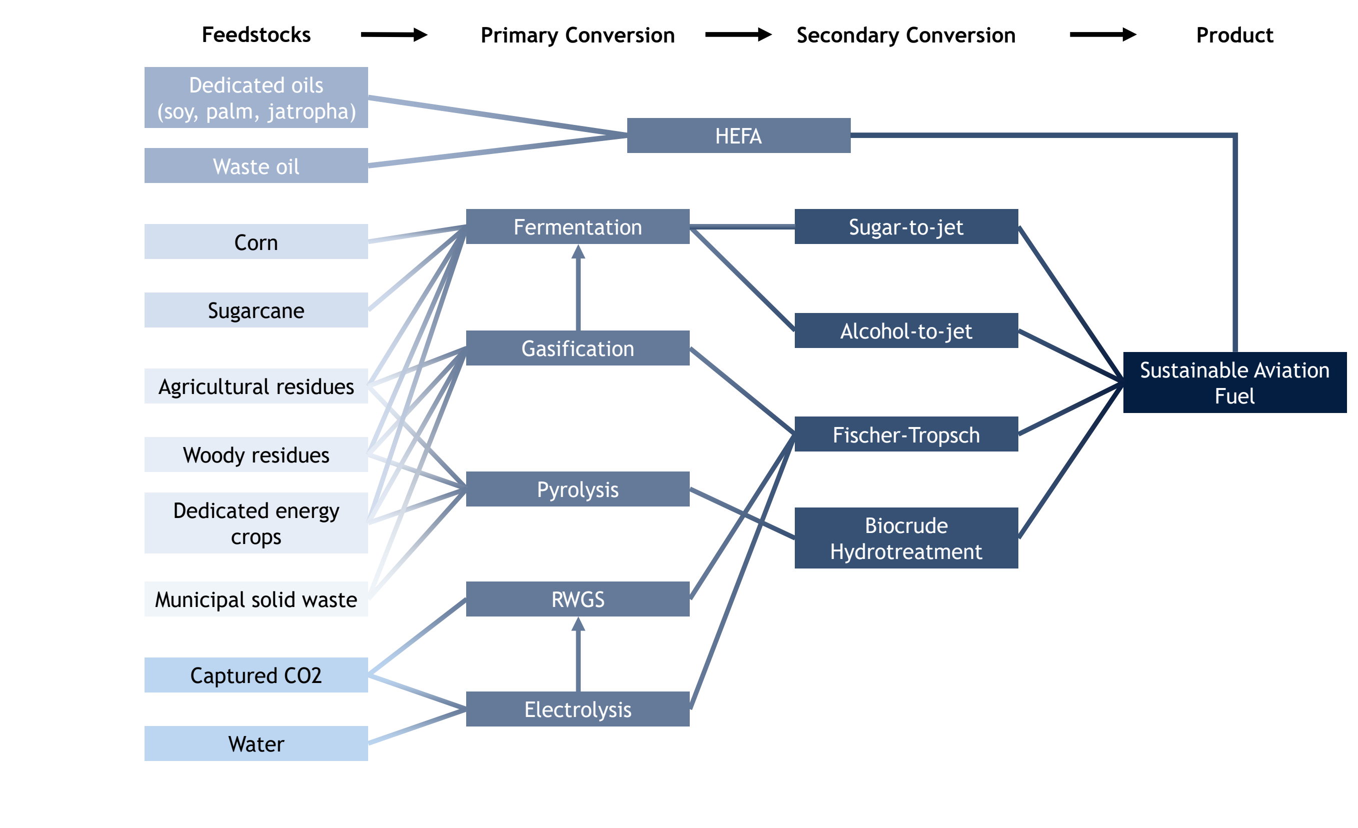
The company successively secured USD108m ad USD400m respectively from Kerogen Capital in February 2022 and Bain Capital in January 2023 as it plans to expand its presence in renewable energy markets.

Founded in 2010, SkyNRG is a Dutch company at the forefront of SAF developments, having supplied the world's first commercial flight using SAF in 2011. Today, the company provides SAF to airlines and corporations worldwide, such as Boeing and KLM Royal Dutch Airlines, and is one of the leading and most active participants in the SAF market.

Specialized in sourcing, blending, distributing, and ensuring sustainability throughout the supply chain, the company is dedicated to providing the aviation industry with sustainable and cost-effective alternatives to jet fuel. SkyNRG is spearheading the development of Europe's first dedicated SAF production plant in Delfzijl based on Topsoe's HydroFlex technology, which is expected to be operational by 2027 and with a projected HEFA SAF output of 100Kt/year accompanied by 35Kt/year of sustainable by-products such as LPG and naphtha. SkyNRG is also developing the Wigeon biomass gasification project in the US, which is expected to start up in 2029 with an expected production capacity of 150Kt/year. SkyNRG also has several pilots under way, including an AtJ project with Lanzajet in Europe and a PtoL pilot with Synkero.

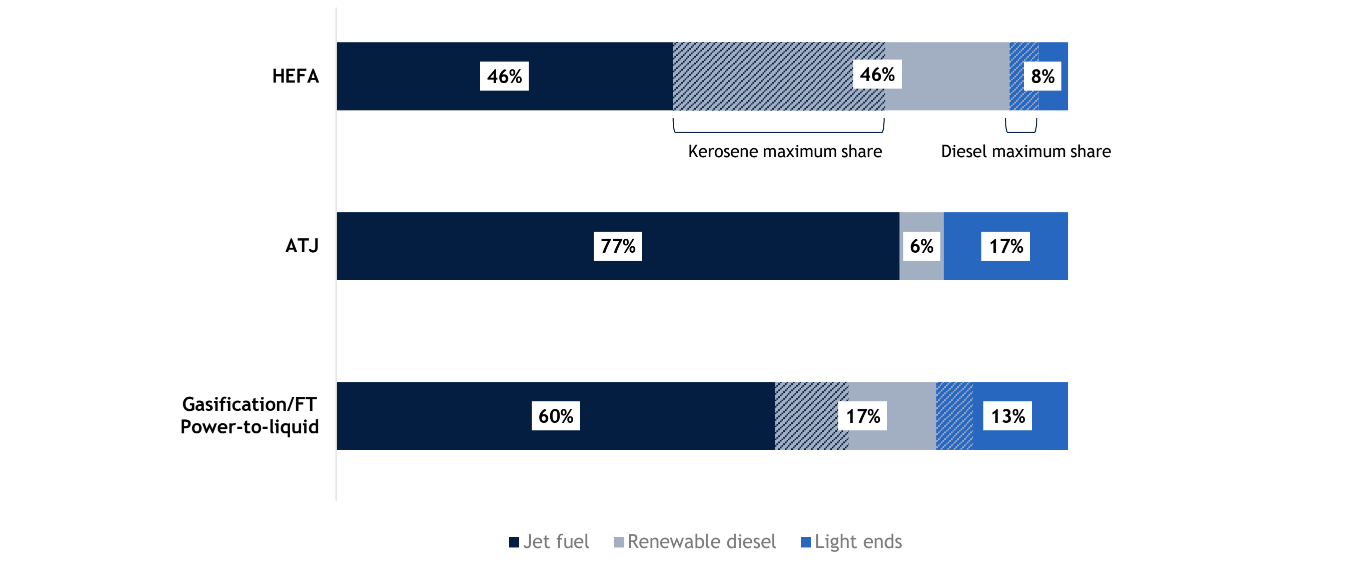
In November 2023, SkyNRG raised €175m from Macquarie Asset Management, supporting its infrastructure investment and further project portfolio developments.

FIG 71: SUMMARY OF SAF TECHNOLOGY PATHWAYS



*Source: Carbon Direct, Stifel**

FIG 72: YIELDS PER SAF PRODUCTION PROCESS

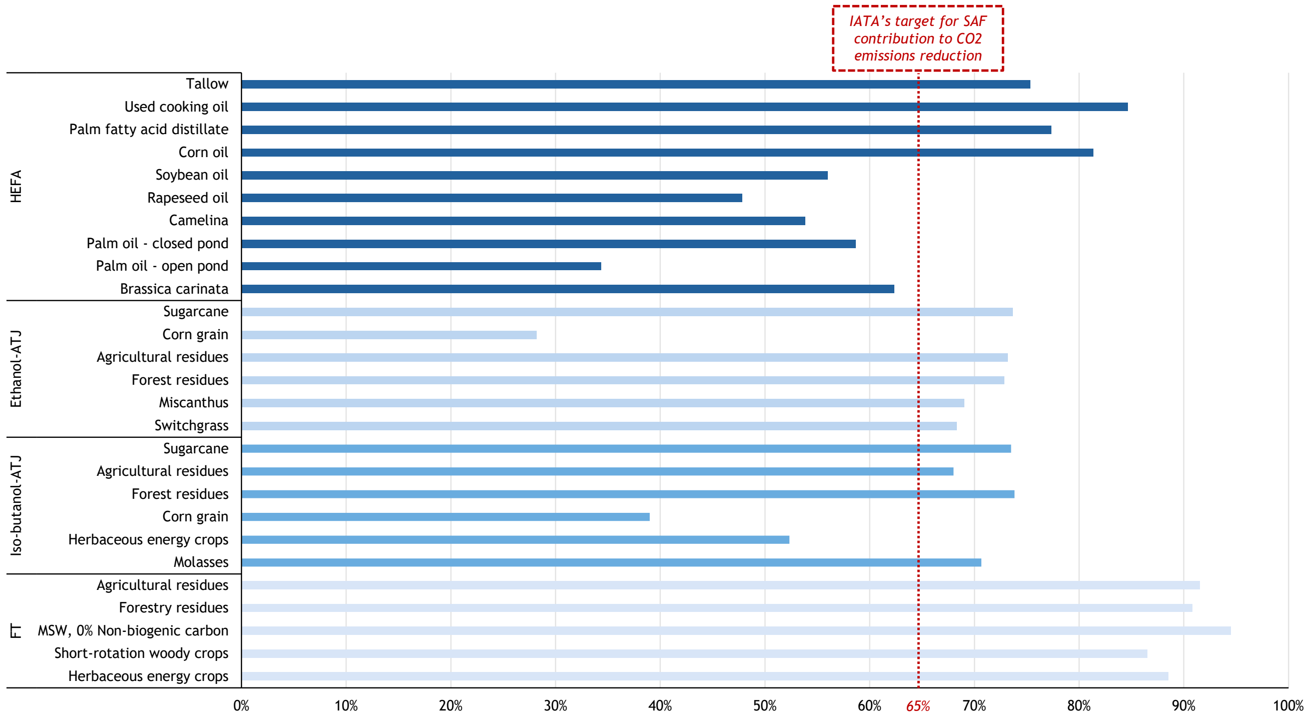


*Source: ICCT, McKinsey, Neste, Stifel**

Yield and selectivity are not the only crucial factor. GHG efficiency, which is also feedstock-related, is the ultimate referee. HEFA remains highly attractive as it offers up to 84% reduction in GHG emissions compared to fossil jet fuel. This reduction potential can be further enhanced by using sustainably produced green hydrogen in the hydroprocessing step. Although the ATJ pathway provides slightly lower emissions reduction compared to HEFA, it still presents a viable option for SAF production, in most cases offering >65% GHG emission reduction compared to fossil sources.

Biomass gasification and the Fischer-Tropsch process are ahead of the two other pathways on emission reductions, ranging from 85% to 94%. However, they present biomass collection challenges, especially relation to forest residue, and variable syngas composition depending on waste quality. Ptol fuels produced from FT-synthesis could emerge as a leading solution, potentially reducing CO2 emissions by more than 100% compared to conventional fuel. But they rely on sourcing scarce biogenic CO2 (but with industrial flue gas tolerated until 2041) and cheap renewable power.

FIG 73: EMISSIONS REDUCTIONS FOR SAF PATHWAYS AND FEEDSTOCK COMPARED TO A FOSSIL FUEL REFERENCE VALUE IN EUROPE (89 G CO2E/MJ)



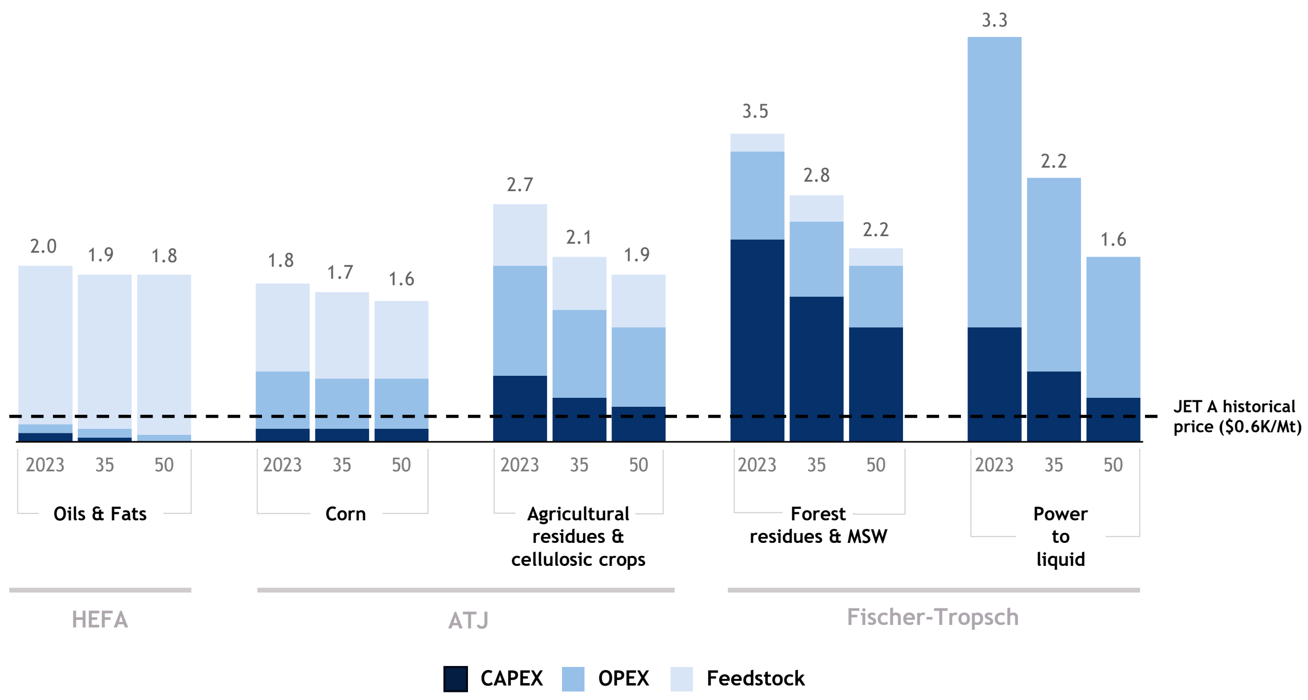
*Source: EASA, Stifel**

Today, HEFA is cheapest solution in terms of GHG reduction potential. PtoL technologies have great promise but are currently almost twice as expensive as other SAF options, and either rely on the complete LCA being reflected into SAF prices or on expectations for cheap power access in the future. Indeed, PtoL's energy-intensive process requires large amounts of renewable electricity, needs substantial water resources and is therefore only scalable in places with large, centralised production facilities. This is why some companies are now focusing on breaking down the production process to offer modular solutions. These address issues such as electricity supply, carbon capture and water usage in smaller plants, and are betting on the development of a decentralised network of production plants, each tailored to their local ecosystem.

Despite the barriers to PtoL fuels, they provide a complementary solution to fully decarbonise the aviation sector. However, their adoption hinges on proper carbon penalties or taxes. As PtoL can potentially reduce CO2 emissions by over 100%, higher carbon taxes would potentially compel producers and airlines to adopt these fuels.

SAF prices remain significantly higher than the historical cost of Jet A fuel. This disparity directly impacts operators' business models and margins, potentially leading to the creation of premium services for customers paying to fly on SAF. In June 2024, Lufthansa announced plans to charge up to €72 per flight to cover the costs of clean fuel. These additional charges will apply to all departures from the European Union, the United Kingdom, Norway, and Switzerland from 1 January 2025. Whether or not they are passed through, SAF costs will most probably increase rather than decrease in the future as a result of rising feedstock costs and increasing investment/process costs. This may lead to higher flight costs and impact demand, given that most jet fuel consumption today is not taxed.

FIG 74: PRICE COMPETITIVENESS OF SAF PATHWAYS ($K PER METRIC TON)



*Source: World Economic Forum, Mission Possible Partnership, Bain & Co, Stifel**

Founded in 2019 in Norway, Norsk e-Fuel is a pioneering company committed to produce eSAF using renewable energy sources. Norsk e-Fuel is at the forefront of the PtoL industry in Europe, leveraging one of the most advanced projects in the region, as well as a pipeline of opportunities by 2030. By then, Norsk e-Fuel expects to supply more than 250 million litres of renewable fuels from three industrial-scale production plants. These facilities should be optimised for e-kerosene production based on a FT pathway, with up to 80% kerosene in the output mix (i.e. representing 170Mt/year of installed eSAF capacities by 2030). The remaining volume would be e-naphtha, a crucial component for the chemical industry.

The inaugural plant in Mosjøen will have a capacity of 50 million litres, with construction starting from 2025, and production from 2026. It will serve as a blueprint for the roll-out of a larger 100 million litres plant.

Supported by strategic investors and carefully selected partners, Norsk e-Fuel is set to bring Power-to-Liquid production to an industrial scale, as highlighted but the recent investments from Norwegian Air Shuttle, Cargolux and further support from Paul Würth, all serving as a foundation to secure approximately €400m in equity and debt over the next 18 months.

Arcadia eFuels is a dedicated to producing sustainable aviation fuels (SAF) and other renewable fuels based on eFuels pathways. Headquartered in Denmark, Arcadia eFuels is at the forefront of eSAF developments, currently developing its first commercial-scale production facility in Vordingborg, Denmark. The facility, initially set to be operational by 2026, will leverage cutting-edge technologies from Sasol/Topsoe to produce approximately 80Kt/year of e-kerosene and e-naphtha (80-20 mix).

Arcadia eFuels already has plans for two additional e-fuel plants (e-diesel and eSAF), currently in development across the UK and US. The output of each plant could be similar to the one in Denmark.

In 2023, Arcadia eFuels was backed by Sven Capital (in January) and KGAL (October), further supporting development. Additionally in November 2023, the company received £12m of government support and a £53m grant from the UK DoT's new AFF fund.

Founded in 2019 and headquartered in Switzerland, Metafuels is a technology provider and renewable fuel producer. The company has developed a proprietary technology, aerobrew. This technology converts green methanol into Sustainable Aviation Fuel (SAF) using a proprietary catalytic system known as the 'missing piece of the jigsaw'. Aerobrew offers high selectivity and yield, enabling scalable, efficient, and integrated SAF production at competitive prices. This innovation not only supports significant carbon footprint reduction for airlines but also allows for scalable large-scale e-SAF production, locating production facilities both near aviation fuel markets and renewable electricity sources, thereby optimizing logistics and sustainability benefits.

In 2023, Metafuels announced that its aerobrew technology will be used to produce e-SAF at one of European Energy's planned e-methanol production facilities in Denmark, with an expected output of 10,000 liters of synthetic e-SAF per day. Metafuels is also set to develop a pilot plant in Switzerland to demonstrate this technology.

Swedish Biofuels is the inventor and company behind the original Alcohol to Jet technology (ATJ) for fully formulated sustainable aviation fuels (FFSAF). The technology was developed in Sweden and patented in 2004. Swedish Biofuels distinguishes itself from other SAF players through its ability to produce ready-to-use biojet fuel rather than a blend component. The FFSAF has undergone successful testing by engine manufacturers under US DARPA, US FAA, and Swedish FMV programs. In 2006, together with 3 other companies, Swedish Biofuels secured US DARPA funding to develop biomass-derived jet fuel, leading to the acceleration of today's ATJ technology. As a result, in 2011, Swedish Biofuels produced the world's first fully synthetic paraffinic jet fuel from wood residues.

Early in March 2023, Swedish Biofuels formed a global alliance with KBR for the sublicensing of its advanced biofuel technology. This partnership thereby allows KBR to sell licenses for Swedish Biofuels' technology. Just before this agreement with KBR, Mitsubishi invested an undisclosed amount in the company to jointly accelerate commercial deployment of renewable fuels using Swedish Biofuels' advanced ATJ technology.

CAPHENIA

Turning CO_2 into fuel

Founded in 2018 in Germany, Caphenia is at the forefront of synthetic fuel production. Its Plasma Boudouard Reactor (PBR) technology is a globally patented Power-and-(Bio)gas-to-Liquid process, combining three known sub-processes to produce synthesis gas from biogas, CO2, water, and electricity. Unlike conventional methods that require multiple reactors and units, Caphenia's process is simpler, faster, and more cost-effective, requiring significantly less electricity, while leveraging scalable modular systems ranging from 500t/year to 50Kt/year of renewable fuel production capacity. Caphenia's energy efficiency of 86% for synthetic gas production sets a new industry standard. When combined with FT-fuel synthesis, overall plant energy efficiency could reach 72% (using one sixth of the electricity needed for other PtoL methods), reducing GHG emissions by up to 92%.

Looking ahead, Caphenia is planning to build a 150kg synthesis gas per hour pilot plant in Germany's Höchst industrial park in 2024, with MAN Energy Solutions already selected to build the reactor. In June 2023, software specialist Amadeus acquired a minority stake Caphenia to support its development.

HEFA, currently the leading pathway, has lower initial infrastructure costs but incurs higher ongoing feedstock expenses, while FT pathway requires significant infrastructure investment but has low feedstock costs. Each pathway also presents distinct maturity levels, with technical and delivery risks. The choice between them will be influenced by local conditions such as the availability of feedstocks, logistics facilities, and the potential to repurpose existing infrastructure.

Its cost advantages mean that most of today's operating and planned SAF projects are HEFA-based, with current capacity of 1.83Mt/year. This trend is expected to persist in the medium term, as most planned capacity expansions use HEFA, potentially reaching 16.6Mt/year early in the next decade and representing 2/3 of total planned capacity to date. As the industry evolves, other SAF alternatives will emerge, with AtJ next in the line, backed by planned investments already representing 3Mt/year. This is mostly led by the US, with the SAF Grand Challenge creating massive demand by 2030. This will be met by either diverting feedstock from conventional road biofuels production or leveraging existing intermediates production to progressively diversify SAF production methods. In Europe, where regulation is setting ambitious demand targets for the industry, projects currently in the pipeline currently add up to less than 5Mt/year. A significant proportion of these are significant FT and PtoL in response to regulatory mandates for RFNBOs. However, reflecting tight feedstock availability and qualification constraints, projects tend to be smaller than in other regions around the world. thereby matching demand by 2030 but probably becoming net SAF importer in the long-run to keep up with ReFuelEU targets.

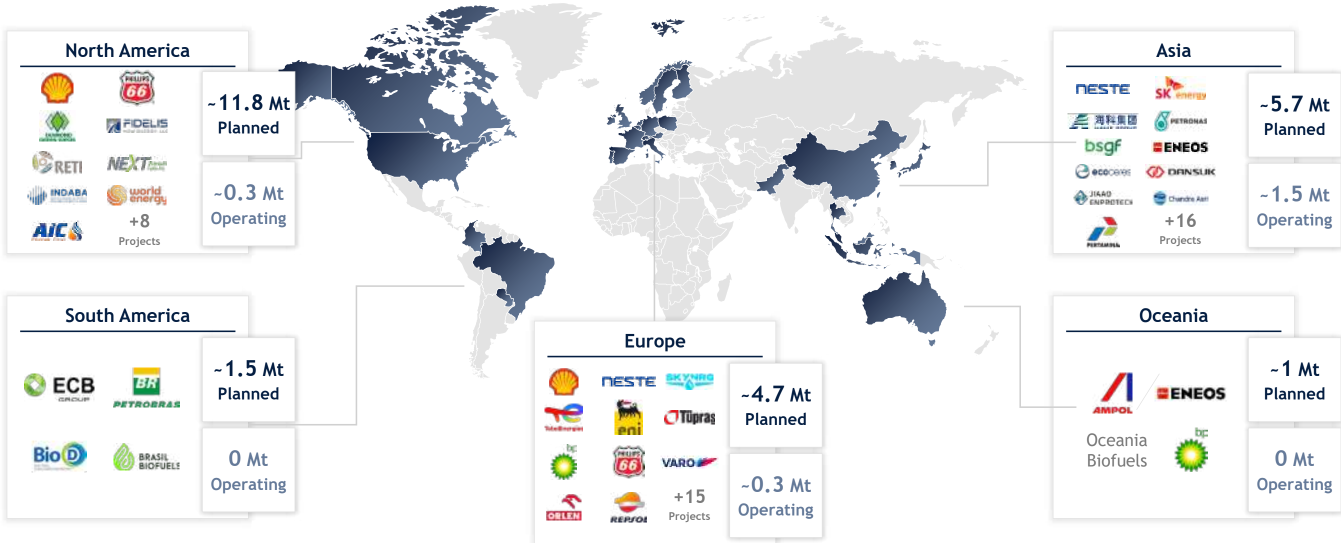
FIG 75: BREAKDOWN OF SAF PROJECTS BY PATHWAY (IN MT)

	HEFA	AtJ	FT-SPK	PtL	Other
Operational	**1.828**	**0.029**	**0**	**0.0005**	**0.254**
North America	0.230	0.029	0	0	0
Europe	0.230	0	0	0.0005	0.104
Asia	1.828	0	0	0	0.150
Planned	**16.555**	**3.072**	**1.572**	**2.365**	**1.185**
North America	8.046	1.967	0.957	0.867	0
Europe	1.250	0.472	0.529	1.442	1.043
Asia	4.959	0.526	0.086	0.010	0.142

*Source: Argus, Stifel**

This geographical distribution underscores the influence of regional policies on the development of SAF production facilities. While HEFA remains the dominant pathway due to its higher maturity and stronger cost competitivity, it is still 1-2 times more expensive than fossil fuel. The emergence of AtJ and PtL technologies indicates a broader shift, reflected by the growing number of offtake agreements between producers and airlines, who are positioning for an advantage with future fuel (and growth).

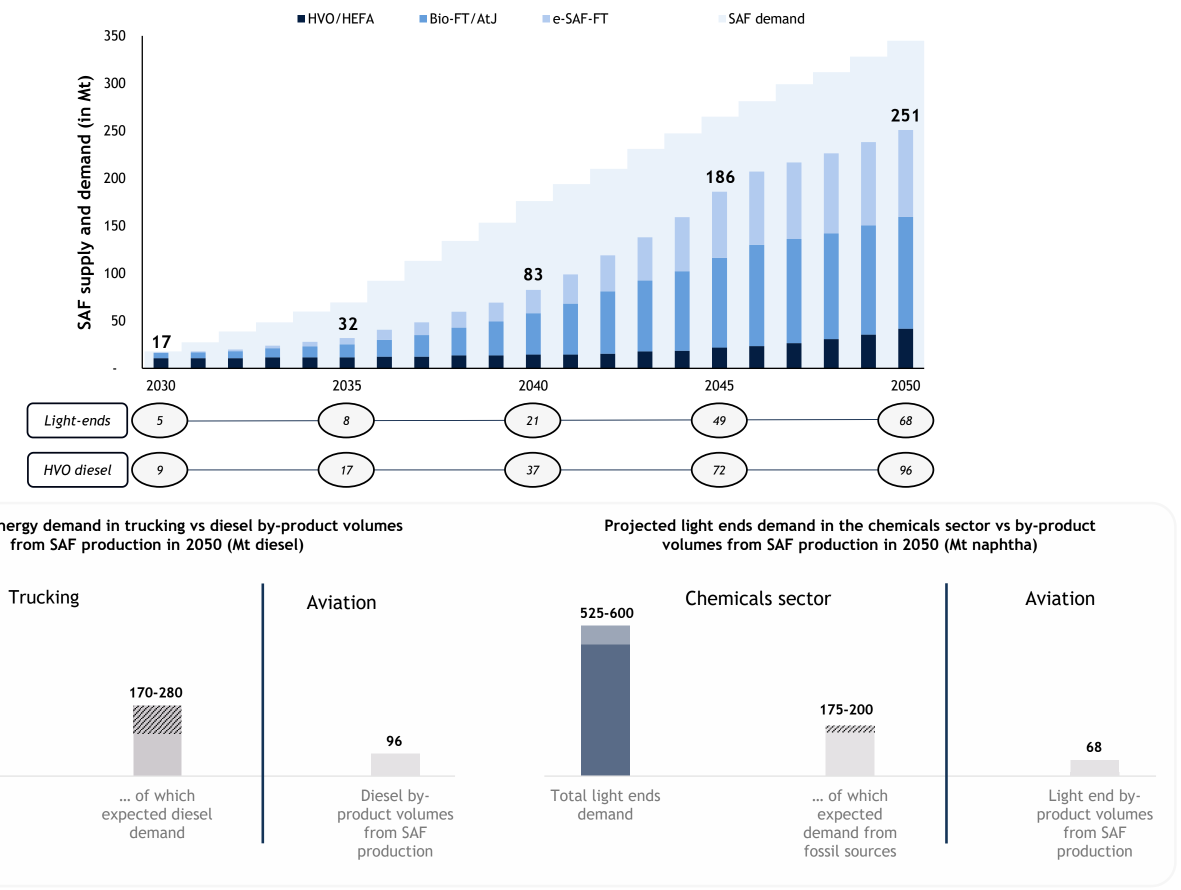
FIG 76: GLOBAL OPERATING AND PLANNED INVESTMENTS IN SAF PROJECTS WORLDWIDE AS OF MAY 2024



*Source: Argus, Stifel**

With SAF demand expected to increase from close to 17-18Mt in 2030 to more than 300Mt by 2050, co-product management will increasingly become a priority, creating synergies and opportunities for downstream sub-sectors. Renewable diesel could be leveraged for road (and maritime in the long run), when light ends such as naphta could replace their fossil counterparts in petrochemical processes such as plastics. While high output selectivity is generally preferred, refiners are accustomed to dealing with a wide array of end-products, which also diversifies their revenue exposure and demands broader industrial integration that raises barriers to entry.

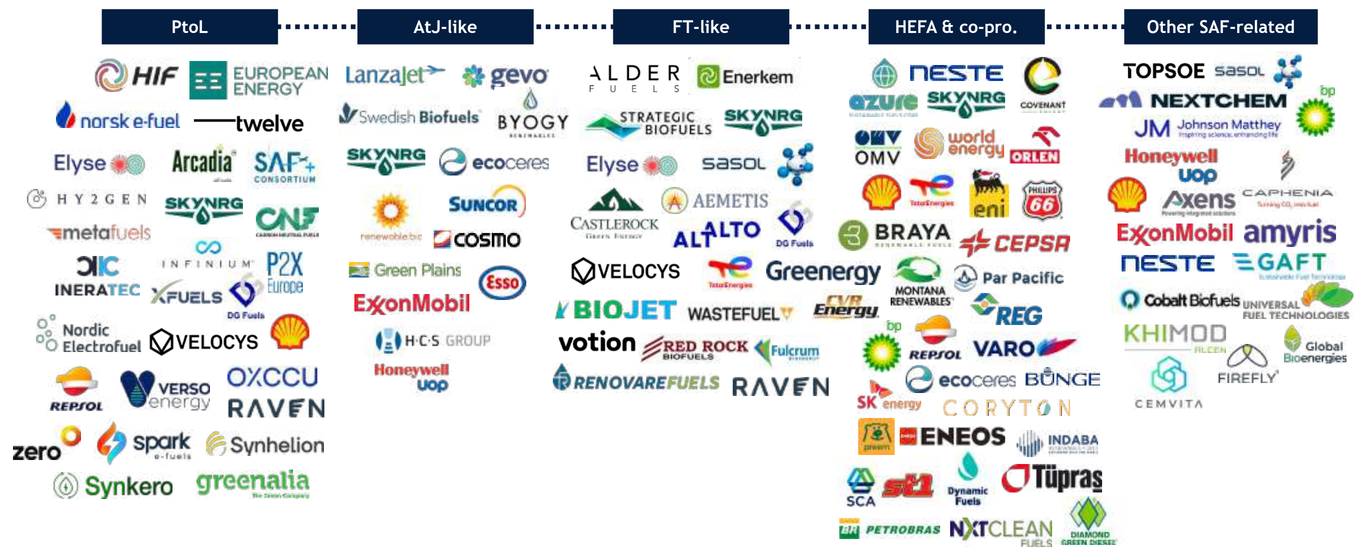
FIG 77: SCENARIOS AROUND SAF PLANTS BY-PRODUCTS AND USE-CASES BY 2030 AND 2050 (MT/YEAR)



*Source: S&P Global, SkyNRG, Mission Possible Partnership, Stifel**

SAF alone will not suffice to fully decarbonise the aviation sector, so complementary measures must be pursued to enhance aeroplane operational efficiency. These include engine and design improvements, software to improve flight planning and help pilots minimise fuel consumption, and battery technology integration that could be used for short-haul and less energy-intensive flight processes.

FIG 78: MAIN SAF PLAYERS

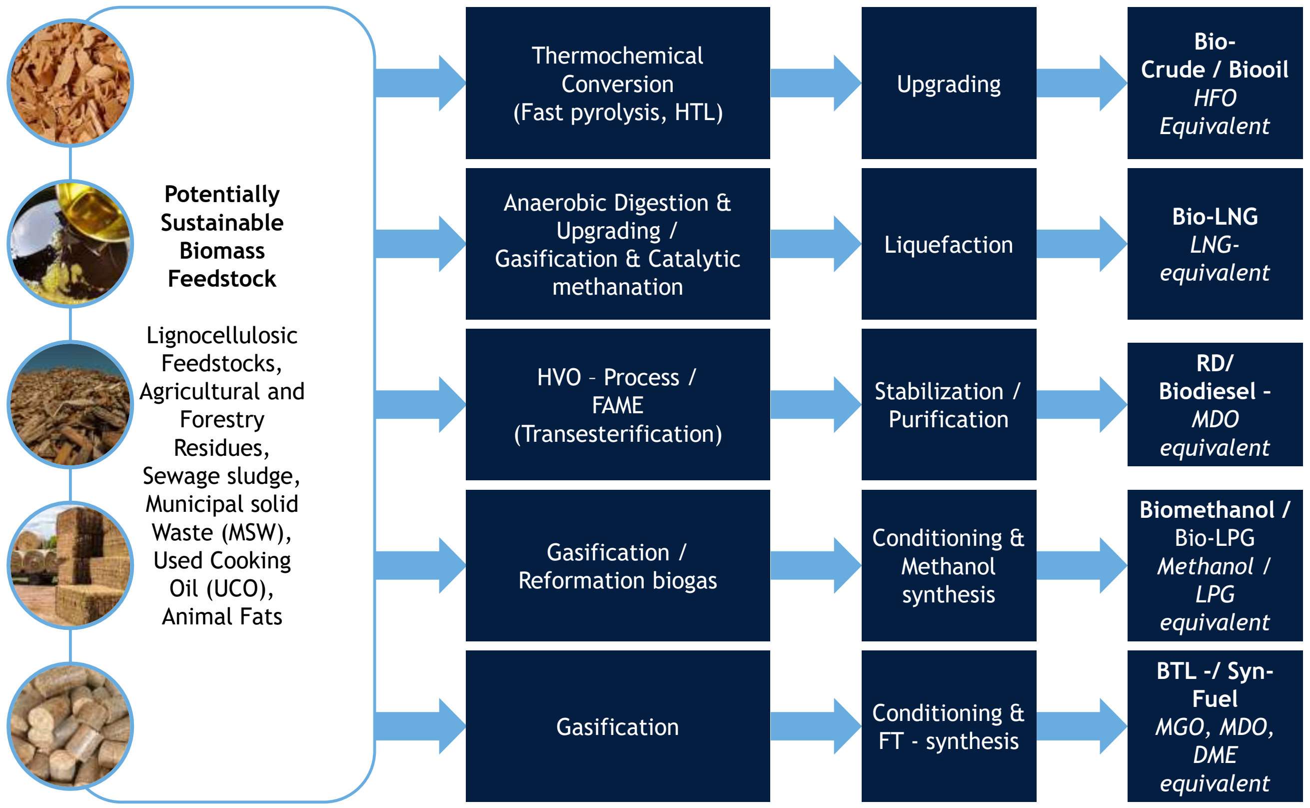


*Source: Stifel**

Maritime decarbonisation as a long-term tailwind

Global climate targets such as the European FuelEU Maritime regulation have driven growing interest in the use of alternative fuels for marine propulsion. Companies are evaluating decarbonisation pathways that minimise costs, beginning with engine replacements and drop-in solutions. However, while electrification or hybrid powertrains are a potential alternative for inland and coastal shipping, deep-water vessels and international shipping require denser primary energy. So while biofuels offer immediate alternatives for marine decarbonisation, any additional demand would be in direct competition with other HDV transport and industrial segments. This opens a path for alternative bunker fuels.

FIG 79: SUMMARY OF BIOMASS-BASED MARINE FUEL PATHWAYS



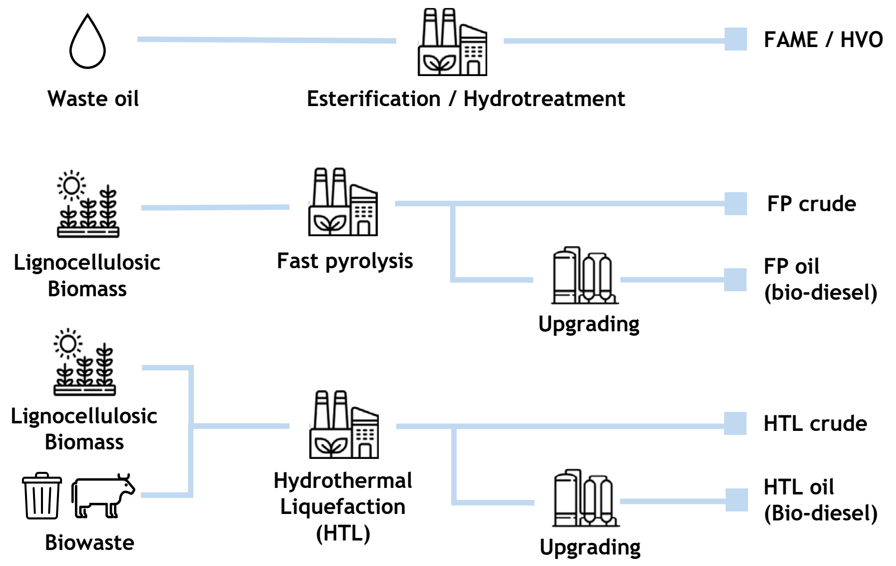
*Source: Sustainable Shipping, GreenFuelHub, Stifel**

- **Bio-oils**

FAME is a contaminant in marine distillate fuel and is only blendable up to 7% without affecting the overall fuel system. HVO does not pose this problem and can fully qualify as a long-term alternative for shipping. However, limited vegetable oil and residual waste feedstock availability mean these fuels will be mostly used for road transport. In the long term, falling demand for road fuel could create surplus that could be transferred to the marine sector.

However, emerging technologies such as fast pyrolysis (FP) and hydrothermal liquefaction (HTL) are moving ahead to produce low-carbon bio-oils from abundant feedstocks such as biomass and biowaste, with maximum blending limits of 30% for FP crude and 40% for HTL crude.

FIG 80: RENEWABLE OILS PRODUCTION PATHWAYS FOR MARINE ENGINES



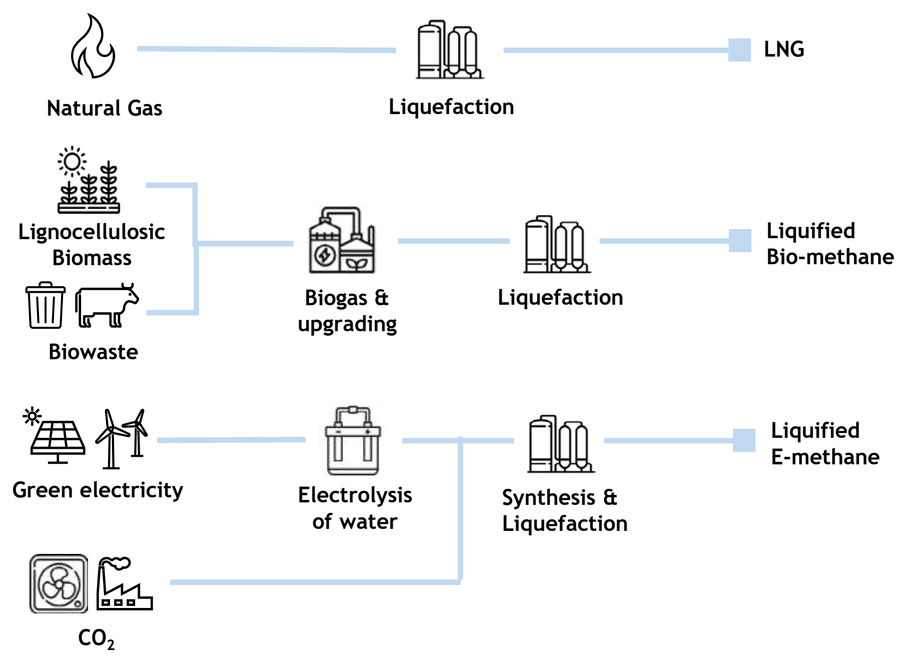
*Source: Sustainable Shipping, GreenFuelHub, Stifel**

- **LNG and methane-based fuels**

Offering shorter-term solution due to established pathways and logistical advantages, LNG is a well-known marine fuel, using boil-offs from tankers to reduce overall consumption, while not being too bulky to restrict useful volumes and payload. However, while LNG can be fossil-sourced and reduce around 20% of the emissions compared to a ship using traditional fossil alternatives, there is significant GHG emission-saving potential stems from the use of bio- and e-methane, albeit with limited supply available.

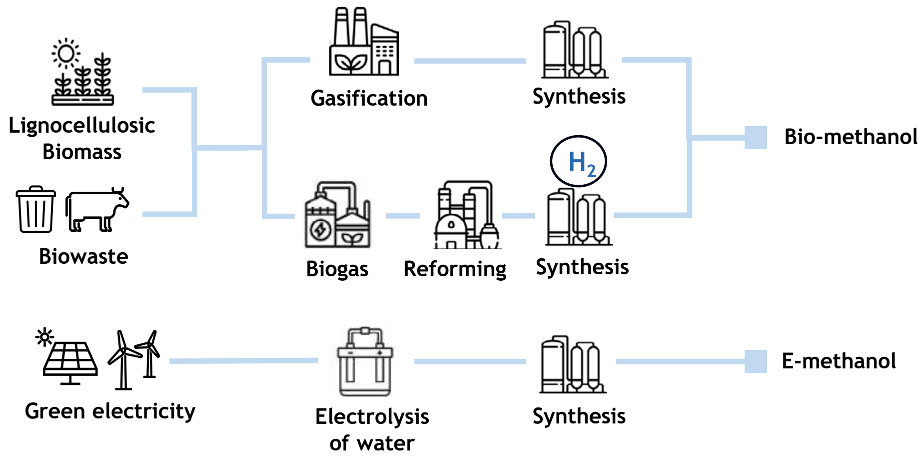
Biomethane can be produced from wet and dry biomass waste and residues using anaerobic digestion, LFG recovery or biowaste gasification, while e-methane can be synthesised from green hydrogen and captured CO2. Biomethane is already available but sought after by industrials to decarbonise their natural gas consumption. E-methane could unlock biomass constraints barriers – but it still requires biogenic CO2 and relies on less mature methanation economics.

FIG 81: LNG AND RENEWABLE METHANE PRODUCTION PATHWAYS



*Source: Maersk Mc-Kinney Moller Center, Stifel**

FIG 82: RENEWABLE METHANOL PRODUCTION PATHWAYS



*Source: Maersk Mc-Kinney Moller Center, Stifel**

- **Methanol**

Certified, convenient and safe, methanol's advantage lies in its status as a sulphur-free fuel that is liquid under ambient conditions, making it easy to transport, store, and bunker using standard diesel procedures. Methanol has a higher volumetric energy content than ammonia or hydrogen and does not require pressurisation or cryogenics, so is suitable for various vessel types and longer routes while requiring less bunkering. It is already available at more than 125 of the world's largest ports. However, grey methanol (manufactured from fossil feedstocks) is widely used as a chemical building block for hundreds of everyday products, ranging from plastics to car parts and construction materials. Industrial applications currently use 110Mt of fossil-derived methanol per year, with 55-65% from natural gas, 30-35% from coal, and the remaining from coking gas.

Bio- and e-methanol can be produced, respectively, through methanolation using heterogeneous catalysts at high temperature with syngas derived from biomass/biowaste gasification, or with renewable hydrogen and captured carbon.

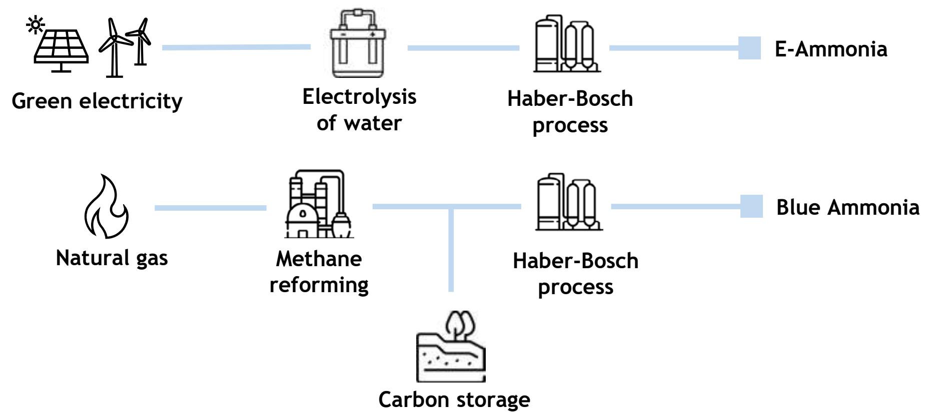
- **Ammonia**

CO2-free when combusted, ammonia has emerged as a promising alternative for the marine industry, with the potential for abundant production from renewable-only sources. Like methanol, ammonia is a well-known commodity chemical building block, with 150-160Mt used worldwide per year, mostly to produce fertilisers (~80%). As far as "well-to-wake" emissions are concerned, only green ammonia can bring significant environmental benefits, as it can be truly CO2-free. According to engine manufacturer Wärtsilä, diverting grey ammonia for fuel would generate about one-third more in carbon emissions compared to HFO.

Moreover, primary challenges remain in using ammonia as a marine fuel due to three factors: (i) toxicity and corrosiveness; (ii) low volumetric energy density and energy efficiency compared to HFO, diesel and LNG systems, which either require larger fuel storage or reduce vessels' operating range; and (iii) ongoing regulatory developments regarding bunkering and fuelling infrastructures as ammonia is only recently becoming used as a fuel at scale.

Lower-carbon ammonia can be produced in different ways, ultimately using the Haber-Bosch process. "Green" or e-ammonia uses upstream water electrolysis and pressure swing adsorption (PSA) based on renewable electricity. "Blue" ammonia uses fossil methane reforming combined with CCUS. Ammonia offers potential for significant emission reductions in maritime use. The cost and availability of renewable electricity, as well as carbon taxation are the major drivers of renewable ammonia's price competitiveness. Its production is energy-intensive, requiring approximately 9-10MWh per ton of green ammonia at a time when demand for renewable power in other industrial sectors is increasing. A reliable supply of certified green electricity for all sectors and a ramp-up of energy-intensive technology pathways are key to scale renewable ecosystems and maximise GHG emission reduction.

FIG 83: RENEWABLE AMMONIA PRODUCTION PATHWAYS



*Source: Maersk Mc-Kinney Moller Center, Stifel**

As the maritime sector faces increasing pressure to reduce emissions, the fuel landscape will gradually shift away from refinery byproducts used without regard to their negative externalities. Nonetheless, finding alternative fuels that closely mimic the properties of HFO and MDO is crucial to minimise the need for extensive fleet retrofits. Ideally, new fuels intended to reduce emissions should closely match the volume and mass characteristics of existing fuels, while also being the cheapest possible option and reducing GHG emissions.

Bio-oils, especially HTL-derived, and LNG stand out for their ability to offering short- and medium-term options for operators. Methanol, ammonia and hydrogen are more bulky and generally require vessel design adjustments.

Elyse

Founded in 2020 and headquartered in France, Elyse Energy was initially backed by Falkor and VOL-V as key shareholders. A prominent player in the European e-fuels sector, Elyse Energy specialises in the design, development, financing, construction, and operation of low-carbon molecule production units for bio- and e-methanol and sustainable aviation fuels (SAF).

Leveraging low-carbon hydrogen production and carbon valorisation, Elyse Energy supplies low-carbon molecules to chemical industry players, maritime operators, and shipping companies. The company is engaged in several large e-methanol projects expected to start operations by 2027/2028i, such as eM-Rhône, aiming to produce 150Kt/year and eM-Iberica, targeting 1Mt/year in Spain and Portugal. Additionally, Elyse Energy is spearheading the BioTJet project (75Kt, 2027), France's first commercial biokerosene production unit from local forestry residues and end-of-life wood waste. Elyse Energy has also developed NeoCarb, an industrial and port platform project in Fos-sur-Mer, France, aimed at integrating two complementary and integrated phases molecule production, with 100Kt of e-methanol available for both shipping and aviation, based on a 50Kt AtJ conversion unit.

With several billion euros of investments ahead, Elyse Energy already benefits from the support of key infrastructure funds, having been joined by Mirova and Hy24 late in 2023.

EUROPEAN ENERGY

Founded in 2004 in Denmark, European Energy has established itself as a prominent renewable energy company specialising in the development, construction, and operation of wind, solar, and biomass projects throughout Europe. With a robust platform spanning 25 markets and encompassing 6 renewable energy technologies, European Energy is positioned for substantial growth and innovation.

European Energy boasts a diversified portfolio including 65GW of pipeline capacity across approximately 800 high-quality projects. The company is committed to new initiatives like Power-to-X, aiming to lead the path towards the production of green fuels globally. Building on the success of the world's largest e-methanol facility to date in Kassø (Denmark) representing 32Mt/year of production capacities, European Energy plans to strengthen its position in e-methanol and expand capabilities in hydrogen markets. The company aims to monetise technology synergies with its development know-how to accelerate the deployment of renewable energy systems for solar, wind, and Power-to-X solutions (green hydrogen, e-methanol, green ammonia, and e-SAF) in its core markets.

In April 2024, in the context of a €700m private raise, Mitsubishi HC Capital acquired a 20% stake in European Energy, tripling available equity and further enhancing its role in the green energy transition.

INERATEC

Founded in 2014 and headquartered in Germany, Ineratec is a privately held company specialising in innovative sustainable energy solutions. Their product portfolio includes a range of e-fuels, such as synthetic fuels for road transport, e-methanol, and e-diesel for shipping, alongside Power-to-X plants that convert renewable electricity into sustainable energy using hydrogen and CO2 extracted from the atmosphere. These plants are designed to be scalable and modular, able to operate wherever green energy and CO2 are available. Additionally, the company produces e-chemicals such as waxes and methanol.

A pioneering plant in Frankfurt, set to commence operations in 2024, will recycle up to 8Kt/year of CO2, yielding up to 3.5 million litres of synthetic fuel, making it the largest power-to-liquid plant globally. In January 2024, Ineratec raised over $129 million in a Series B funding round led by Piva Capital, with participation from investors such as HG Ventures, TDK Ventures, and Samsung Ventures. This funding aims to scale up Ineratec's e-fuel production, transforming 1GWeq of renewable energy into 125 million gallons of sustainable fuel by 2030

HY2GEN

Founded in 2017 and headquartered in Germany, Hy2gen is a renewable fuel production project developer, specialising in the development, financing, construction, and operation of Power-to-X (PtX) fuel plants. The company's strategic focus spans the entire value chain, from renewable hydrogen to PtX, acting as a development platform for industry, transportation, and power generation worldwide.

Currently, Hy2gen operates a 6.3MW plant dedicated to renewable hydrogen production for road freight transport. However, the company is rapidly scaling its operations, with 8 additional plants under construction and 15 more in development. This ambitious expansion is supported by a robust project pipeline in planning and constructing, representing 1.9GW, and with a development pipeline exceeding 12GW.

In June 2024, Hy2Gen reached a significant milestone with the award of a block of energy from Hydro-Québec for its Courant green ammonia project. Still pending FID, Hy2gen plans to begin construction of the plant in H2 2026 and start production in 2029. The last capital raise occurred in February 2022, when Hy2gen secured €200m in development capital from Hy24, Mirova, CDPQ and Technip Energies, supporting its capability to execute an ambitious growth plan.

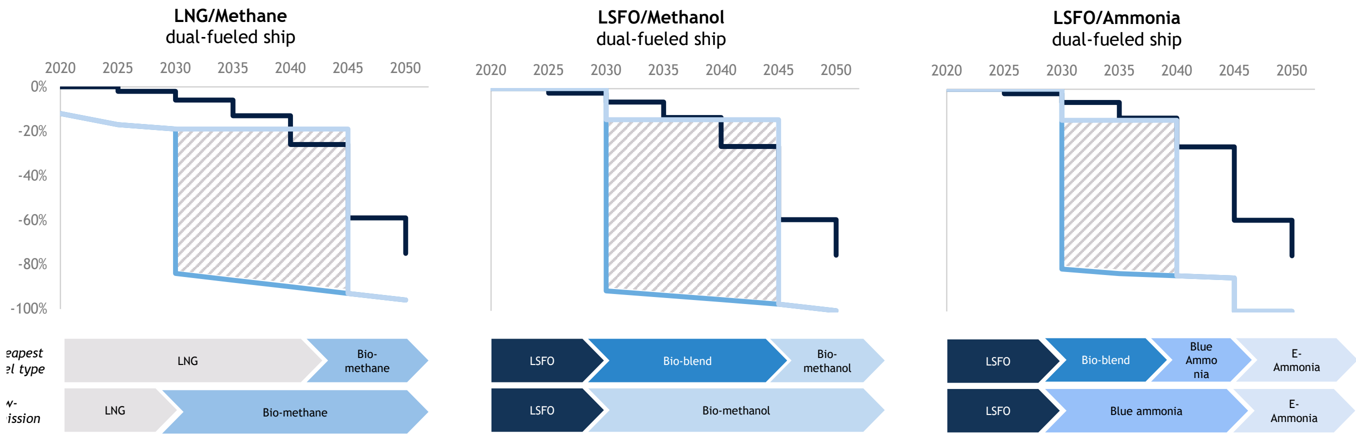
north ammonia

North Ammonia is a prominent player in the green ammonia production sector, focused on sustainable energy solutions for maritime applications. Established as a joint venture in 2021, the company is equally owned by Grieg Edge and Vergia, North Ammonia has a portfolio of 4 green ammonia projects.

It secured a significant milestone in May 2024, having been granted 171MW of power access in Eydehavn for its flagship project near the port of Arendal (Norway). This first project should represent 150Kt/year of green ammonia production, slated to start operations by 2028, with FID expected in 2025. In 2023, North Ammonia reached an agreement with Höegh Autoliners for the supply of at least 100Kt/year of green ammonia from 2030. Ammonia production capacity from the two disclosed projects (Eydehavn and Slagen) adds up to 250Kt/year.

The Slagen plant is developed in partnership with Esso Norge, Grieg Edge, and GreenH, with production envisaged by 2027/28.

FIG 87: DUAL-FUELLED VESSEL FLEXIBILITY CAN PROVIDE SHIP OWNERS WITH ENOUGH FLEXIBILITY TO TEST AND COMPLY IN THE LONG RUN



*Source: Zero Carbon Shipping, Maersk Mc-Kinney Moller Center, Stifel**

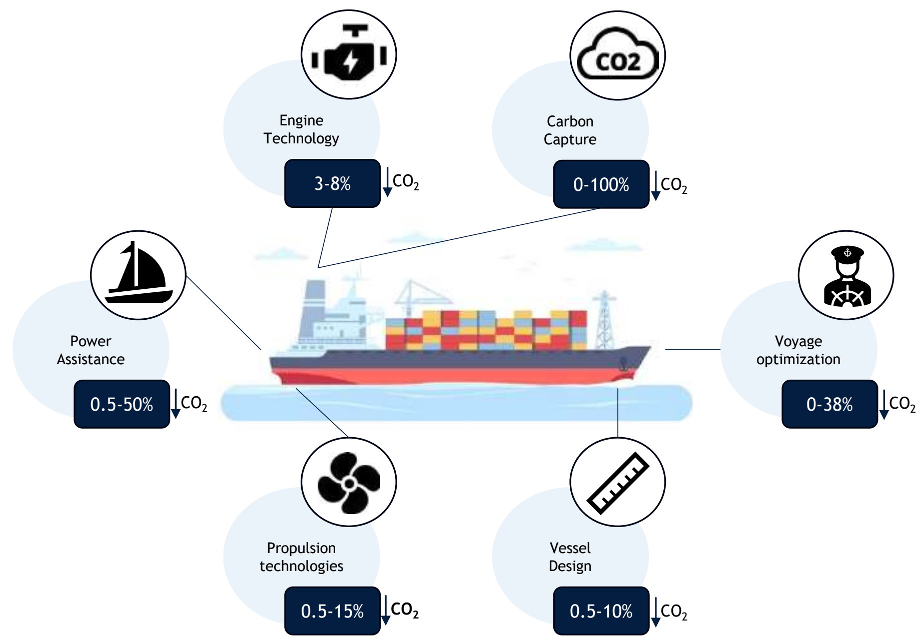
FIG 88: PLAYERS ACTIVE IN RENEWABLE METHANOL AND AMMONIA PROJECTS

*Source: Stifel**

Additionally, since January 2023, all existing ships are required by the IMO to report under the Energy Efficiency Ship Index, establishing an annual operational carbon intensity indicator. This system rates ships based on their energy efficiency, with grades ranging from A to E, where A is the highest. The index takes into account retrofits and new engine investments as well as overall efforts in reducing fuel consumption. Alternative fuels are part of the emissions reduction toolkit for shipping fleet operators.

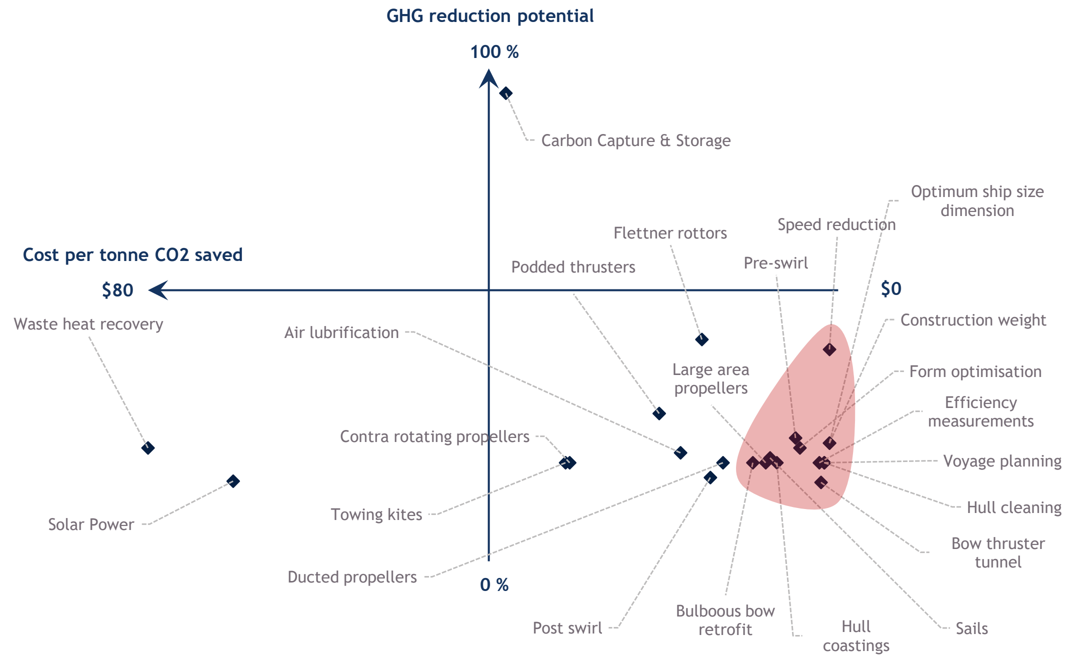
Ship GHG footprint optimisation starts with route/speed optimisation, hull cleaning and other measures to reduce drag. Vessels can also leverage secondary power systems such as wind, solar and batteries to reduce fuel consumption. These measures can enhance a ship's overall energy efficiency and reduce carbon intensity without relying on alternative fuels, buying time until regulatory frameworks and producer economics mature.

FIG 89: PLENTY OF OPTIMISATION ROUTES AVAILABLE FOR IMPLEMENTATION …



*Source: IMO, Ricardo, Stifel**

FIG 90: … WITH CHEAPER TCO-ROUTES TO REDUCE SHIPS' CARBON INTENSITY (RED AREA)



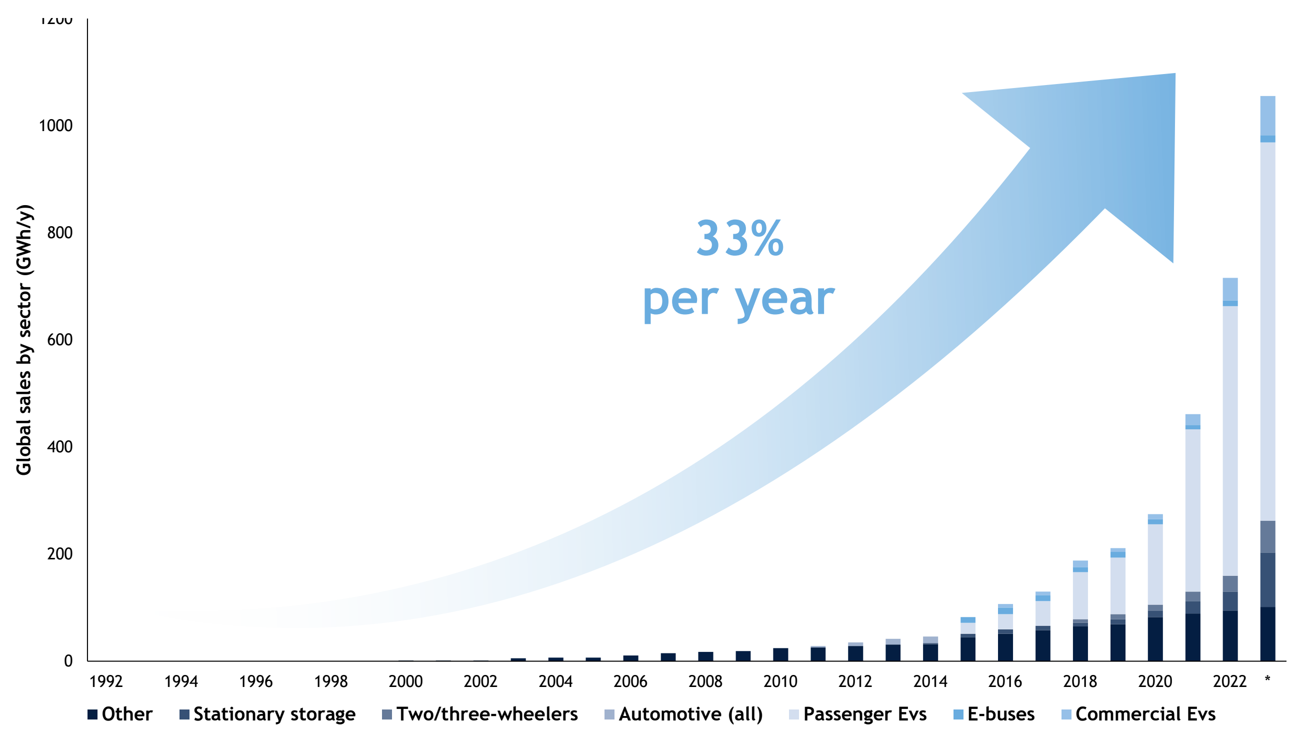
*Source: Ricardo, Stifel**

Where will the battery revolution end?

While uptake of BEVs took place gradually over the past five years, a battery domino effect could happen in other sectors and spread to all road transport sub-segments. Leveraging developments and volume growth from electronics, battery innovation has gathered momentum, boosted by pioneering industrials and increasing geopolitical competition to scale battery technologies. Consequently, batteries have now been integrated into light mobility vehicles, 2-3 wheelers, buses and cars. In Europe, 35-40% of bus sales and 15-20% of passenger EV sales are now of battery-powered vehicles.

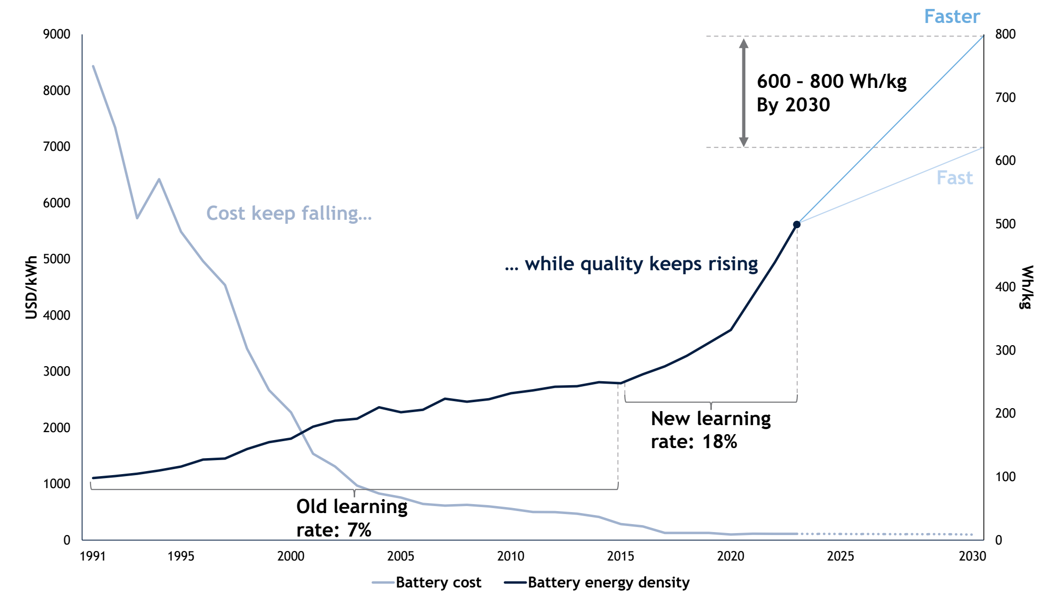
Mass battery production started within Asia and is focused in China. Western countries are slowly catching up, backed by local incentives and tariffs on overseas manufacturing, in a reshoring effort designed to accelerate the development of local battery ecosystems. Consequently, as the regulatory landscape matures and private investments increase to satisfy growing battery demand, battery energy density and fast-charging capabilities should continue to increase, opening new markets, creating more mature supply chains, and reducing battery costs. The higher the volume, the faster the investment cycle. This is highlighted by CATL's leading position in the battery market, leveraging 35-40% market shares (with China capturing close to two-thirds of the market in 2023), and producing breakthrough energy density of up to 500Wh/kg, which potentially enables the electrification of small passenger aircraft.

FIG 91: GLOBAL BATTERY SALES BY SECTOR SINCE THE EARLY 1990S (IN GWH/YEAR)



*Source: RMI, Stifel**

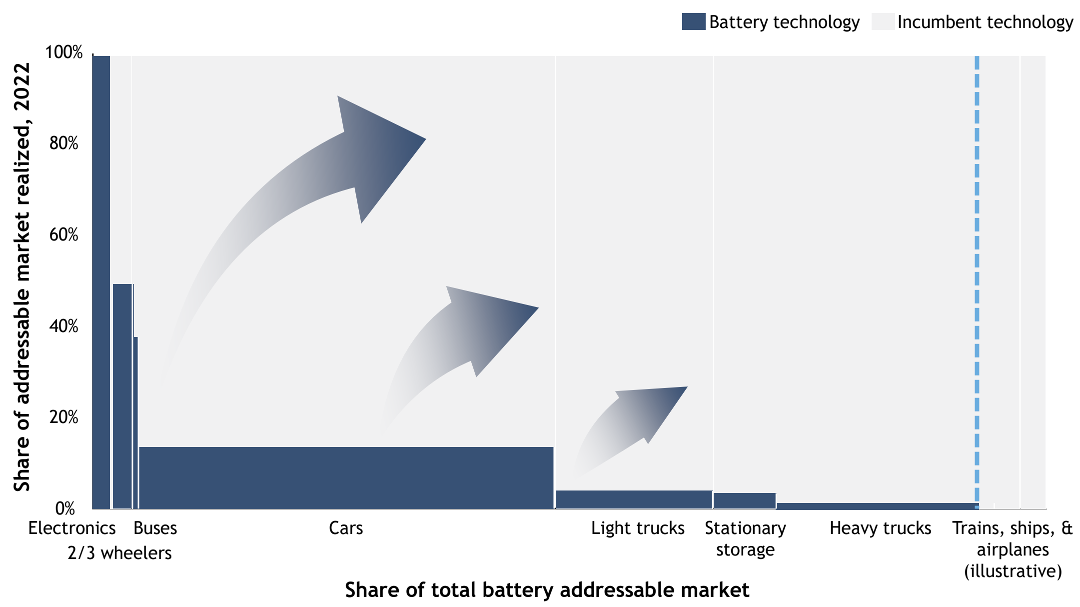
FIG 92: GLOBAL BATTERY SALES BY SECTOR SINCE THE EARLY 1990S (IN GWH/YEAR)



*Source: RMI, Stifel**

Changes are already underway in the truck segment, with range improving as energy density rises and the charging infrastructure continues to scale. Alongside a steady increase in passenger BEV adoption, a gradual uptake in e-truck demand could accelerate developments for hard-to-abate transport segments, at least with hybrid systems. These technologies could support taxiing developments for aeroplanes, reduce at-berth emissions or act as the primary power systems for shorter haul segments.

FIG 93: RMI'S "BATTERY DOMINO" EFFECT ON ADDRESSABLE MARKETS

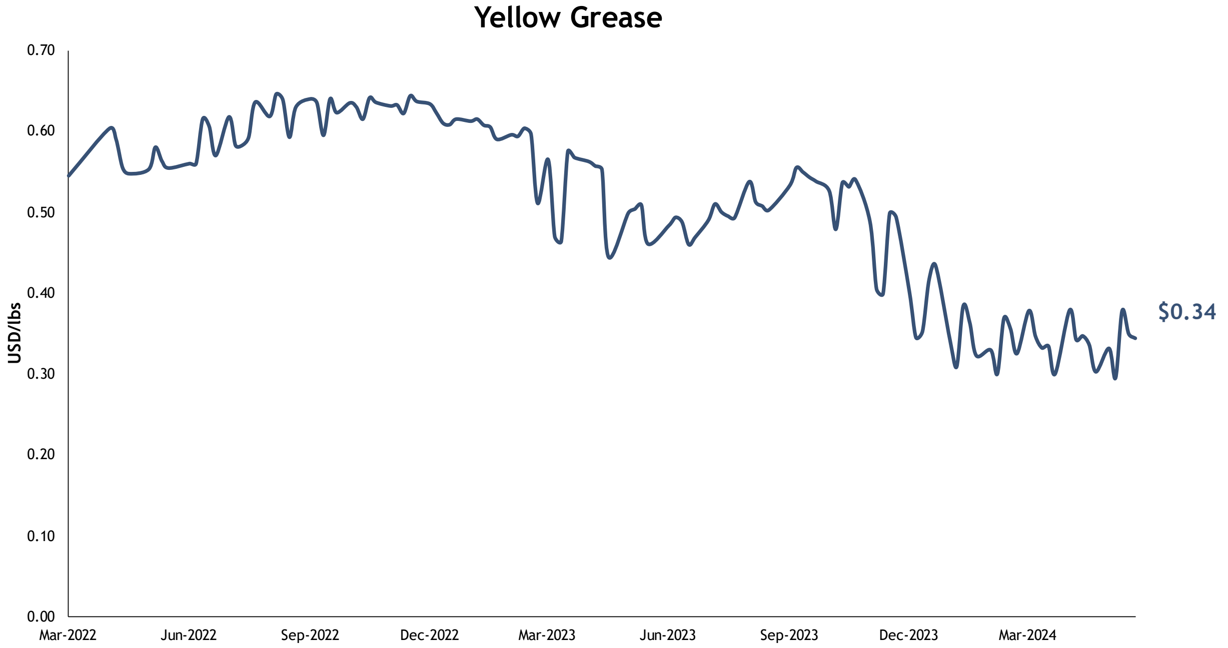


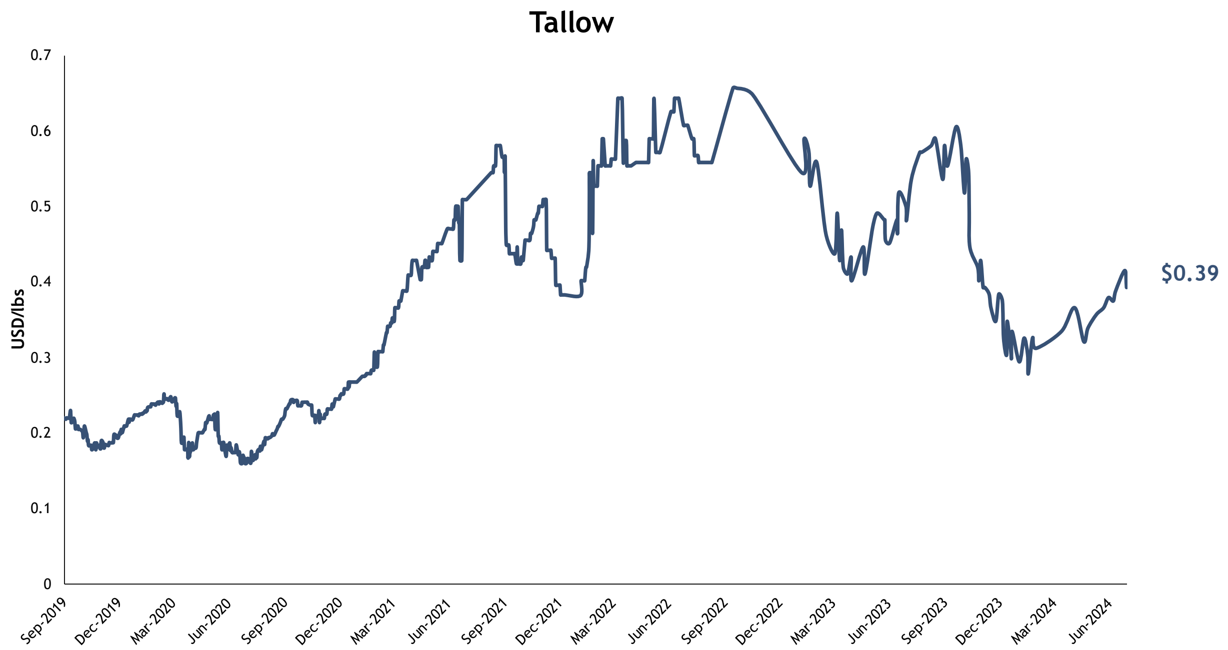
*Source: RMI, Stifel**

BIO- AND ALTERNATIVE FUEL'S **TOOLKIT**

Feedstock and credit price dynamics as primary proxies

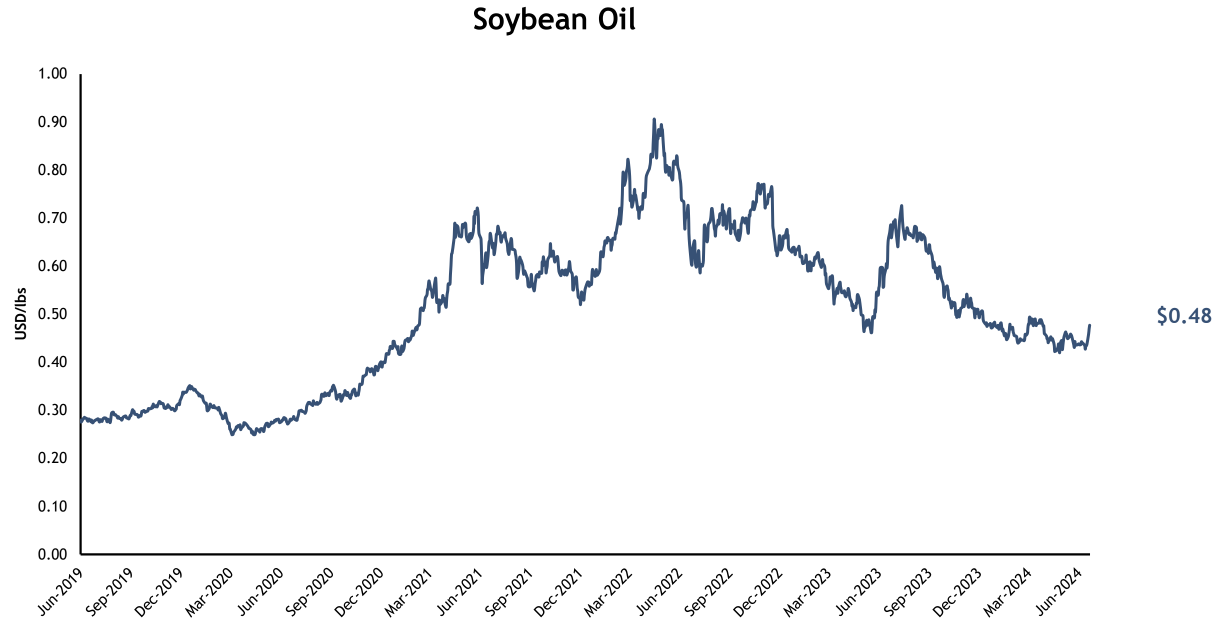
FIG 94: MAJOR BIOFUELS FEEDSTOCK PRICE DYNAMICS (1/3)

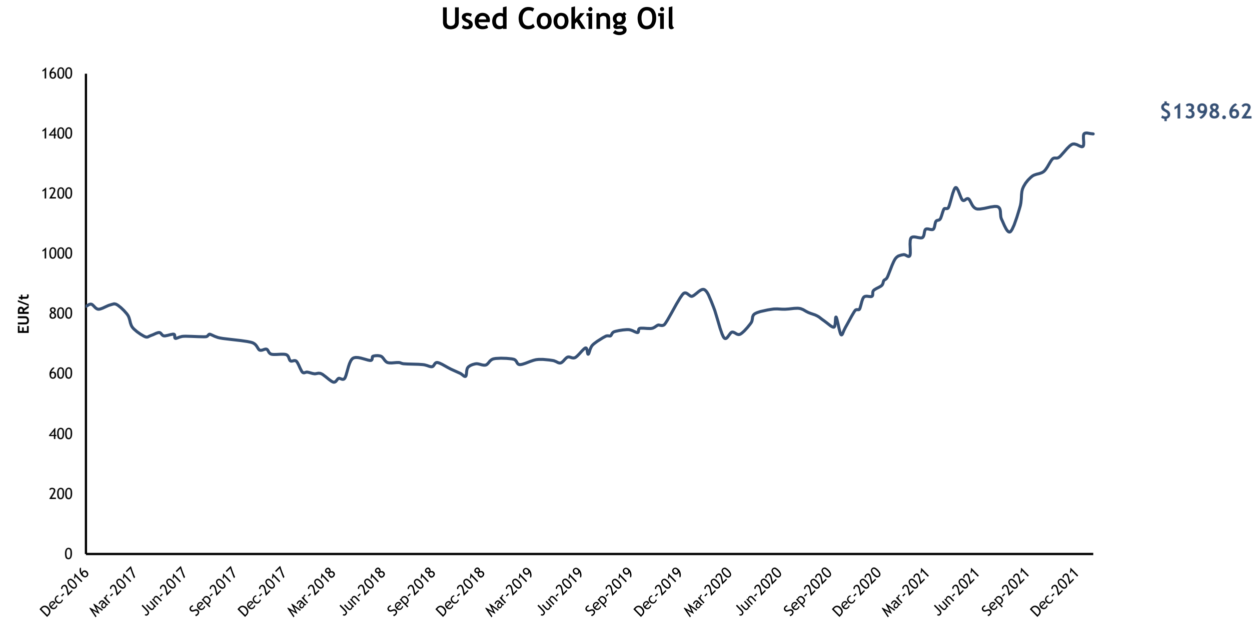




*Source: Bloomberg, Stifel**

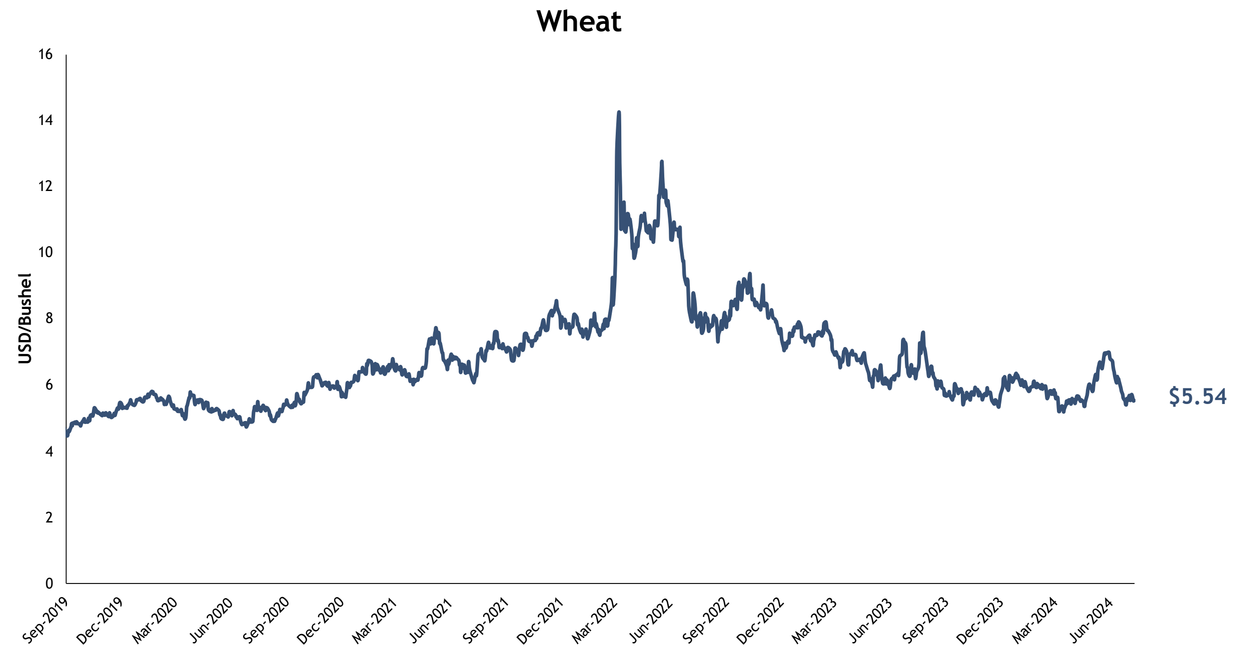
FIG 94: MAJOR BIOFUELS FEEDSTOCK PRICE DYNAMICS (2/3)





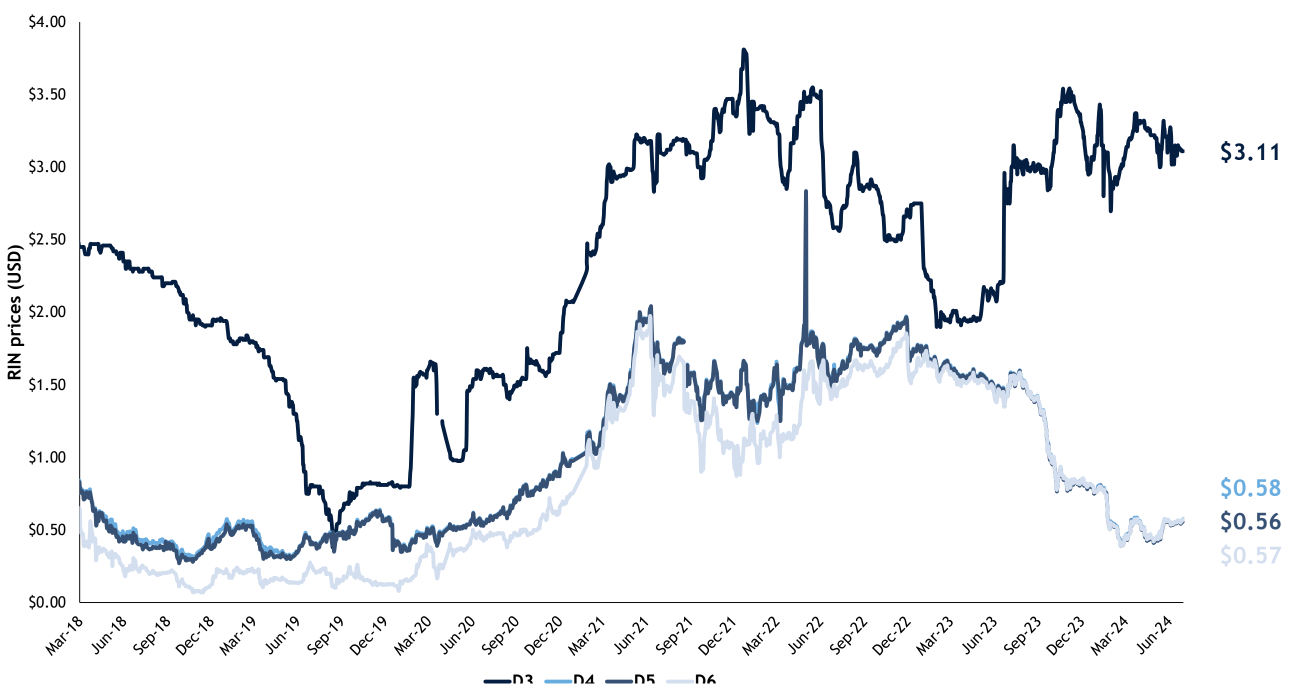
*Source: Bloomberg, Greenea, Stifel**

FIG 94: MAJOR BIOFUELS FEEDSTOCK PRICE DYNAMICS (3/3)



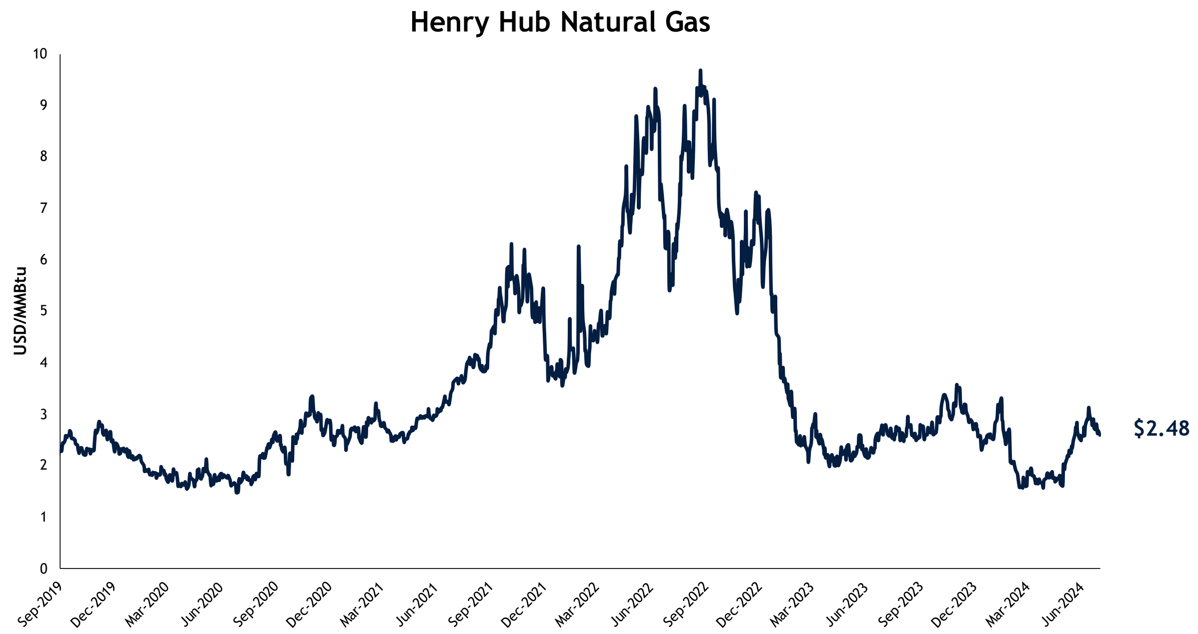
*Source: Bloomberg, Greenea, Stifel**

FIG 95: HISTORICAL RIN PRICES SINCE Q1 2018



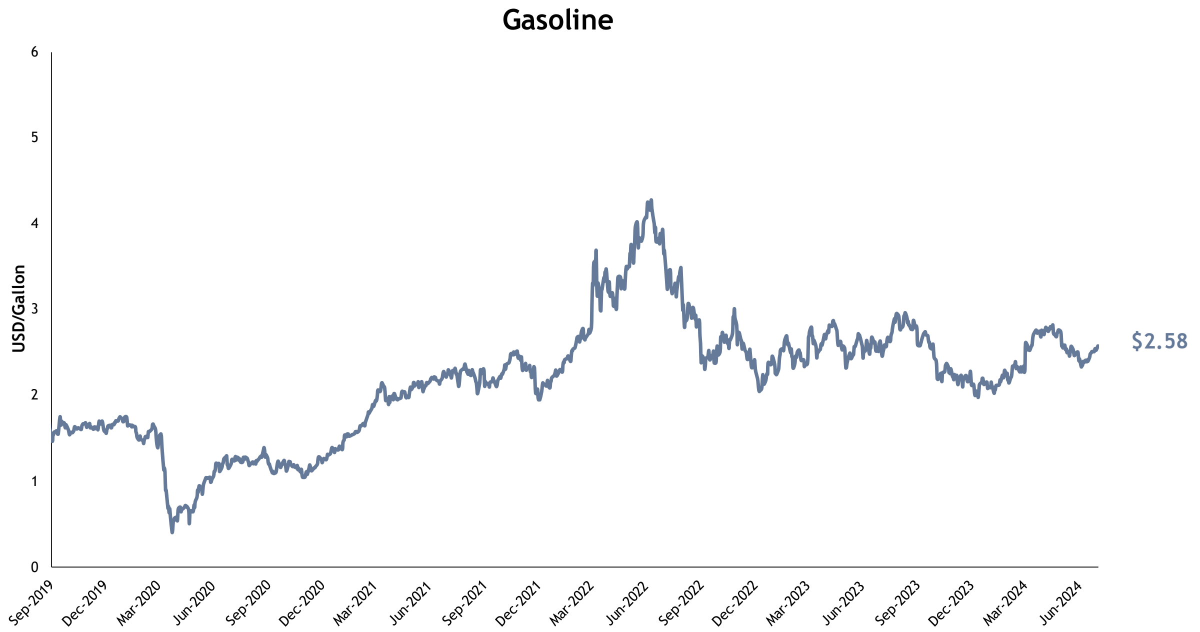
*Source: Bloomberg, Stifel**

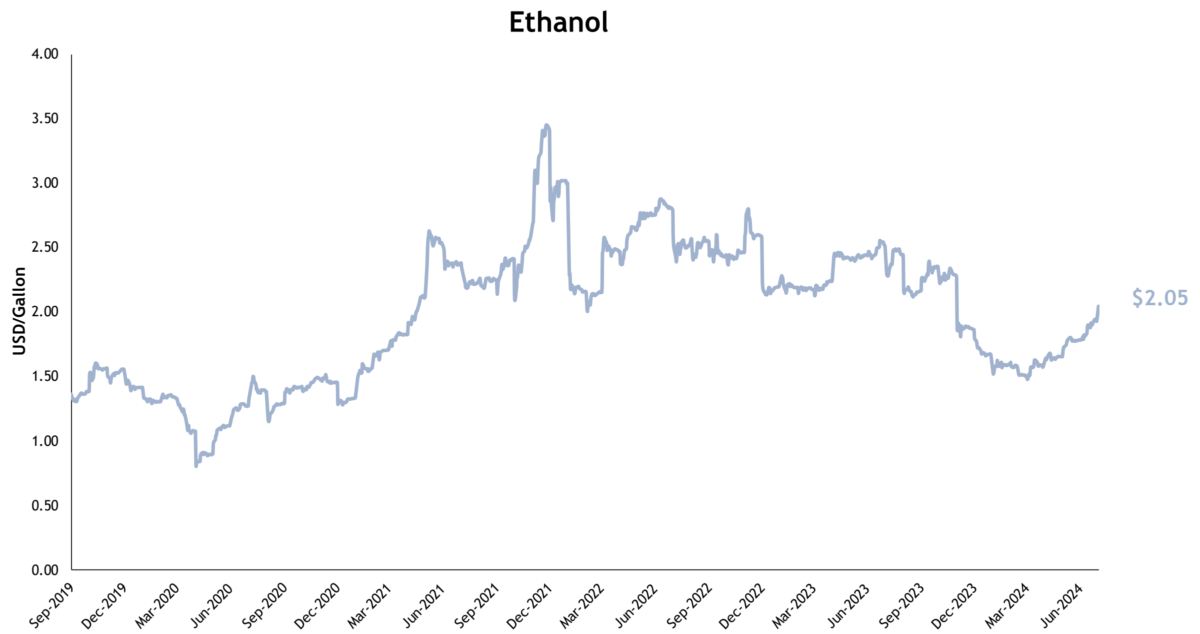
FIG 96: FOSSIL FUEL HISTORICAL PRICES SINCE Q3 2019 (1/3)



*Source: Bloomberg, Stifel**

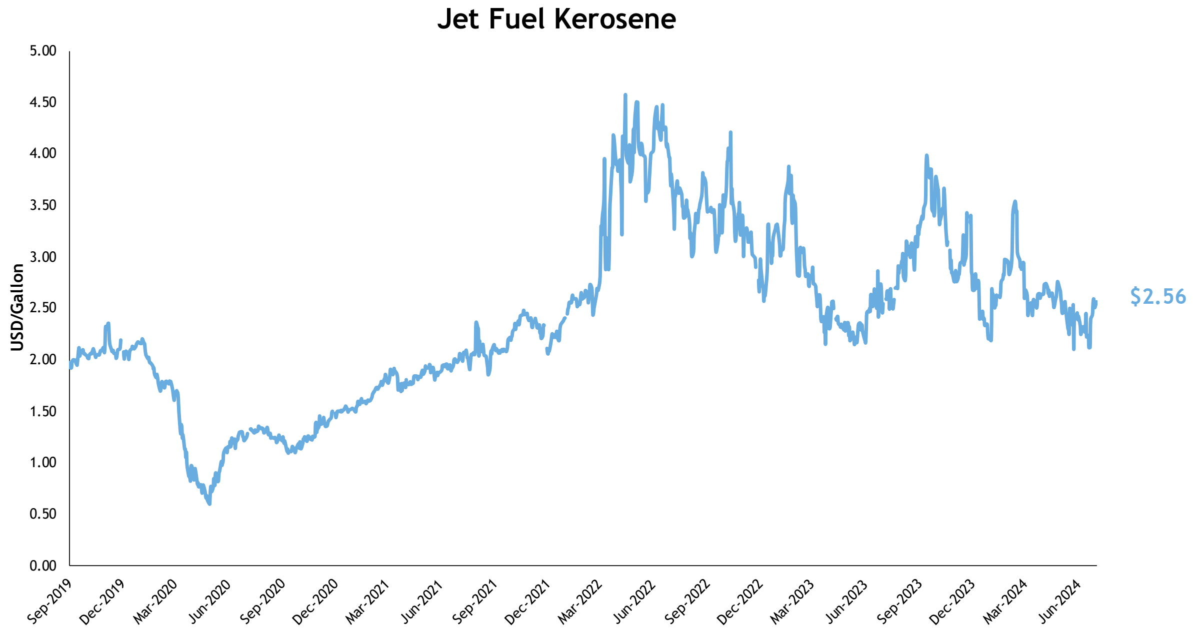
FIG 96: FOSSIL FUEL HISTORICAL PRICES SINCE Q3 2019 (2/3)

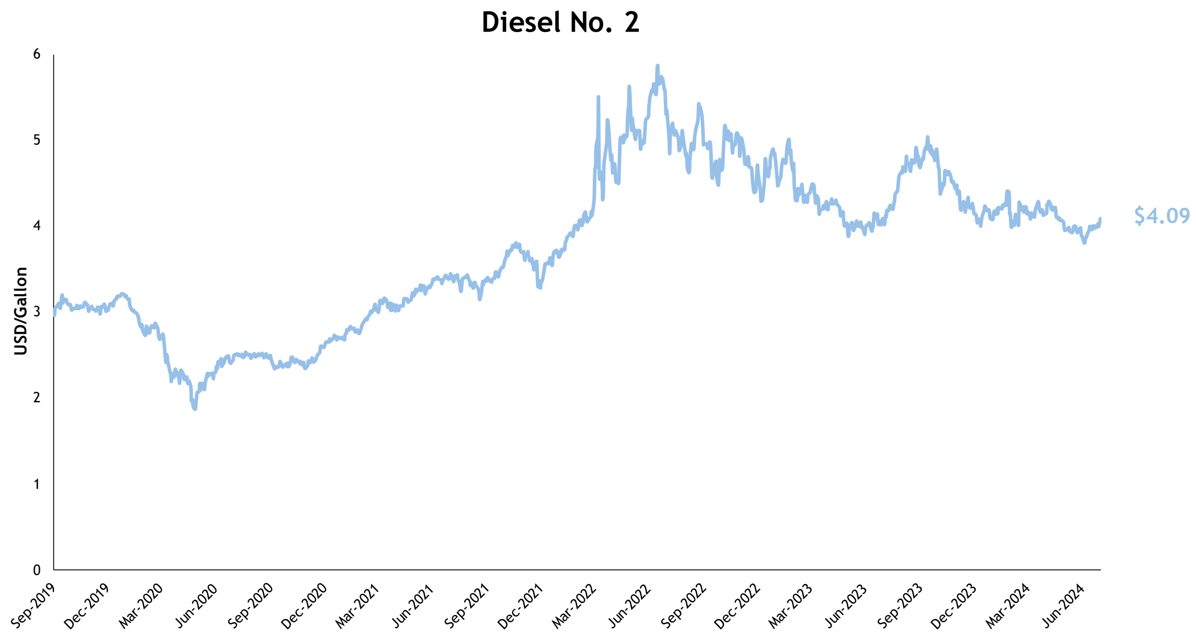




*Source: Bloomberg, Stifel**

FIG 96: FOSSIL FUEL HISTORICAL PRICES SINCE Q3 2019 (3/3)

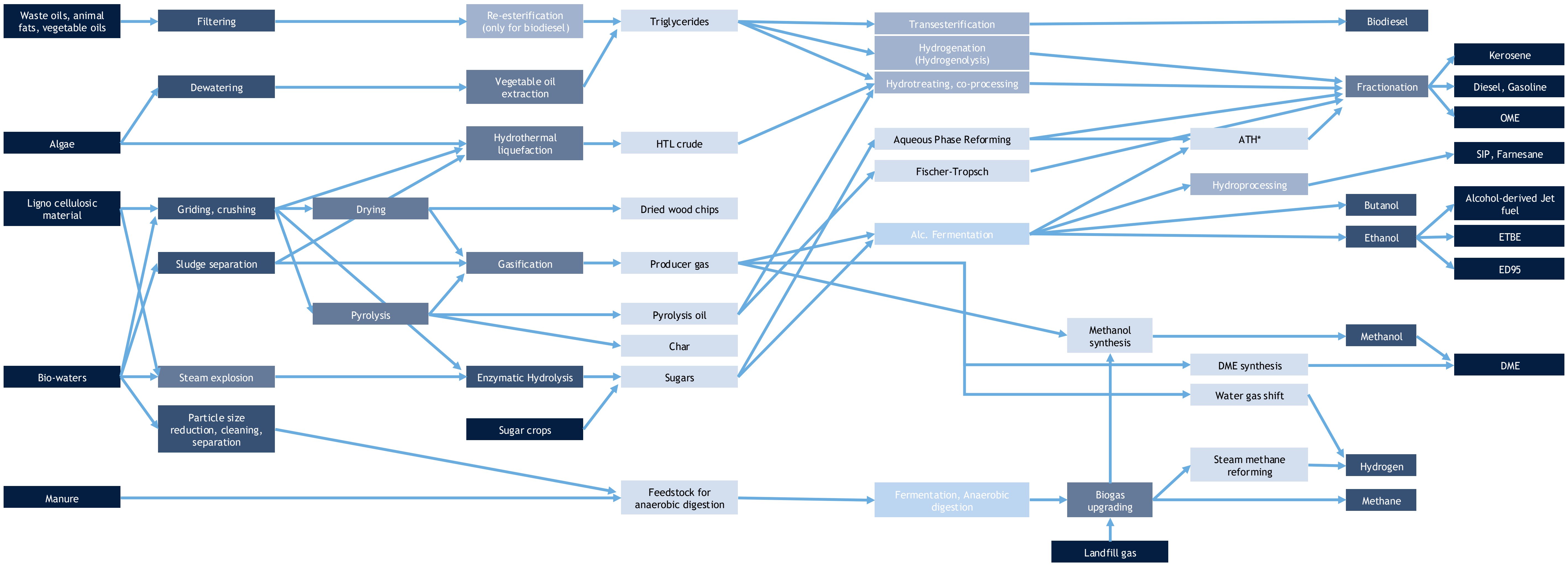




*Source: Bloomberg, Stifel**

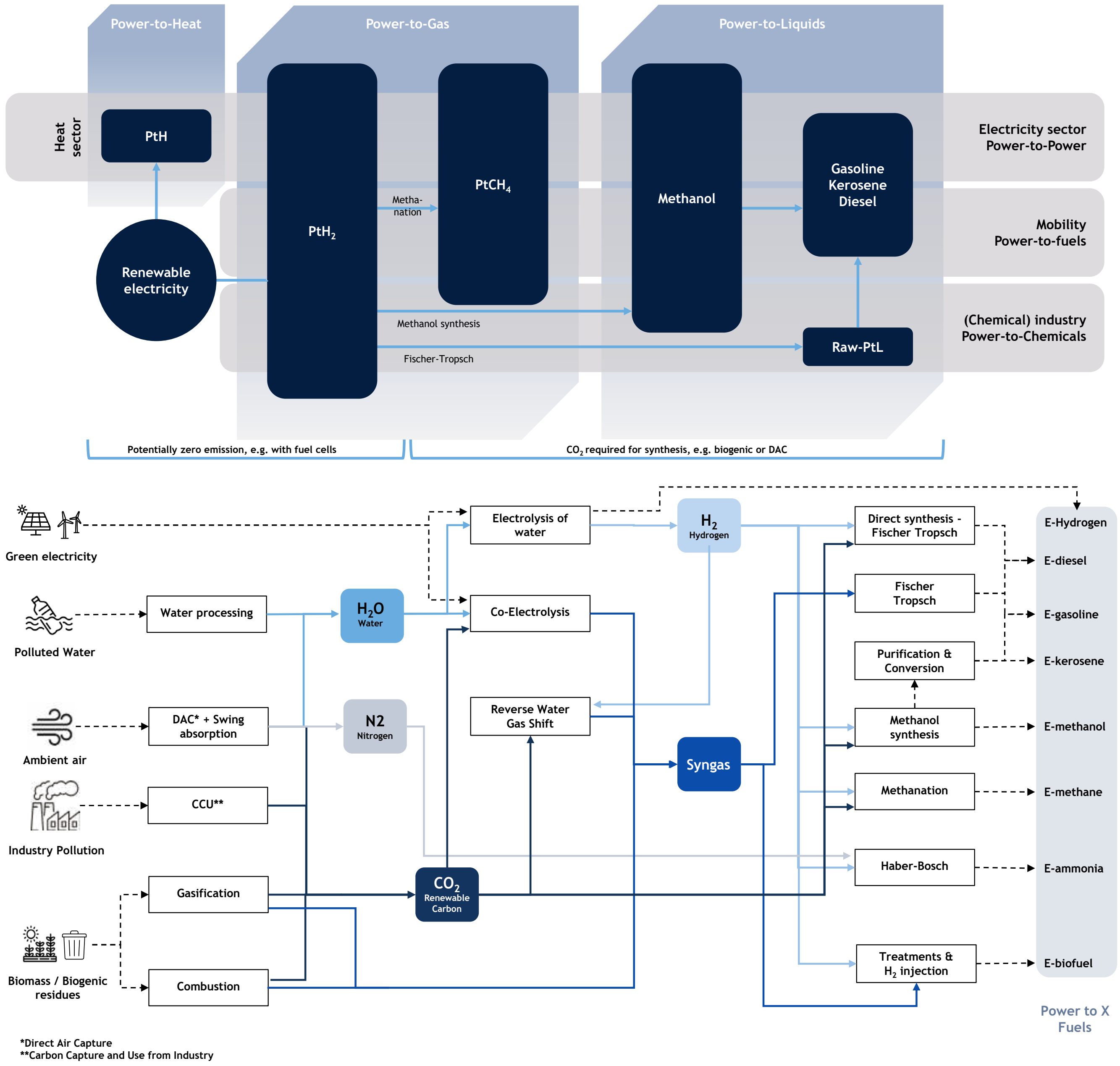
Browse available bio- and e-fuels production pathways

FIG 97: AVAILABLE ALTERNATIVES TO PRODUCE EU ANNEX IX BIOFUELS



*Source: EU Joint Research Center (via EU ECA), Stifel**

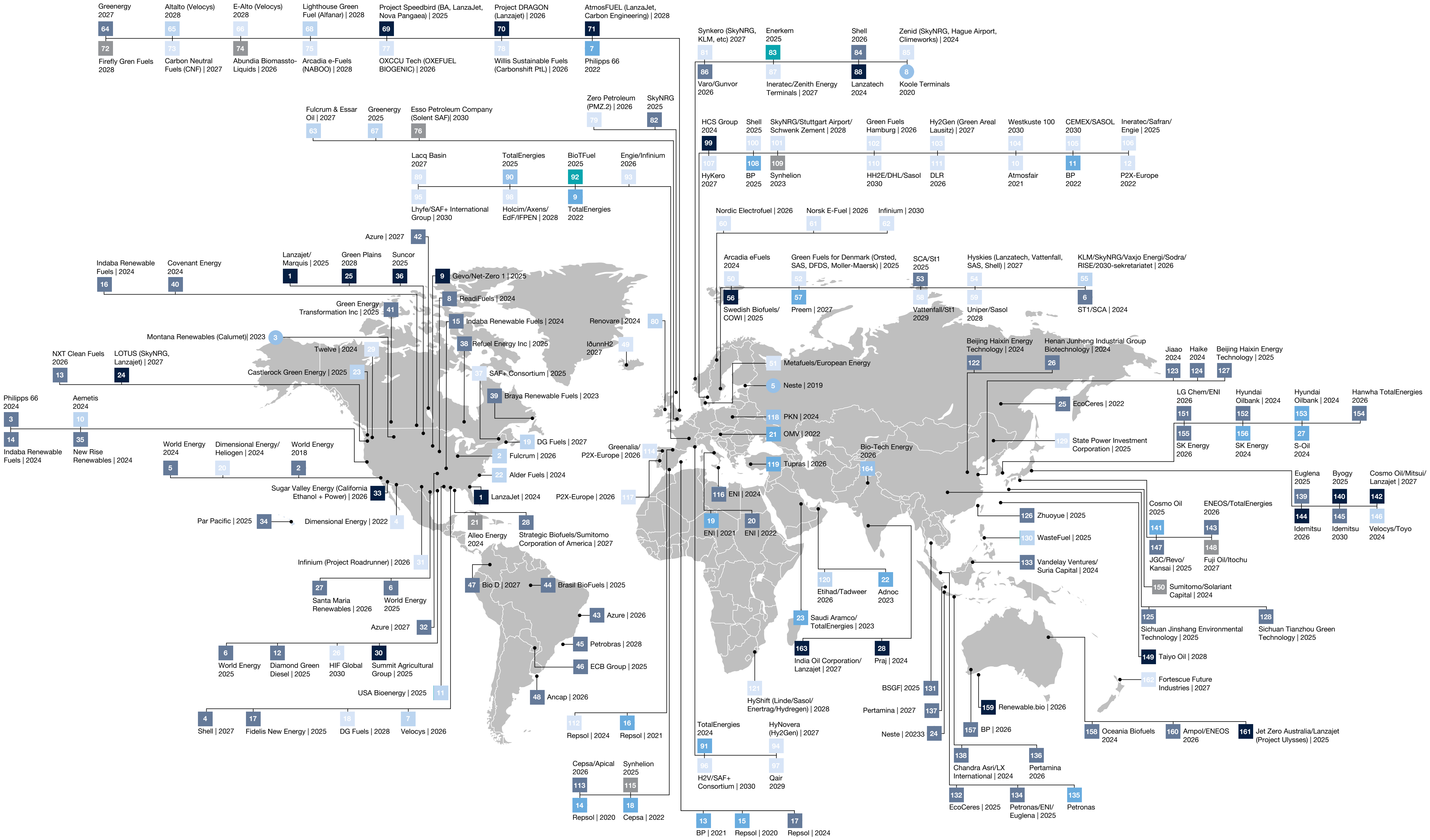
FIG 98: OPENING THE PTOX ALTERNATIVES BOOK



*Source: EU Joint Research Center (via EU ECA), Stifel**

Mapping tomorrow's projects in bio- and e-fuels initiatives

FIG 99: GLOBAL SAF PROJECT MAP AS OF MAY 2024



Operational | Operational Year

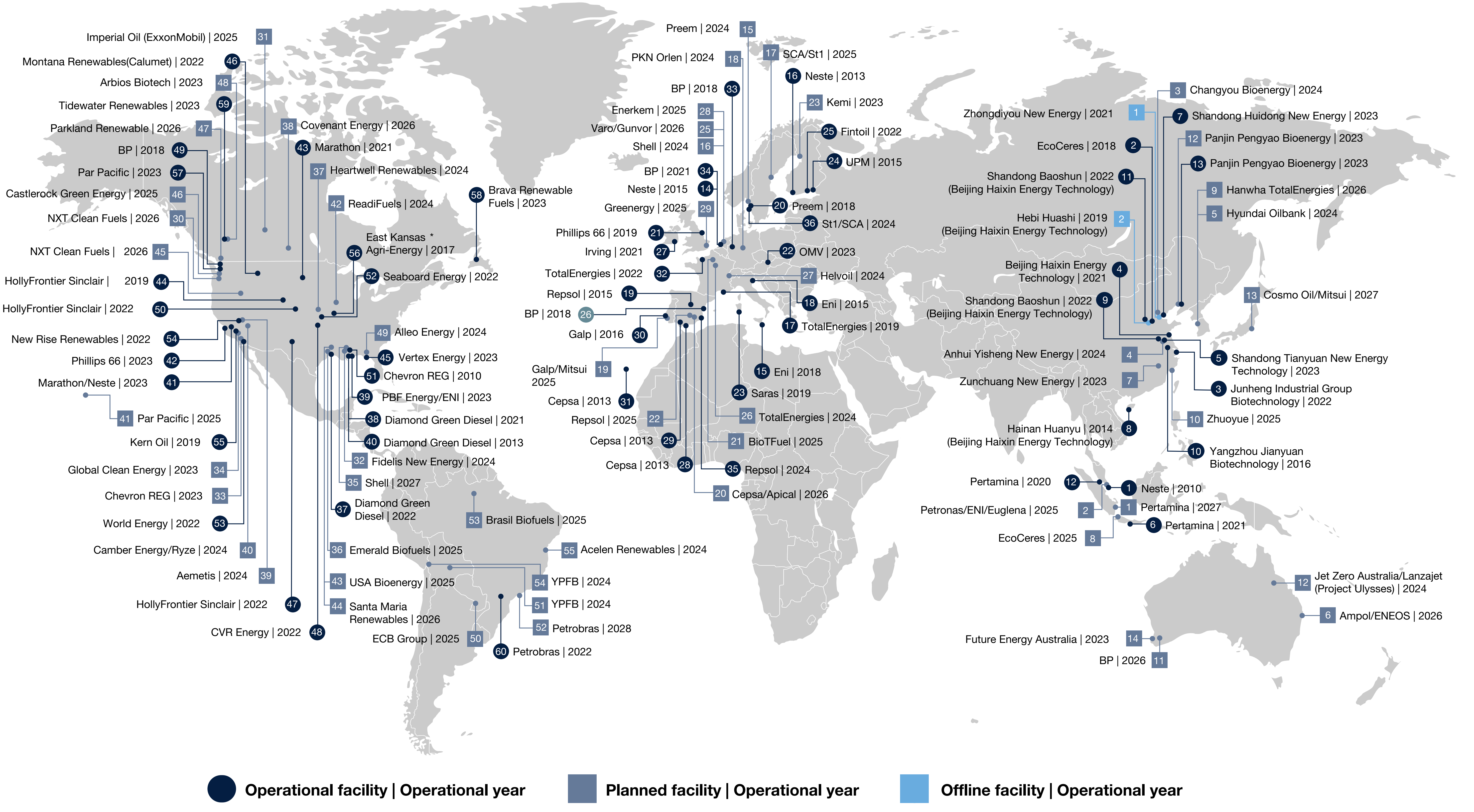
- Operational
- Planned

Type of facility (color)

- Alcohol-to-Jet Synthetic Paraffinic Kerosene
- **HEFA** Hydroprocessed Esters and Fatty Acids
- **Co-processing**
- **Distillation**
- **FT-SPK** Fischer-Tropsch Synthetic Paraffinic Kerosene
- **PtL** Power-to-Liquid
- Other (CHJ/HEFA-SPK, Gasification/ methanol-to-jet, HTL, Pyrolysis, Pyrolysis/hydrotreating, Sun-to-Liquid, Thermal cracking, blanks (nothing)

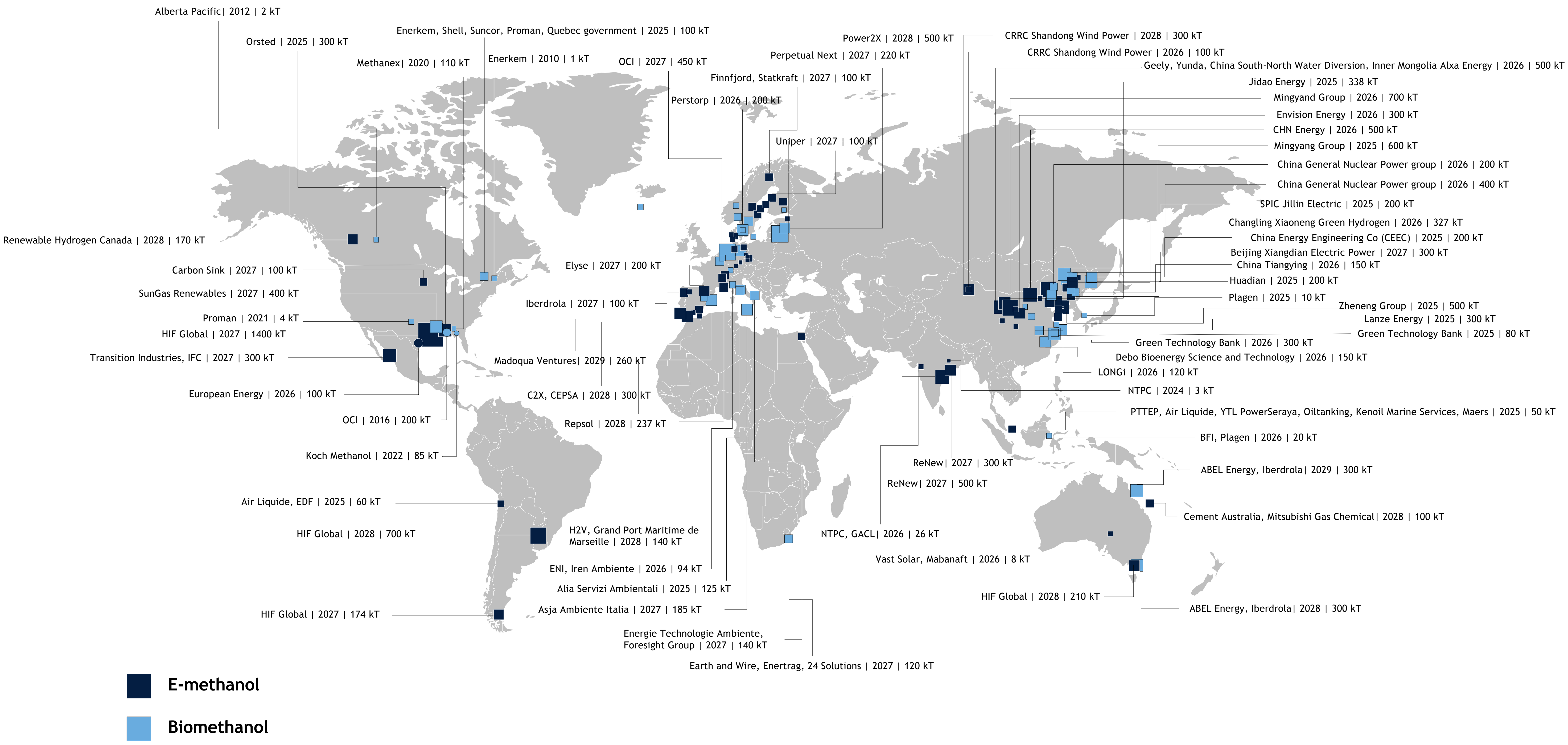
*Source: EU Joint Research Center (via EU ECA), Stifel**

FIG 100: GLOBAL HVO PROJECT MAP AS OF MAY 2024



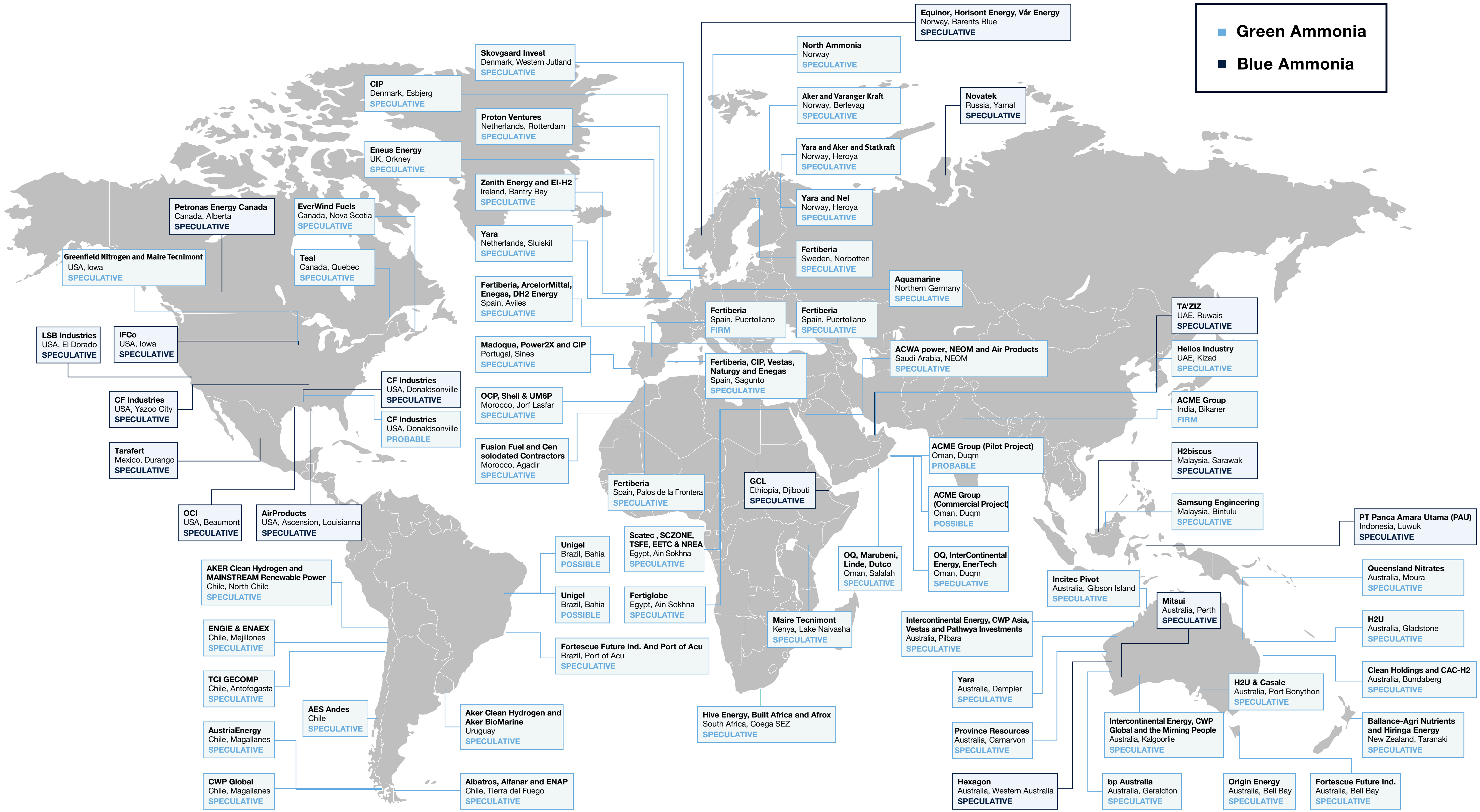
*Source: Argus, Stifel**

FIG 101: GLOBAL RENEWABLE METHANOL PROJECT MAP AS OF MAY 2024



*Source: The Methanol Institute, Stifel**

FIG 102: GLOBAL LOW-CARBON AMMONIA PROJECT MAP AS OF MAY 2024



*Source: Argus, Stifel**

THE **ALTERNATIVE FUELS** JOURNEY

SECTION 4

RECENT TRANSACTIONS

Full scope of opportunities

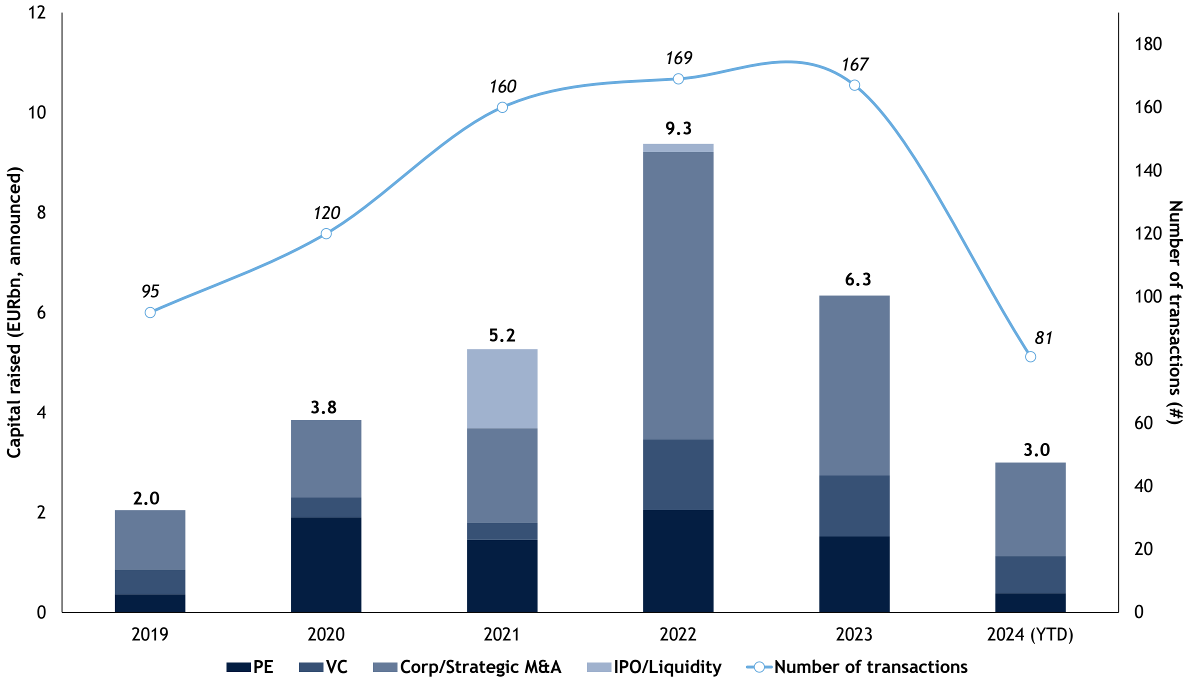
From a transaction standpoint, biofuels enjoyed a "honeymoon" period between 2021 and 2022, with total investments in the ecosystem multiplied almost by a factor of 5 between 2019 and 2022, supported both by improving refining margins and solid regulatory support. Since then, with macroeconomic headwinds slowing the pace of renewables, feedstock volatility due to geopolitic tensions and growing sustainability debates around feedstock access and imports, the pace slowed back to pre-Covid levels. However we are entering into a new capacity expansion period for infrastructure developers, with a corresponding change in cash cycles for mature players and increased technology needs for pioneers.

Given the amount of capital to be deployed in alternative fuel hubs – from greenfield collection and storage to brand-new facilities and refinery retrofits - the upward fundraising trend should continue to see strong developments. This is further highlighted by steady interest from corporate end-users such as airlines and chemical companies, keen on venturing capital in disruptive pathways. Infrastructure capital from large corporates and investors is also being made available to next-generation fuel project developers focusing on the aviation and marine sectors.

Whereas traditional biofuels represent the vast majority of today's production volumes, more and more second-generation and RFNBO projects will gradually start operations over the next five years, with supportive regulation coordinating the sector, but also feedstock security and overall process economics acting as a referee.

The following charts show past transactions in the ecosystem since the beginning of 2019:

FIG 103: ALTERNATIVE FUELS TRANSACTIONS YTD 2024 AND OVER THE PAST 5 YEARS



Source: Stifel* IRIS, Pitchbook

FIG 104: TRANSACTIONS FROM THE LAST 18 MONTHS (1/10)

Deal Date	Companies	Country	Description	Investors	Deal Type
Jul-24	LanzaJet	USA	Operator of a sustainable fuels technology company intended to accelerate the energy transition by embracing the circular economy. The company produces safe, sustainable fuels from waste and low-carbon sources, enabling clients to reduce their carbon footprint.	AIRBUS GROUP	VC
Jul-24	ClearSky Global	CAN	Operator of a low-carbon fuel production company intended to provide sustainable alternatives for the transportation industry. The company specializes in developing eco-friendly aviation and diesel fuels, as well as fuel treatments, enabling firms to reduce greenhouse gas emissions and improve engine performance while maintaining economic viability.	Undisclosed	VC
Jun-24	IGNIS P2X	ESP	IGNIS P2X, a new Power-to-X (P2X) platform to develop primarily green hydrogen and ammonia projects for industrial applications in hard-to-abate sectors. IGNIS P2X will develop green hydrogen, ammonia, e-methanol, e-fuels and SAF production plants serving blue chip corporates active in refining, steel, chemicals, fertiliser, among other sectors, as well as traditional renewables, largely wind and solar, associated with the hydrogen and ammonia projects.	KKR, IGNIS	JV
Jun-24	Aether Fuels	SGP	Developer of sustainable fuel technology designed to decarbonize aviation and ocean shipping. The company offers technologies that enable the scalable and economical production of sustainable fuels from waste biomass and biogenic carbon dioxide, enabling clients to produce sustainable fuels that are practical, economical, and scalable.	ZEON, Chevron, cdp	VC
May-24	280earth	USA	Developer of an air scrubber system designed to improve the climate. The company's system uses a network of engineered trees to capture carbon dioxide from the atmosphere and convert it into biomass, creating sustainable products like bioplastics and biofuels and helping mitigate climate change by removing excess carbon dioxide from the atmosphere, enabling clients to help pull CO2 permanently out of ambient air.	Alphabet, builders	VC
May-24	CIRCTEC	GBR	Producer of renewable fuels intended for chemical, petrochemical and oil sectors. The company produces sustainable drop-in fuels and circular chemicals from the vast amount of end-of-life tires that are disposed of every year, thereby contributing to a cleaner world.	novo holdings, A.P. Møller Capital	PE Growth
May-24	COWBOY CLEAN FUELS	USA	Producer of a renewable energy gas intended to commercialize a process of producing renewable natural gas from alternative biomass feedstocks. The company specializes in creating renewable natural gas from depleted coalbed methane wells and alternative biomass feedstocks, while also geologically sequestering significant volumes of carbon dioxide, enabling consumers with carbon-negative renewable energy and a source of clean fuels.	Machan Investments	VC
May-24	FERBGAS	PRT	Operator of a biomethane producer based in Lisbon, Portugal. The company offers a wide range of environmental services including origination and development, financing, engineering and construction, and operation and maintenance, thereby assisting customers with their requirements.	WHITE SUMMIT CAPITAL	Buyout/LBO
May-24	LanzaJet	USA	Operator of a sustainable fuels technology company intended to accelerate the energy transition by embracing the circular economy. The company produces safe, sustainable fuels from waste and low-carbon sources, enabling clients to reduce their carbon footprint.	Microsoft, Southwest	VC
May-24	GazoTech	FRA	Developer and distributor of a renewable gas production solution designed for the conversion of various biomass and waste feedstocks into renewable energy sources. The company specializes in developing biomass gasifiers that enable the decentralized production of green energy, gas and chemicals, it offers a wide range of gasification-based solutions to profitably convert biomass waste streams into energy including heat, electricity, green hydrogen, biomethane, bioethanol and more.	CRISTAL UNION C'est ensemble que nous avançons	Corporate
May-24	HIF	CHL	Developer and operator of e-fuel plants focused on accelerating decarbonization by producing carbon-neutral fuels. The company develops clean, carbon-neutral fuels via electrolysis and carbon dioxide from the atmosphere and industrial and biogenic sources, helping clients use green energy and replace fossil fuels.	AME, EIG, Baker Hughes, Idemitsu	PE Growth
May-24	aviation tech partners	DEU	Developer of risk management software based in Berlin. The company's product features the ability to eliminate risk for biofuel procurement and investment, providing clients with a predictive model for biofuel production projects.	APX by Axel Springer & Porsche	VC
May-24	SEA6 ENERGY	IND	Operator of a biofuel company intended to harness the unlimited potential of the oceans sustainably and ethically. The company's primary focus is on deriving ethanol fuel from seaweed and converting it into biofuel, plant growth stimulants, plant defense products, animal feed ingredients, and other bio-renewable products, enabling companies to circumvent problems posed by traditional feedstock such as land use and opportunity costs, freshwater requirements, and nutrient use.	TTV TWIN TOWERS VENTURES	VC
Apr-24	Greenhitech	IND	Greenhitech Ventures Ltd is engaged in trading of various petroleum-based products for the different categories of industries based on their requirement. This includes the supply of biofuels, bitumen, light-density oils, furnace oils, etc. The company is also engaged in Operation & Maintenance as a Job worker for Ethanol manufacturing in government-owned distilleries. It understands the market needs and upgrades its team constantly with growing technology and market trends. The company provides business solutions and services to consumers of Fuels and other alternative materials across India.	Undisclosed	IPO
Apr-24	ZYMOBIOTECH	CHN	Developer of green synthetic biomanufacturing designed for multiple industries. The company offers industrial cell factories to produce biofuels and biomaterials using sustainable non-food feedstocks such as lignocellulosic biomass and waste starches in the fields of systems biology, metabolic engineering, and synthetic biology, enabling the usage zymomonas mobilis with many industrial fermentation advantages as the chassis cells.	CDH INVESTMENTS 鼎晖投资	VC
Apr-24	Eco-Power Environmental	GBR	Provider of waste recycling services intended to help businesses and municipalities to reduce their environmental impact. The company utilizes state-of-the-art processing plants to handle and recycle commercial and municipal waste and offers bio-drying, manual picking lines, automated recycle lines, and sustainable fuel production services, diverting it from landfills and promoting a more sustainable waste management system.	Biffa, ECP	Buyout/LBO
Apr-24	GeoMit	BRA	Manufacturer of biogas and biomethane intended to diversify domestic gas supply with renewable alternatives. The company intends to convert organic waste from sugar cane, such as vinasse, to produce renewable gases that are emerging as substitutes for natural (fossil) gas in the energy transition process.	GEO energética, MITSUI & CO.	JV
Apr-24	RAVEN	USA	Developer of waste conversion technology intended to create environmentally friendly, efficient and clean hydrogen and synthetic fuels. The company's technology transforms biomass, municipal solid waste, bio-solids, industrial, sewage, medical waste and natural gas into hydrogen, sulfur and nitrogen-free liquid fuels, additives, solvents and electricity, thereby providing clean technology to convert waste into renewable fuels and energy.	ASCENT, Chevron, STELLAR J, ITOCHU	PE Growth
Mar-24	Cool Planet Technologies	GBR	Operator of a carbon capture company intended to reduce the cost of removing carbon dioxide from industrial flue gas emissions using a membrane-based technology. The company's energy-efficient technologies can capture carbon dioxide from flue gas and export it as either a gas or liquid with purity, enabling industries and applications to have rapid start-up, shut-down response, and turn-up/down capability operations.	Undisclosed	VC
Mar-24	SAFFiRE RENEWABLES	USA	Producer of sustainable aviation fuel intended to pilot and commercialize renewable ethanol fuel technology. The company's fuel helps to accelerate the production of biofuels and bioproducts through waste feedstock that converts into renewable ethanol, enabling industries to reduce carbon emissions.	Southwest	M&A
Mar-24	CNF CARBON NEUTRAL FUELS	GBR	Operator of a technology integrator e-fuel production system intended to accelerate the world's transition to sustainable energy systems. The company uses carbon removal technologies to sequester atmospheric carbon dioxide, which combined with clean hydrogen produces sustainable fuels, enabling industries to deploy sustainable fuels which will drive a significant reduction in emissions.	SFC Capital	VC

Source: Stifel* IRIS, Pitchbook

FIG 105: TRANSACTIONS FROM THE LAST 18 MONTHS (2/10)

Mar-24	sunfire	DEU	Developer of industrial electrolyzers designed to convert renewable electrical energy into fuels and gases. The company's renewable hydrogen and syngas as substitutes for fossil energy sources and offers electrolyzers based on alkaline and solid oxide technologies, enabling chemical, fuel, and steel industries to transform energy.		VC
Mar-24	terragia	USA	Developer of biological conversion systems designed to convert non-food cellulosic biomass to fuels and chemicals. The company uses thermophilic bacteria to process biomass without added enzymes and with little or no pretreatment converted to fuels and chemicals, enabling clients to reduce costs and improve yields in producing renewable fuels and chemicals.	Energy Impact Partners, The Engine Ventures	Seed
Mar-24	VIA BioFuels	USA	Producer of synthetic aromatic substances intended to promote proprietary engineered yeast strains to produce energy. The company engages in producing a scalable, bio-organism-sourced aromatic of high purity where 3-MA can be transformed into other valuable compounds, enhancing its market potential and investment appeal, enabling consumers to replace traditional fuels without blending restrictions.	Indie Bio SOSV	Seed
Mar-24	RENOVARE FUELS	GBR	Developer of a fuel production technology intended to convert everyday waste into transportation fuels. The company's technology combines transformative catalyst technologies that are capable of producing fuel from landfill gas thus converting an environmentally harmful waste gas into value renewable liquid fuel in demand, enabling businesses to solve the existing problem of processing landfill gas.	Undisclosed	VC
Mar-24	Redexis Renovables	ESP	80-GWh biogas plants located in Murcia, Spain. The plants produce biomethane and manage 211000 tons of agri-food, agro-industrial, and livestock waste per year and inject renewable gas into the network through an upgrading unit and its connecting branches.	Redexis, atp, USS	Buyout/LBO
Mar-24	Reformed Energy	USA	Operator of a waste-to-energy company intended to serve the energy industry. The company offers plasma gasification technology to generate sustainable power and produce synthetic fuels such as sustainable aviation fuel.	RIOT	Corporate
Mar-24	Jinxiang Environmental Tec	CHN	Operator of biofuel business intended to serve the region of China. The company specializes in using wasted cooking oil, animal oil and palm oil as a raw material for biofuels such as sustainable aviation fuel.	SK energy	Corporate
Mar-24		AUS	Developer of a sustainable resource designed to reduce the use of aviation fuel. The company is developing the jet fuel (ATJ) facility, taking surplus ethanol production, and creating the replacement of aviation fuel, enabling the aviation industry with zero emissions and reducing the carbon footprint.	Qantas, Dragonfly, idemitsu, Airbus Group	VC
Mar-24	Suiso	GBR	Developer of a methane-cracking process designed to use existing electrical, natural, or bio-gas assets and infrastructure to produce clean low-cost hydrogen. The company's technology offers features like De-carbonising natural gas and biomethane and making clean carbon black, enabling clients to generate Hydrogen from methane using microwave energy.	mercia asset management	Seed
Mar-24	Schmack Biogas AG	ITA	Provider of sustainable energy services based in Bolzano, Italy. The company specializes in offering a complete range of services, starting with the feasibility study and design, taking care of the permit process and construction, assembly and start-up, and providing routine and special maintenance, thereby enabling clients to generate electricity from biogas or biomethane.	Hitachi Zosen INOVA	M&A
Mar-24	SORA FUEL	USA	Manufacturer of climate technology products based in Cambridge, Massachusetts. The company produces e-fuels from carbon directly captured from the air, in a closed-loop system reliant only on water and electricity, enabling clients to capture, utilization, and fuel synthesis processes dramatically reduce overall energy inputs, and eliminate the need for feedstocks.	The Engine Ventures	VC
Mar-24	ZAFFRA	NLD	Developer, owner and operator of ventures producing sustainable aviation fuels intended to serve the green energy sector. The company will produce sustainable fuels derived from non-fossil feedstock, utilizing green hydrogen, sustainable sources of carbon dioxide and biomass.	TOPSOE, Sasol	JV
Feb-24	NXTCLEAN FUELS	USA	NXTCLEAN Fuels Inc is a developer and future operator of advanced biofuel refineries with a focus on renewable fuel. It is currently developing renewable fuel production projects at two locations in the State of Oregon. Through its wholly-owned subsidiary, NXT is in the process of permitting its first proposed refinery located at Port Westward, Oregon to produce renewable fuel.	sojitz	VC
Feb-24	GREENCOP	SGP	Developer of sustainable biofuel intended to reduce greenhouse gas emissions globally. The company provides novel solutions for processing various biowaste materials, including sugar cane bagasse, corn stover, and rice straw, with a non-energy-intensive pretreatment process, enabling clients to advance their sustainability journey by providing efficient and environmentally friendly fuel solutions.	Enco, KenGen	VC
Feb-24	MISSION ZERO TECHNOLOGIES	GBR	Manufacturer of a filtration device designed to capture air to remove carbon dioxide. The company's device permits bringing low-energy and clean carbon dioxide as a product, enabling consumers to work in an environment without polluted air by offering affordable carbon capture services at any scale.	2150	VC
Feb-24	KVASIR	DNK	Developer of carbon emissions technology intended to produce biofuel from non-edible biomass. The company's technology helps to eliminate carbon emissions from heavy transportation, by harnessing natural and abundant sources of biomass that do not compete with food and replicate the natural process of turning biomass into oil, enabling consumers to have climate-friendly fuel.		Seed
Feb-24	CYCLIZE	DEU	Developer of a defossilizes technology designed for chemical industry using mixed plastic waste and CO2 as feedstock to produce syngas (a gas mixture of carbon monoxide and hydrogen). The company's technology serves as the basic building block of advanced chemicals and is used to produce plastics, methanol, hydrogen, e-fuels and can be obtained through the linear use of fossil resources such as natural gas, enabling clients to use this gas to build higher-quality chemicals and achieve outcomes while minimizing reliance on fossil resources such as natural gas.	UnternehmerTUM, LVC Partners, Aurum Impact	Seed
Feb-24	BLUSHIFT	USA	Operator of an aerospace company intended to make bio-fuel powered rockets. The company engages in providing basic testbed launch vehicles, upgraded testbed vehicles, low-earth orbit (LEO) launch vehicles and other related products, enabling clients to send small satellites to space at affordable rates.	Undisclosed	Seed
Feb-24	WAGA ENERGY	FRA	Waga Energy SA is an independent biomethane producer, specialized in landfill gas upgrading into cost-competitive and grid-compliant biomethane. Equipped with unique expertise in gas engineering and patented proprietary technology, the company develops, finances, builds, commissions and operates purification units using its proprietary technology.	CMA CGM, noria	PIPE
Feb-24	astern Plantations / Knowled	IDN	Operator of a biomethane plant intended to reduce carbon emissions. The company will produce 775 m3 biogas per hour and will purify the biogas to increase the methane content.	KG Group	JV
Jan-24	noovoleum	SGP	Operator of a mobile application and collection box designed for the collection and recycling of used cooking oil. The company offers convenient collection points, credit for deposited oil, and tracking of transactions, enabling households and small businesses to dispose of used cooking oil while earning money and supporting eco-friendly practices.	Generator Advisors	Seed
Jan-24	Cyns	BRA	Operator of a biotechnology company intended to create sustainable insect-based animal nutrition. The company specializes in upcycling organic food waste using the black soldier fly into insect protein for animal feed, insect oil for biodiesel, and insect frass for farming and delivers high bioconversion rates with minimum HVAC requirements, enabling food, personal care, pet and pharmaceutical industries to promote the consumption of all-natural insect-based agricultural products while utilizing the medical benefits of insect larvae which, otherwise, are eliminated using pests.	Lambarin, Sumitomo	Seed
Jan-24	Femogas	ITA	Operator of the agricultural biomethane sector to produce renewable energy. The company is involved in managing plants to produce biogas and biomethane powered by agroforestry and renewable energy matrices.	BNL Banca Nazionale del Lavoro	PE Growth
Jan-24	Blue biofuels	USA	Manufacturer of petroleum products based in Florida. The company offers sustainable aviation fuel and renewable propane and butane as co-products from ethanol, thereby helping clients contribute significantly to reducing carbon emissions.	Blue, Vertimass	JV
Jan-24	Inherit	NOR	Provider of environmental services intended to work with biomethane facilities to become carbon removal factories. The company's services specialize in removing carbon dioxide from the atmosphere by working with organic waste facilities to harvest biogenic from the process of anaerobic digestion and then storing it underground in a geological formation, enabling businesses to utilize a durable and nature-friendly technique for carbon removal.	Farvatn venture, equinor, Arkwright, Sumitomo	Seed

Source: Stifel IRIS, Pitchbook*

FIG 106: TRANSACTIONS FROM THE LAST 18 MONTHS (3/10)

Jan-24	SpiralWave	USA	Opertor of a sustainable platform intended to remove atmospheric carbon dioxide at a giga-scale for a clean environment. The company uses plasma technology that not only removes CO2 but also fosters a circular economy and covert it into valuable methanol, helping individuals to mitigate climate change impacts and shape a cleaner and greener world through an innovative approach.	Indie Bio SOSV	Seed
Jan-24	Environment Recycling	KOR	Manufacturer of products from waste intended to transform waste materials, including waste batteries, and waste oil. The company's product exemplifies circular economy principles while offering a diverse range of offerings through various business ventures, enabling businesses to contribute to sustainable resource management and national development.	Hyundai Glovis	VC
Jan-24	FIVE BIOENERGY	ESP	Operator of a renewable energy power generation based in Madrid, Spain. The company specializes in promoting and developing renewable and sustainable energy projects and specializes in biomethane plants, providing cleaner and more sustainable energy alternatives.	Asterion Industrial	Buyout/LBO
Jan-24	norsk e-fuel	NOR	Supplier of renewable energy and fuel intended to achieve climate-neutral transportation. The company generates and distributes fuel made from carbon dioxide and water using renewable electricity and is then refined to final products.	cargolux	M&A
Jan-24	SunCHEM	NLD	Operator of an agro-technology company intended to facilitate sustainable feedstock production. The company's services specialize in producing a non-GMO crop with a high yield of seed and biomass by applying the biorefinery principle, obtaining and applying biomass suitable for biogas fermentation, and deriving biofuels for pharmaceuticals, enabling farmers and poultry operators to increase sustainability as a local source of protein for animal feed.	UPM	VC
Jan-24	INERATEC	DEU	Operator of sustainable fuels (e-fuels) and chemical product manufacturers are intended to use the power-to-X or gas-to-X process. The company's technology produces hydrogen from renewable electricity converted with greenhouse gases such as CO2 into e-kerosene by CO2-neutral diesel, synthetic waxes, methanol or SNG allows dynamic, safe, and efficient operation of exothermic and endothermic chemical reactions such as methanol synthesis, methanation, and synthesis gas generation via catalytic partial oxidation, thereby enabling chemical plant operators to have integration of the entire chemical plant in transportable containers.		VC
Jan-24	Helvetia	CHE	Provider of waste management and biofuel services based in Carouge, Switzerland. The company offers waste-management services for public spaces, as well as the recovery and processing of secondary materials for the production of biofuels, soil enhancements and recycling.	PAPREC	Corporate
Jan-24	KOKO	KEN	Operator of a climate technology company intended to transform smart fuel resources. The company offers business-to-consumer technology aimed at the urban cooking fuel market that leverages existing downstream oil infrastructure to deliver new liquid cooking, enabling customers to lead towards sustainable energy without polluting the environment.	Maersk, The Footprint Firm, EIFO	VC
Jan-24	CHAT Biometano	ITA	Operator of biomethane plants for energy use based in Verona, Italy. The company's services include valorizing agricultural areas and sustainable development, producing biomethane, enabling development for investors and society, and enhancing biomethane plants and biomass.	Suma Capital	Buyout/LBO
Jan-24	Resynergi	USA	Manufacturer of biorefining technology systems intended to convert traditionally non-recyclable plastics into fuel and chemical products. The company's microwave-based system transforms unrecycled waste plastic into biodiesel from a broadened range of feedstocks, enabling clients to avail low carbon-intensity fuels extracted from waste.	Lummus Technology, Transitions First	VC
Jan-24	Green Plains Partners LP	USA	Green Plains Partners LP is operational in the United States energy sector. Through its subsidiary, it was formed to assist its parent company in the business of fuel, especially ethanol storage and transportation. The company acquires ethanol storage tanks, terminals, transportation, and other related assets essential for its activities. Its Partners generate a substantial portion of its revenues under fee-based commercial agreements for receiving, storing, transferring, and transporting ethanol and other fuels.	Green Plains	M&A
Jan-24	CIELO	CAN	Cielo Waste Solutions Corp is a Canada-based company principally engaged in the business of refining municipal and construction waste into high-grade renewable fuels. Its technologies are focused on materials recovery, renewable diesel, and landfill reduction through responsible diversion practices. The business operations of the company are carried out in Canada and the United States.	Undisclosed	PIPE
Jan-24	OCTAVIA CARBON	KEN	Developer of direct air carbon capture technology designed to filter carbon dioxide directly from the air. The company's technology filters carbon dioxide directly from the air, which can then be turned into rocks underground, or used as an industrial gas to replace dirty fossil carbon dioxide, enabling industrial power users with renewable power and helping them fight against energy poverty in East Africa.	Renew Capital	VC
Jan-24	biogy	FRA	Provider of agricultural mechanization service intended to produce biomethane. The company specializes in valorizing agricultural and agri-food co-products, thereby producing green, renewable, local, and non-relocatable agricultural that replace fossil fuels.	enowe, TempoCap, Meridiam	Buyout/LBO
Jan-24	CARBON AMS	IRL	Operator of anaerobic digestion (AD) plants intended for converting grass to renewable gas. The company's pioneering bio-nutrient ecosystem ensures quality biomethane, nutrient-rich bio-fertilizer, and improved biodiversity, delivering feedstock growers, rural economies, energy consumers, and the environment, enabling farming families with a sustainable income source and the potential to realize value from carbon buildup on their farms.	BVP Business Venture Partners	VC
Jan-24	DELTA OIL	EGY	Provider of used cooking oil recycling services intended to reduce the environmental impact caused by to disposal of cooking oil. The company's services include a collection of used cooking oil from a network of collection points of small shops and independent collectors in exchange for goods, enabling the biodiesel industry to recycle the used cooking oil into biodiesel for consumption purposes.	DEN VC	VC
Jan-24	NEW ERA Energy	GBR	Distributor of fuels and lubricants intended to serve fleet, commercial, plant, machinery, agricultural and marine applications. The company offers HVO fuel, lubricants, kerosene, industrial heating oil, pumps and hoses, thereby providing a nationwide, next-day tracked delivery service whilst using the latest technology to ensure accuracy and punctuality.	Hanover Investors	PE Growth
Dec-23	SK eco prime	KOR	Manufacturer of biodiesel and biofuel oil intended to serve the transport and power generation sectors. The company produces biodiesel with ingredients such as the by-products of palm oil extraction and refining as well as bio-heavy oil made of by-products from biodiesel processing, animal fats and food waste oil, thereby providing cost-effective products that reduce greenhouse gas emissions.	Hillhouse Capital	Buyout/LBO
Dec-23	Splight	USA	Developer of innovative energy systems designed to revolutionize the sector with tools for stakeholders, optimizing resources and ensuring sustainability. The company's platform utilizes artificial intelligence and energy advancements to build a collaborative ecosystem to transition to a cleaner, sustainable energy landscape, enabling businesses to optimize energy operations, and have minimal environmental impact.	Draper B1, Savia, Fen Ventures	VC
Dec-23	ECOIL	IND	Operator of an oil recycling company intended to offer biodiesel fuels. The company collects used cooking oil from restaurants and turns it into biodiesel to reduce waste, enabling users to generate sustainable energy by proper disposal and recycling of agricultural wastes and reducing the environmental effect.	Shell Energy	Seed
Dec-23	Reneron.	LTU	Operator of a renewable energy company based in Vilnius, Lithuania. The company is focused on biogas and biomethane business development and operations, thereby sustainably treating organic wastes and converting them to green energy and organic biofertilizers.	Vitol	M&A
Dec-23	UNIVERSAL FUEL TECHNOLOGIES	USA	Developer of sustainable fuel technology designed to make sustainable aviation fuel, gasoline, liquefied petroleum gas from alcohols, renewable naphtha, and light olefins. The company's technology converts various feeds into drop-in fuels or petrochemicals, depending on which, products can be fully or partially renewable, thus allowing the operator to manage the speed of their energy transition.	Undisclosed	Seed
Dec-23	USD PARTNERS	USA	Operator of a Colton rail terminal based in Houston, Texas. The company provides sustainable fuel distribution services.	Undisclosed	M&A

Source: Stifel IRIS, Pitchbook*

FIG 107: TRANSACTIONS FROM THE LAST 18 MONTHS (4/10)

Dec-23	cropenergies	DEU	CropEnergies AG is a German company which manufactures bioethanol for the fuel sector from cereals and sugar beet. The company also produces various food and animal feed products such as ProtiWanze, a liquid protein animal feed for feeding ruminants and pigs, as well as a high-grade dry stillage protein animal feed. In addition, it produces neutral alcohol for the beverage, food, cosmetics and pharmaceutical industries, as well as for industrial applications, such as the production of windscreen washer fluid and disinfectants.	SÜDZUCKER GROUP	M&A
Dec-23	Aether Fuels	SGP	Developer of sustainable fuel technology designed to decarbonize aviation and ocean shipping. The company offers technologies that enable the scalable and economical production of sustainable fuels from waste biomass and biogenic carbon dioxide, enabling clients to produce sustainable fuels that are practical, economical, and scalable.	ventures, DORAL TechEnergy, XORA	Seed
Dec-23	OORJA	IND	Operator of farming as a service company intended to power rural livelihoods in emerging markets. The company finances, installs, operates, and maintains solar energy systems, provide irrigation facilities, and also produces biofuel from agricultural plant waste and powers off-grid villages in rural India, enabling consumers to displace fossil fuels, reducing carbon emissions, and improving the lives of people.	Undisclosed logos	VC
Dec-23	TITAN	NLD	Provider of liquefied natural gas (LNG) and liquefied biomethane (LBM) intended to serve marine and industrial sectors. The company offers bunkering services, supply and distribution, stationary installation, pricing, sourcing, trading, cooldown and commissioning services, thereby enabling clients with low-carbon and carbon-neutral marine fuels as per their requirements.	MOL GAS	Corporate
Dec-23	SEABOUND	GBR	Developer of carbon capture systems platform designed to reduce CO2 emissions in cargo ships. The company's technology fits onto existing ships and other cargo ships where an onboard device traps emissions from a ship's exhaust and stores their carbon in solid form and later sold for utilization or sequestration, enabling ships to reduce the greenhouse gas emission and pollution caused.	LEAP FORWARD VENTURES, COLLABORATIVE Fund	VC
Dec-23	HutanBio	GBR	Operator of a biotech company intended to provide sustainable algae biofuels. The company develops a low-carbon, scalable, and drop-in replacement fuel through its algal farms, enabling clients from the marine, land, and aviation sectors to lower their emissions and meet environmental norms.	CLEAN GROWTH FUND	Seed
Dec-23		CAN	Developer of a spacecraft docking system designed to conquer the challenges and expense of transporting, accessing, and re-fueling in space. The company's docking mechanism offer solutions in the fields of In-space refueling with sustainable fueling stations that can be an essential part of space exploration, enabling spacecraft to reach further destinations and travel longer distances, reducing the cost of space missions and eliminating the launch of new spacecraft and reducing the environmental impact by building in space, sustainable refueling infrastructure for satellites, rockets and orbital transfer vehicles.	10X CAPITAL	Seed
Nov-23	L&L ENERGY FROM PLANET	ITA	Portfolio of two biomethane plants based in Italy. The project involves the construction of physical distributors of biofuels, which will be fed with biomethane introduced into the network by the plants and taken back from the network by the distributors.	green arrow CAPITAL The Alternatives Platform	Buyout/LBO
Nov-23	SKYNRG	NLD	Producer of sustainable aviation fuel developed to help the airline industry meet its net-zero commitment. The company sources, blends, distributes and guarantees sustainability throughout the supply chain while also developing regional SAF supply chains, enabling the aviation industry to have sustainable and affordable alternatives to fossil fuels thereby reducing the lifecycle carbon dioxide emissions.	MACQUARIE	PE Growth
Nov-23	CarbonCapture	GBR	Provider of carbon removal and storage services intended to capture biogenic carbon dioxide (CO2) emissions. The company specializes in the capturing and removal of CO2 produced from organic processes such as whisky fermentation and uses it for social benefits, thus enabling global companies including distillers, energy-from-waste (EFW) firms and biomethane plants to achieve net zero targets effectively.	iona capital	PE Growth
Nov-23	DG FUELS	USA	Producer of renewable hydrogen and biogenic-based, synthetic emissions aviation and diesel fuel intended for aircraft. The company's manufacturing process only uses cellulosic biomass in the form of agricultural waste and renewable power for water electrolysis generated hydrogen and oxygen feedstock, helping clients to reduce lifecycle greenhouse gas emissions.	AIRFRANCEKLM GROUP	Corporate
Nov-23	BANYU CARBON	USA	Developer of a carbon removal technology powered by light designed to capture carbon dioxide from seawater. The company's process uses the surface ocean as a vast collector for atmospheric CO2 and then removes the accumulated carbon through energy-efficient photochemical reactions, seawater naturally concentrates carbon dioxide from the atmosphere, enabling the power generation industry and other industries with high carbon emissions to achieve their climate goals.	Carbon Removal Partners, PROPELLER, Neglected Climate Opportunities, UNITED AIRLINES VENTURES, Grantham Foundation, ReGen ventures	Seed
Nov-23	talus	USA	Developer of green ammonia system technology intended to provide a renewable energy infrastructure. The company engages in generating lower-cost, carbon-free ammonia eliminating supply chain length for agriculture, mining, and industrials, with additional applications in maritime shipping, renewable energy storage, and power generation, providing industries with cheaper, cleaner, and more reliable raw materials.	XORA, RICE	VC
Nov-23	DAH Gruppe	DEU	Operator of an agriculture and energy company intended to generate gas, electricity, and heat from renewable energy sources. The company operates a biogas plant, developing photovoltaic projects, and energy generated in the form of electricity, heat, cold, and biomethane supplies companies and households.	igneo Infrastructure Partners	Buyout/LBO
Nov-23	PLASMALEAP Technologies	AUS	Developer of ammonia & e-fuel technology designed for the synthesis of green fuels and chemicals. The company specializes in developing zero-emissions chemical reactors for reaction pathways capable of synthesizing zero-emissions ammonia and hydrocarbon e-fuels the technology replaces fossil fuels with new green chemicals and cleans hazardous industrial waste, providing industries with technological keys for industrial problems and supports a sustainable environment.	Hudson Land Trust, WILSON INVESTMENT PROPERTIES, McCarty Capital	VC
Oct-23	NJORD OFFSHORE	SWE	Provider of energy production services based out of Sweden. The company offers wind power production, wind power development and hydrogen & e-fuel solutions.	Statkraft	M&A
Oct-23	AZANE Fuel Solutions	NOR	Developer of ship bunkering infrastructure technology based in Oslo, Norway. The company's platform, in collaboration with leading project consortium partners, is building the first units in an ammonia fuel bunkering network, realizing a complete green ammonia fuel value chain from production to consumption, enabling the shipping industry to transition towards more sustainable fuel options.	NAVIGATOR GAS, Yara Growth Ventures	VC
Oct-23	LIQUIDPISTON	USA	Manufacturer of advanced rotary internal combustion engines intended for unmanned aerial vehicles and the automotive industry. The company's technology has different thermodynamic cycles, architecture, and operations that make engines smaller and lighter than traditional diesel engines, providing customers with compact, efficient, low-vibration, and multi-fuel capable combustion engines.	Undisclosed	VC
Oct-23	Silva Green Fuel	NOR	Producer of biofuels catering to the green energy industry. The company develops advanced biofuel to replace fossil fuels and contribute towards the decarbonization of the transport sector, thereby producing from residual raw material from the forest providing a reduction in emissions of up to 95 percent.	Statkraft	M&A
Oct-23	azure	CAN	Developer of a renewable fuel production facility intended to provide a significant source of Sustainable Aviation Fuel (SAF). The Company is focused on a modularized design utilizing commercially proven technology, allowing for efficiencies in both growth opportunities and expansions, enabling the aviation sector to meet current domestic and international mandates related to the reduction of CO2(carbon dioxide) emissions	Undisclosed	Seed
Oct-23	RENFUEL LIGNIN BIO OILS & MATERIALS	SWE	Manufacturer of lignin-based bioproducts and plastics intended to replace finite fossil fuels with sustainable biogasoline and biodiesel. The company utilizes a patented catalytical technology that converts forest lignin found in all trees and plants into different types of materials and bio-oils, thereby enabling the bioenergy and biomaterials sectors to convert their petrol and diesel vehicles to environmentally friendly cars	comstock	Corporate
Oct-23	AESSEAL-Torishima Japan	JPN	Provider of mechanical seals and sealing support systems intended for automotive, biofuels, chemical and pharmaceutical, food and beverage, marine, metal processing and other industries. The company's product portfolio includes mechanical seals, bearing protectors, seal support systems and packing products as well as offers services including inventory management, engineer call-out, training, water-saving audits, repair and replacement services.	AESSEAL, TORISHIMA	JV

Source: Stifel IRIS, Pitchbook*

FIG 108: TRANSACTIONS FROM THE LAST 18 MONTHS (5/10)

Oct-23	Alvus	ITA	Provider of biomethane-related services intended to ensure eco-sustainable energy production. The company offers technology solutions for plants fed with agricultural byproducts, consulting services related to biomethane such as due diligence analysis, business plan verification, site selection, biomass research, choice of power supply plan, selection of the most suitable technology and more, thereby helping clients transform a good idea into a biomethane project	VORN BIOENERGY	M&A
Oct-23	Maabjerg Energy Center	DNK	A planned second-generation bioethanol plant in Western Jutland, Denmark. The plant will annually produce 80 million liters of bioethanol, ca. 50 million cubic meters of biogas and generate at least 1,000 permanent jobs.	CIP	Buyout/LBO
Oct-23	Arcadia eFuels	USA	Producer of eFuels intended to protect the environment and produce power. The company's fuels include diesel and jet fuels that are produced using renewable electricity and water to produce Green Hydrogen and combine with captured carbon using proven technology, thereby enabling energy industries to transition to no carbon emissions and meet market demands.	KGAL	PE Growth
Oct-23	SGP BioEnergy	USA	Developer of bioenergy products intended to produce more renewable products. The company develops scalable, affordable and flexible ways of producing renewable products, power and fuel, enabling clients to make a sustainable future and address climate change.	gem global emerging markets	PE Growth
Oct-23	CNF CARBON NEUTRAL FUELS	GBR	Operator of a technology integrator e-fuel production system intended to accelerate the world's transition to sustainable energy systems. The company uses carbon removal technologies to sequester atmospheric carbon dioxide, which combined with clean hydrogen produces sustainable fuels, enabling industries to deploy sustainable fuels which will drive a significant reduction in emissions.	SFC Capital	VC
Oct-23	galdieria	JPN	Developer of microalgae technology designed to improve the recycling rate of precious metals. The company's microalgae aim to produce high-quality and low-cost biofuels which will reduce dependence on fossil fuels and offers valuable metal recovery and environmental purification, enabling clients to avail of sustainable and eco-friendly alternative to fuel.	MIYAKO CAPITAL	VC
Oct-23	metafuels	CHE	Developer of sustainable aviation fuel technology intended to provide affordable air travel. The company's technology provides a route to large-scale production of e-kerosene, with high SAF selectivity and yields, overcoming the scale-up challenges and high costs of alternative routes, helping the aviation industry reach net zero emissions, and helping them reduce their carbon footprint.	Contrarian Ventures, ENERGY IMPACT PARTNERS	VC
Oct-23	WayTrade	USA	Developer of marketplace platform designed for renewable fuels. The company provides on-premise mobile fueling options for transportation, construction, agriculture, rail, data centers, and aviation, enabling acceleration of the global transition to a low-carbon future.	SILENCE	Seed
Oct-23	Laniakia	KOR	Provider of sustainable air mobility service intended to keep the planet safe. The company offers eco-friendly aviation that protects the skies for all of us through the use of sustainable aviation fuel SAF, the gradual introduction of electric airplanes, and investment in carbon reduction non-profit projects, enabling people to avail sustainable air mobility.	BLUEPOINT	Seed
Oct-23	Votion	SWE	Operator of biorefineries technology development company intended to reverse global warming for the mobile society. The company offers to produce advanced biofuels, sustainable aviation fuel (SAF) and specialty biochemicals, enabling clients to get energy services.	SUSTAINABLE ENERGY ANGELS	Seed
Sep-23	FUTURE FUELS	NLD	Manufacturer of sustainable fuel intended to serve the throughout the Netherlands. The company manufactures hydrotreated vegetable oil, renewable diesel, blue diesel and fossil fuels along with supplying various technical materials like hoses, nozzles, tanks and filters.	Comfort energy	M&A
Sep-23	Elyse	FRA	Operator of an energy industrial company intended for the production of low-carbon molecules. The company designs, develops, finances, builds, and operates low-carbon molecule production plants and sustainable aviation fuel production plants, enabling industrialists, maritime operators, and airlines to support energy transition and decarbonization.	H24, mirova	VC
Sep-23	High Plains	USA	Operator of a bio diesel plant based out in Las Vegas, New Mexico.	bp	JV
Sep-23	Greenda	KOR	Developer of recycled fuel technology intended to produce raw materials from food waste. The company practices resource circulation by recycling by-products and producing them as insect feed and various plastic raw materials for biodiesel and bio-jet fuel from food waste through food waste and patented technology, enabling industries to reduce carbon emissions and contribute to eco-friendliness.	STAR VENTURES, SK securities, ORACLE VC, infobank	Seed
Sep-23	OCTAVIA CARBON	KEN	Developer of direct air carbon capture technology designed to filter carbon dioxide directly from the air. The company's technology filters carbon dioxide directly from the air, which can then be turned into rocks underground, or used as an industrial gas to replace dirty fossil carbon dioxide, enabling industrial power users with renewable power and helping them fight against energy poverty in East Africa.	CATALYST FUND, SHARED FUTURE FUND	Seed
Sep-23	al Services / Green Solution	SAU	Provider of alternative fuel from waste and market catering to locally and globally.		JV
Sep-23	General Galactic	ITA	Operator of a low capex distributed system intended for renewable fuel. The company is currently operating in stealth mode.		VC
Aug-23	FLYORO	SGP	Developer of sustainable aviation blending technology designed to offer on-demand sustainable aviation fuel blending (SAF), flexibility in blended production, and a robust supply chain. The company offers asset-light modular manufacturing technologies that tap into the jet fuel logistic network making sustainable aviation fuel easily available to airlines directly at airports, enabling clients to curb the carbon dioxide emissions from flights.	AUDACY VENTURES, she1K, investible	Seed
Aug-23	ECOSolutions	KOR	Producer of alternate fuel focused on preserving nature. The company engages in converting waste cooking oil into biodiesel.		Buyout/LBO
Aug-23	nordsol	NLD	Developer of a liquified biomethane technology designed to reduce the fuel industry's carbon footprint. The company's technology takes over the additional function of flash gas and boil-off gas compressor, heat exchange at a relatively high temperature, therefore, less sensitive to freeze-out of trace contaminants and the treated biogas can be used as a refrigerant in the methane-expansion cooling cycle, enabling clients to produce and trade fuels at a competitive cost with a pathway to net-zero emissions.	ROM Utrecht Region, Shell Ventures	VC
Aug-23	BluH ENERGY	ITA	Operator of an alternative green investment platform based in Assago, Italy. The company specializes in the biomethane and green hydrogen sector across the fields of asset management and origination designed to provide net-zero emissions for national energy security.	abrdn	PE Growth
Aug-23	Licella	AUS	Developer of hydrothermal upgrading systems designed to facilitate the production of advanced biofuels. The company's systems offer a catalytic hydrothermal reactor that can convert various residues, waste and non-edible biomass, end-of-life plastic, used lubrication oil and lignite into a stable bio-crude or synthetic crude oil, enabling businesses to produce advanced biofuels and renewable chemicals.	Mondelēz International, amcor	VC
Aug-23	NHP	JPN	Developer of food processing technology intended to shorten the food fermentation process without using any chemicals. The company powder and liquid raw materials that break molecular bonds such as dietary fiber, carbohydrates, and proteins to reduce the molecular weight, enabling clients to brew and ferment products with low environmental load and a small amount of power and gas.	大和企業投資, アグリビジネス, MUFG	VC
Aug-23	Yield10	USA	Yield10 Bioscience Inc is an agricultural bioscience company. It is leveraging advanced genetics to develop the oilseed Camelina sativa as a platform crop for large-scale production of sustainable seed products. These seed products include feedstock oils for renewable diesel and sustainable aviation biofuels; omega-3 (EPA and DHA+EPA) oils for pharmaceutical, nutraceutical and aquafeed applications; and, in the future, PHA bioplastics for use as biodegradable bioplastics.	Undisclosed	PIPE
Aug-23	ZYMOBIOTECH	CHN	Developer of green synthetic biomanufacturing designed for multiple industries. The company offers industrial cell factories to produce biofuels and biomaterials using sustainable non-food feedstocks such as lignocellulosic biomass and waste starches in the fields of systems biology, metabolic engineering, and synthetic biology, enabling the usage zymomonas mobilis with many industrial fermentation advantages as the chassis cells.	HC, 凯风创投	VC

Source: Stifel IRIS, Pitchbook*

FIG 109: TRANSACTIONS FROM THE LAST 18 MONTHS (6/10)

Aug-23	LUPROMAX	IDN	PT Lupromax Pelumas Indonesia Tbk is engaged in Wholesale Trading of Solid, Liquid and Gas Fuels and YBDI Products. This group includes wholesale trading of gas, liquid and solid fuels and similar products, such as crude oil, diesel fuel, gasoline, fuel oil, kerosene, premium, diesel, kerosene, coal, charcoal, coke, wood fuel, naphtha, biofuels and other fuels including gaseous fuels (LPG, butane and propane gas, etc.) and polishing oils, lubricating oils and refined petroleum products, as well as nuclear fuel.	Undisclosed	IPO
Aug-23	proweps	DEU	Provider of technical solutions around the recycling of municipal, industrial and agricultural organic waste and biomass, based in Esslingen, Germany. The company offers anaerobic digestion, biomethane production, waste recycling and plant optimization services as well as consulting and engineering services.	gps	M&A
Aug-23	CARBONWAVE	USA	Manufacturer of plant-based biomaterials intended to enhance biodiversity in seas and soils. The company collects, processes, and grows seaweed profitably at scale, turning seaweed into ultra-sustainable materials that heal the planet and transition to an oil-free future, enabling users to harvest and process biostimulants and natural fertilizers that will expand to grow kelp on a massive scale.		VC
Aug-23	Synthica	USA	Developer of a renewable natural gas-producing facility designed to divert food waste from non-sustainable outlets intended to remove carbon dioxide from the atmosphere. The company focuses on developing food waste-based organics-to-energy facilities, organic by-products, brewery washouts and many other wastes, at a competitive price to produce biogas, thereby providing commercial power plants and pipeline injection customers with food waste renewable natural gas.	Goldman Sachs Asset Management	PE Growth
Aug-23		ESP	Developer of plant-based photobioreactor intended to generate clean energy. The company develops, produces and markets novel products derived from microalgae-nutritional, agricultural bacteria and mosses, thereby enabling businesses through the production of biofuels.	SOFIPROTEOL, DE SANGOSSE	Buyout/LBO
Aug-23	MASH MAKES	DNK	Operator of carbon removal and biofuel production company intended to burn sewage sludge and manufacture bio-oil. The company's technology specializes in taking waste resources and turning them into sustainable commodities such as electricity, biofuels, hydrogen, and biochar, enabling clients to acquire commodities at a price similar to that of traditional energy and material products and production of carbon-negative energy commodities at a large scale and low cost.	NORDEN	VC
Aug-23	SUNCOAL	DEU	Operator of a waste-renewal company intended to offer facilities to produce synthetic coal from bio-waste. The company's platform develops, builds, and operates plants that refine organic waste into a proprietary biofuel, enabling users to generate an alternative source of energy from waste.		M&A
Jul-23	DG FUELS	USA	Producer of renewable hydrogen and biogenic-based, synthetic emissions aviation and diesel fuel intended for aircraft. The company's manufacturing process only uses cellulosic biomass in the form of agricultural waste and renewable power for water electrolysis generated hydrogen and oxygen feedstock, helping clients to reduce lifecycle greenhouse gas emissions.	AIRBUS GROUP	Corporate
Jul-23	RAVEN	USA	Developer of waste conversion technology intended to create environmentally friendly, efficient and clean hydrogen and synthetic fuels. The company's technology transforms biomass, municipal solid waste, bio-solids, industrial, sewage, medical waste and natural gas into hydrogen, sulfur and nitrogen-free liquid fuels, additives, solvents and electricity, thereby providing clean technology to convert waste into renewable fuels and energy.	RockCreek	PE Growth
Jul-23	NOVAPANGAEA TECHNOLOGIES	GBR	Developer of biomass conversion technology designed to convert plant residues to biofuels, biochemicals, and biopolymers. The company utilizes the plant residues left after extraction of the food or other primary products, and generates the highest possible yield of biofuels and biochemicals from plant biomass, enabling clients to access highly efficient, reliable, clean, and adaptable, producing biochemicals and biofuels.	mercia, par equity, IAG	VC
Jul-23	ETFUELS	IRL	Operator of an energy platform intended to unleash the full potential of renewable energy at scale. The company's platform offers a new model to disrupt current approaches to decarbonization and provide a pathway to energy security, enabling clients to easily decarbonize their economies and supply chains.	EXF, SWEN	PE Growth
Jul-23	WASTEFUEL	USA	Producer of renewable fuels intended to address the climate emergency and revolutionize mobility. The company utilizes proven, scalable technologies to convert municipal and agricultural waste into low-carbon fuels including green methanol, enabling industries with sustainable fuel that complies with industry standards.	bp ventures, MAERSK	VC
Jul-23	Carbon America	USA	Developer of carbon capture and sequestration technology intended to capture and sequester as much carbon dioxide as possible. The company's technology serves in capturing billions of metric tons of carbon dioxide from industrial sources annually and provides a multi-strategy approach to sequester carbon dioxide in a cheaper way, enabling clients to reduce carbon emissions and counter global warming.	ENERGY IMPACT PARTNERS	VC
Jul-23	REGAENERGY Renewable Gas Solutions	PRT	Provider of biomethane and green hydrogen to cement, glass, ceramics, chemicals and steel industries. The company develops, finances, builds, owns and operates plants, helping heavy industries decarbonize through direct delivery or renewable gas purchase agreements.	SWEN Capital Partners	PE Growth
Jul-23	MC	USA	Provider of a low-cost, scalable green hydrogen and syngas system intended to commercialize a thermochemical process for the production of green hydrogen. The company's products are competitive with conventional, polluting methods with lower operating and construction costs than electrolysis, and also offer green hydrogen efficiently, at process-relevant pressures, with zero emissions, and also build off existing thermochemical processes, enabling users to allow for efficient scaling and economies of scale.	SUSQUEHANNA	Seed
Jul-23	LBG AB	SWE	Operater of a biogas upgrading plant based in Gothenburg, Sweden. The company focuses on developing and operating the production and processes concerning sustainable renewable vehicle gas and produces biogas from organic waste streams.	Gasum	M&A
Jul-23	Golden Arrow	NLD	Supplier of renewable bunkers that lower emissions and replace fossil fuels intended for all shipowners, charterers and operators. The company offers various grades and blends of bio bunkers and a comprehensive portfolio of both fossil and sustainable marine fuel blends at competitive prices and provides you with the tools you need to compensate for your carbon footprint and reduce your emissions.	ACT, Bridgepoint	Buyout/LBO
Jul-23	TAGADDOD	EGY	Operator of a renewable energy company intended to empower communities and businesses to build sustainable impact and income through waste management. The company specializes in the production of renewable energy, green fuels and bio-diesel which are made from wind, solar energy, natural underground heat and clean fuels, enabling clients to get sustainable and clean energies while reducing environmental pollution.	A15	VC
Jun-23	azure	CAN	Developer of a renewable fuel production facility intended to provide a significant source of Sustainable Aviation Fuel (SAF). The Company is focused on a modularized design utilizing commercially proven technology, allowing for efficiencies in both growth opportunities and expansions, enabling the aviation sector to meet current domestic and international mandates related to the reduction of CO_2(carbon dioxide) emissions	Undisclosed	VC
Jun-23	WASTEFUEL	USA	Producer of renewable fuels intended to address the climate emergency and revolutionize mobility. The company utilizes proven, scalable technologies to convert municipal and agricultural waste into low-carbon fuels including green methanol, enabling industries with sustainable fuel that complies with industry standards.	bp ventures, NET ZERO, NETJETS, MAERSK	VC
Jun-23	Lyxia Sun Sea Sustenance	CHN	Provider of bio-technology platform to harness the prolific bio-fuel yield from micro-algae. The company provides a platform to cultivate microalgae and cyano-bacteria in order to harness the prolific products including hydrocarbon-based biofuel, feedstock and high-value byproduct.	Hotchip Capital, 番茄资本	VC
Jun-23	POLYVENTIVE	USA	Manufacturer of polymer chemicals intended to offer specialty construction and textile chemical products. The company engages in the production of environmentally safe chemicals, oils, and adhesives used in the oil and gas, pulp and paper, construction, agro and electronics protection industries, enabling clients to operate efficiently.	Undisclosed	M&A
Jun-23	St. Bernard Renewables	USA	Operator of biorefinery intended to support growing demand for low-carbon fuels. The company produce reneweable resources, mainly hydrotreated vegetable oil, commonly known as renewable diesel, that enable to contribute to diversified sources of energy for the global mix while lowering the carbon intensity of the operations and the products manufactured.	eni, PBF	JV

Source: Stifel IRIS, Pitchbook*

FIG 110: TRANSACTIONS FROM THE LAST 18 MONTHS (7/10)

Jun-23	CARBON RECYCLING INTERNATIONAL	ISL	Producer of renewable methanol intended to develop transformative projects creating valuable products from waste gases and renewable energy. The company's renewable methanol is produced from carbon dioxide, hydrogen, and electricity for energy storage, fuel applications, and efficiency enhancement, enabling users to produce renewable methanol from carbon dioxide and hydrogen, for more sustainable fuels, chemicals, and products.	equinor, SJÓVÁ, GILDI	VC
Jun-23	Renewable Energy Services	NLD	Provider of renewable energy services intended to reduce carbon emissions and promote sustainability. The company offers biomethane from various decentralized production facilities through market knowledge, providing liquidity and tailoring services, enabling its clients to avail of renewable energy.	VARO, The Carlyle Group	Buyout/LBO
Jun-23	ECO OIL	VNM	Operator of waste treatment and disposal facility intended to create a sustainable environment through recycled energy. The company engages in the collection of waste material such as used waste or used cooking oil to convert it into biofuel, enabling businesses to turn waste into resources and contribute to a circular economy.	ANTLER, theventures	Seed
Jun-23	energielenker	DEU	Biogas and biomethane energy platform operating across Northeast Germany. The asset includes a 60 megawatts portfolio of 35 biogas plants and 10 biomethane plants.	Partners Group	Buyout/LBO
Jun-23	energielenker solutions	DEU	Operator of a biogas and biomethane energy platform based in Germany. The company produces CO_2 - neutral energy in the form of biogas, heat and electricity along with marketing biomethane as well as offers supplementary services such as biology, monitoring and energy services for operators of biogas plants.	Partners Group	Buyout/LBO
Jun-23	C2 ICODOS	DEU	Producer of (electricity) e-methanol production technology intended to de-fossilize the shipping and chemical industries with a patented technology for the production of e-methanol. The company's e-methanol production is reshaping the landscape for the decarbonization of the chemical and shipping industries, through a patented hybrid process, it has created a platform for step-change e-methanol production, resulting in more efficient CO_2 capture and reduced operating costs, thereby enabling industries with scalable, low-cost, and highly robust green methanol.	Katapult Ocean	VC
Jun-23	Libra CO2 Storage Solutions	USA	Operator of a carbon dioxide sequestration project intended for industries and governments. The joint venture specializes in the operation, design and implementation to capture and store atmospheric carbon dioxide deep underground, enabling its clients to achieve their climate goals.	Lapis, Denbury	JV
Jun-23	TEKAT	GBR	Manufacturer of industrial chemicals Specializing in fuel additives. The company is engaged in manufacturing of engine additives, heating oil, additives, components and Biofuels.	TRIBORON	M&A
Jun-23	AMOGY	USA	Provider of emission-free, high-energy-density power fuel technology intended to focus on the decarbonization of transportation. The company's technology substantially increases energy density, and provides renewable fuel with zero carbon emission during the operation at an affordable cost, enabling the transportation industry to use emission-free mobility applications using ammonia as a fuel.	Marunouchi Capital, PLUGANDPLAY	VC
Jun-23	Ash Creek Renewables	USA	Operator of a renewable feedstock supply platform designed to provide low carbon intensity feedstocks to the biomass diesel and sustainable aviation fuel industries. The company provides renewable fuel feedstock marketing and aggregation services to the biomass diesel and sustainable aviation fuel industries.	TAILWATER CAPITAL	PE Growth
Jun-23	ESTUAIRE	FRA	Developer of environmental impact and decarbonization metrics software intended for the aviation sector. The company offers a holistic carbon accounting approach, including contrails and aircraft lifecycle impact assessment, enabling lessors, airlines, and carbon calculators to diagnose and improve the impact of climate change.	XAnge, Siparex XAnge Venture	VC
Jun-23	HYCO1	USA	Operator of a carbon conversion and utilization company intended to turn CO_2 emissions into high-value, sustainable products. The company works with commercial and industrial point-source emitters to cost-effectively convert waste into purity streams of building-block chemical gases and later convert them into low-carbon chemicals, enabling clients to reduce their emissions and get benefits from the processed products.	Undisclosed	Corporate
Jun-23	SAND TO GREEN	FRA	Developer of an agroforestry technology designed to rehabilitate arid lands into a useful orchard. The company's technology includes deploying endemic agro-forestry plantations and using solar desalination and carbon offset mechanisms for fruit and biofuel plantations irrigated by desalination of seawater, enabling customers to have sustainable and healthy plantations as food products.	CATALYST FUND, Katapult	Seed
Jun-23	WATERWHELM	GBR	Developer of a self-sustaining wastewater treatment system designed to generate electricity or biodiesel. The company offers technology for self-powered wastewater treatment that uses sewage to create freshwater, renewable energy, and fertilizer, enabling customers to use recovered sludge water for effective transportation and water management.	Dunelm	VC
May-23	Nopetro Energy	USA	Operator of an investment platform intended to build and operate renewable energy infrastructure. The company focuses on the construction of renewable natural gas (RNG) and biofuel infrastructure.	Nopetro, NOVA Infrastructure	JV
May-23	CLEANJOULE	USA	Manufacturer of sustainable aviation fuels (SAF) committed to creating a sustainable planet, reducing global carbon emissions and combatting climate change. The company specializes in producing eco-friendly fuels and renewable bio-rubber from biomass that can be used in various consumer and commercial products, enabling the aviation sector to get sustainable fuel for emission-efficient functioning.	Clearhill Partners, GenZero, FRONTIER, WIZZ, Volaris, IndiGo	PE Growth
May-23	SAF One	ARE	Operator of a platform based in Dubai, United Arab Emirates. The company is focused on delivering sustainable aviation fuels (SAF) to the global aviation industry, thereby enabling reduction in carbon emissions and promotion of more sustainable future for aviation.	SENRIC, NOVUS AVIATION CAPITAL	JV
May-23	MASH MAKES	DNK	Operator of carbon removal and biofuel production company intended to burn sewage sludge and manufacture bio-oil. The company's technology specializes in taking waste resources and turning them into sustainable commodities such as electricity, biofuels, hydrogen, and biochar, enabling clients to acquire commodities at a price similar to that of traditional energy and material products and production of carbon-negative energy commodities at a large scale and low cost.	FUTURE FIVE	VC
May-23	OXCCU	GBR	Developer of renewable energy technology designed to deliver a circular economy for fuels, chemicals, and plastics. The company's technology combines carbon dioxide from the air with hydrogen from water and renewable electricity to make fuels, chemicals, and biodegradable plastics, enabling clients to use sustainable products.		VC
May-23	ReFuels	NLD	Refuels NV operates as a renewable biomethane supplier for decarbonizing heavy goods vehicles. The company is rolling out a network of stations offering renewable biomethane fuels to heavy goods vehicles, with hydrogen and electricity to be added.	Undisclosed	IPO
May-23	DELTALYS	FRA	Operator of a biogas purification system intended to offer optimization of gas production. The company improves industrial installations gas production including renewable gas such as biogas, biomethane, and natural gas synthesis, assisting producers and operators of renewable gas recovery units to sustainably improve the profitability and environmental performance of their units, enabling an economy to contribute to the use of biogas while promoting local employment.	SIPAREX, TILT CAPITAL, SWEN	VC
May-23	ENSYN	CAN	Producer of bio-crude from the forest and agricultural residues intended to offer sustainable energy. The company's bio-crude is produced by converting the residual non-food biomass from the forest and agricultural sectors and is suitable for heating and cooling applications and further upgrading in existing oil refineries to low-carbon transportation fuels, enabling companies to use cost-efficient biofuel.	bdc	VC
May-23	CARBON CENTRIC	NOR	Provider of carbon-capturing services intended to help businesses in reducing their carbon emissions. The company offers a complete carbon capture service that includes designing, handling applications, installing, operating, and storing CO_2, enabling businesses to manage their carbon emissions.	Obligo, vardar	VC
May-23		USA	Developer of a proprietary system designed to reduce emissions and costs for a sustainable future. The company's system is based on a traditional piston engine that utilizes affordable, clean, and renewable fuel derived from water and ethanol, enabling people to get safe and environmentally friendly fuel.	WAVE	VC

Source: Stifel IRIS, Pitchbook*

FIG 111: TRANSACTIONS FROM THE LAST 18 MONTHS (8/10)

Apr-23	ECOMEMBRANE	ITA	Ecomembrane SpA operates in the sector of design, sale and installation of components for biogas and biomethane production plants and gas storage systems, such as biogas, methane, CO2 and hydrogen. Specifically, it carries out production activity which mainly takes the form of cutting, high-frequency welding and packaging of membrane covers using, as the main material, PVC-coated polyester fabric. The company operates globally and has the most extensive network in the world in terms of installations as well as production structure. Its products include 3Master, 2 Master, Cupola M2- heat shield, Cupola M3, Econtainer, M1 cone, and Claricover.	Undisclosed	IPO
Apr-23	NXTCLEAN FUELS	USA	NXTCLEAN Fuels Inc is a developer and future operator of advanced biofuel refineries with a focus on renewable fuel. It is currently developing renewable fuel production projects at two locations in the State of Oregon. Through its wholly-owned subsidiary. NXT is in the process of permitting its first proposed refinery located at Port Westward, Oregon to produce renewable fuel.	Undisclosed	VC
Apr-23	roadgas	GBR	Provider of alternative fuel infrastructure designed to support the decarbonization of fleets. The company offers bespoke biomethane refueling station infrastructure, CNG, LNG, LCNG, biomethane options and hydrogen gases, enabling fleet and logistics managers to reduce GHG emissions and achieve net-zero sustainability goals.	MERCURIA	Buyout/LBO
Apr-23	CarbonCapture	GBR	Provider of carbon removal and storage services intended to capture biogenic carbon dioxide (CO2) emissions. The company specializes in the capturing and removal of CO2 produced from organic processes such as whisky fermentation and uses it for social benefits, thus enabling global companies including distillers, energy-from-waste (EFW) firms and biomethane plants to achieve net zero targets effectively.	STEYN GROUP	PE Growth
Apr-23	FIREFLY	GBR	Provider of a sustainable biofuel company based in England, United Kingdom. The company specializes in a process to convert sewage sludge and low-value waste product.	Wizz	Corporate
Apr-23	norsk e-fuel	NOR	Supplier of renewable energy and fuel intended to achieve climate-neutral transportation. The company generates and distributes fuel made from carbon dioxide and water using renewable electricity and is then refined to final products.	norwegian	Corporate
Apr-23	BRAYA RENEWABLE FUELS	USA	Operator of an oil refinery intended to offer renewable diesel and sustainable aviation fuel refining facility. The company specializes in the production and distribution of propane gas, heating oil and lubricants to residential, commercial and wholesale customers in the United States and Canada, thereby meeting the growing global demand for renewable fuels.	ECP	PE Growth
Apr-23	DOUGLAS	USA	Manufacturer of conveyor components catering to North America, Central America, South America and the Caribbean. The company offers heavy-duty drums, mine-duty drums, quarry-duty drums, extreme-duty drum and wing pulleys, premier-duty drums with integral end discs, engineered class pulleys, pulley lagging, ceramic pulley lagging and shafting for aggregate, pulp & paper, ship loading and unloading, steel, chemical, cement, coal, fertilizer, biofuel, biomass, coal fired power generation and agriculture.	RULMECA	M&A
Apr-23	Azzera	CAN	Developer of a carbon offsetting and compliance platform intended to help clients measure their carbon footprint. The company's platform provides brokerage, sale and trade services of carbon credits and sustainable aviation fuel by intending to support climate-positive projects to stay naturally net-zero, by helping them to integrate sustainability into clients' businesses, enabling companies to be eco-friendly and maintain zero carbon footprint.	Undisclosed	VC
Apr-23	oint Venture (CESPA / Bio-O	ESP	Operator of a biofuel plant based in Huelva, Spain. The joint venture supply of raw materials comes from organic waste such as agricultural waste or used cooking oils.	BioOils energy S.A.; CEPSA	JV
Apr-23	ňia Española de Petróleos/E	ESP	Operator of an organic waste management project intended to produce sustainable aviation fuel. The joint venture engages in building processors to produce renewable diesel to further decarbonize aviation, maritime and land transportation, enabling the reduction of carbon dioxide emissions compared to traditional fuels.	BioOils energy S.A.; CEPSA	JV
Apr-23	Capture-to-Use	DEU	Provider of carbon capture and utilization facility catering to the cement industry. The company offers the facility will enable the captured CO_2 from cement production to be reused as a valuable raw material in manufacturing applications.	Linde; Heidelberg Materials	JV
Apr-23	nlm vantinge	DNK	Provider of recycling and upcycling services focused on industrial by-products and residues for the biogas industry. The company offers to recycle by-products from industries that produce margarine, surfactants, soaps, emulsifiers, fatty acids, biodiesel, glycerol, milk powder, chips, etc. that are based on vegetable fat and oil products and produce feed additives for primarily dairy cows, helping increase milk production and fat content from the cows and thereby contribute to reducing the CO2 footprint from milk production.	CATACAP	Buyout/LBO
Apr-23	RTFS	GBR	Provider of biogas services intended to provide biomethane for transport. The company product include biomethane, enabling clients to meet their fuel needs.	CNG	M&A
Apr-23	Lyte Gro	GBR	Operator of a biotech company converts waste bananas into products that enhance the productivity of industrially important microbes. The company makes 'Baclyte', technology and products derived from such dramatically reduce the time and improve the performance and yield of important industrial processes such as fermentation and anaerobic digestion, enabling users to improve productivity and profitability whilst also reducing the resource, water, and energy footprints.	BNVpartners	VC
Apr-23	ADURO CLEAN TECHNOLOGIES	CAN	Aduro Clean Technologies Inc is a developer of patented water-based technologies to chemically recycle plastics and transform heavy crude and renewable oils into feedstocks and higher-value fuels. The company's technology activates unique properties of water in a chemistry platform that operates at relatively low temperatures and costs.	Undisclosed	PIPE
Apr-23	DYNAMIC RENEWABLES	USA	Operator of waste management and anaerobic digestion renewable fuel projects intended for agricultural and food processing industries across the United States. The company engages in developing and transforming ideas and technologies into efficient solutions by integrating systems in the areas of landfill diversion, anaerobic digestion, nutrient concentration and water treatment, enabling clients with anaerobic digestion renewable fuel.	ARES; NorthWestern Energy	Buyout/LBO
Apr-23	HAMR ENERGY	AUS	Developer of a hydrogen-assisted molecular recycling process intended to turn garbage into chemicals for fuels and building materials. The company's services use renewable hydrogen to recycle carbon at the molecular level in a process that takes feedstock through the gasification, syngas cleaning, and catalysis stages and produces chemicals and fuels as the results, enabling customers to have a reliable path of decarbonization and close the circular economy gap.	VICTORIAN CLEAN TECHNOLOGY FUND	VC
Mar-23	hobré ANALYZER SOLUTIONS	NLD	Manufacturer of line analyzers and sampling solutions intended for industries related to chemical, power generation, oil, and gas, beverages, and metal industries The company offers zero-emission analyzers, fuel gas combustion measuring systems, conditioning systems as well and natural gas quality analyzers, thereby enabling clients to improve sustainability, related to emission reduction, hydrogen, biogas, metal recycling, biofuels from waste.	SUPCON	M&A
Mar-23	COWBOY CLEAN FUELS	USA	Producer of a renewable energy gas intended to commercialize a process of producing renewable natural gas from alternative biomass feedstocks. The company specializes in creating renewable natural gas from depleted coalbed methane wells and alternative biomass feedstocks, while also geologically sequestering significant volumes of carbon dioxide, enabling consumers with carbon-negative renewable energy and a source of clean fuels.	Machan Investments	VC
Mar-23	Sustainable Syngas	USA	Operator of a climate-driven project development company intended for sustainable aviation and marine fuels. The company develops large-scale biomass gasification projects in the sustainable liquid biofuels sector specializing in project development and management, procurement and contracting, ESG and stakeholder engagement.	Aether Fuels	M&A
Mar-23	OPTIMUS TECHNOLOGIES	USA	Developer of a fuel management technology designed to help medium and heavy-duty truck fleets. The company's technology helps fleets run exclusively on biodiesel and reduce operating costs without rebuilding, replacing, or significantly modifying existing engines, enabling fleet operators to reduce fuel costs and emissions while addressing renewable fuel targets.		VC

Source: Stifel IRIS, Pitchbook*

FIG 112: TRANSACTIONS FROM THE LAST 18 MONTHS (9/10)

Mar-23	EQTEC	GBR	EQTEC PLC is a developer of clean energy infrastructure focused on reducing greenhouse gas emissions and wastes through gasification technologies. The company provides solutions to manage rising levels of waste and meet the growing demand for clean energy the group design and supplies advanced gasification solutions and have a higher efficiency product offering that is modular and scalable from 1MW to 30MW and the solutions produce synthesis gas (syngas), that can be used for the widest applications in the generation of clean energy, hydrogen, and biofuels, enabling the Net Zero Future through advanced solutions for hydrogen, biofuels, SNG, and other energy production.	Undisclosed	PIPE
Mar-23	AMOGY	USA	Provider of emission-free, high-energy-density power fuel technology intended to focus on the decarbonization of transportation. The company's technology substantially increases energy density, and provides renewable fuel with zero carbon emission during the operation at an affordable cost, enabling the transportation industry to use emission-free mobility applications using ammonia as a fuel.		VC
Mar-23	Bennamann	GBR	Developer of methane storage technology designed to deliver a local clean energy revolution. The company's technology fuels farm machinery charges electric vehicles, and provides heat and power to homes and businesses, enabling customers to use biomethane as a replacement for fossil fuels in a wide range of applications.	CNH INDUSTRIAL	M&A
Mar-23	Malay Carbon	MYS	Developer of carbon capture and sequestration projects catering to the Southeast Asia region.		JV
Mar-23		AUS	Provider of carbon capture and sequestration services intended to provide a simple way to directly mitigate atmospheric carbon emissions by growing seaweed on hemp rope. The company plants seaweed to mitigate the amount of excess carbon in the atmosphere, thereby taking direct action against climate change.	ADEC INNOVATIONS	M&A
Mar-23	Resynergi	USA	Manufacturer of biorefining technology systems intended to convert traditionally non-recyclable plastics into fuel and chemical products. The company's microwave-based system transforms unrecycled waste plastic into biodiesel from a broadened range of feedstocks, enabling clients to avail low carbon-intensity fuels extracted from waste.	Undisclosed	VC
Mar-23	twelve	USA	Developer of carbon dioxide recycling devices designed to create a climate-positive world and a fossil-free future. The company's technology bolts onto any source of carbon emissions, and with only water and electricity as inputs, transforms that carbon into critical chemical products, enabling industries to reduce their carbon footprint while creating a new revenue stream from waste products.	HIGHLAND; NUCLEATION CAPITAL; Microsoft; northstar.	VC
Feb-23	RAVEN	USA	Developer of waste conversion technology intended to create environmentally friendly, efficient and clean hydrogen and synthetic fuels. The company's technology transforms biomass, municipal solid waste, bio-solids, industrial, sewage, medical waste and natural gas into hydrogen, sulfur and nitrogen-free liquid fuels, additives, solvents and electricity, thereby providing clean technology to convert waste into renewable fuels and energy.	STELLAR J	Corporat
Feb-23	Swedish Biofuels	SWE	Producer of biofuels intended to offer an alternative to fossil motor fuels. The company specializes in delivering science, processing architecture and engineering for the production and conversion of alcohols to sustainable transport fuels and valuable chemicals, thereby enabling users to avail improved performance, cost efficiency and decreased emissions without any change in distribution.	MITSUBISHI MOTORS	Corporat
Feb-23	The Green Vector	ESP	Producer of biomethane from organic waste intended to promote decarbonization, the circular economy and the reduction of energy dependence. The company integrates all the actors in the waste value chain, which includes the production, distribution and final consumption of biomethane.	enagas renovable; genia	JV
Feb-23	aqualung	NOR	Developer of carbon capture technology designed to provide services to deal with their emission challenges. The company offers the lowest cost, smallest footprint, and environmentally friendly carbon capture services based on its unique second-generation membrane technology, enabling industries with an all-natural process for capturing CO2.	Denbury	VC
Feb-23	discoil	ESP	Supplier and collector of cooking oil and food waste based in Madrid, Spain. The company supplies a range of cooking oils and collects used cooking oil and food waste which is converted into high-grade biofuels and renewable energy and fertilizer, thereby helping clients reduce their environmental impact of carbon dioxide equivalent.	olleco	M&A
Feb-23	RAFRINOR	ESP	Supplier and collector of cooking oil and food waste headquartered in Ortuella, Spain. The company offers a range of cooking oils and collects used cooking oil and food waste which is converted into high-grade biofuels and renewable energy and fertilizer, thereby helping clients reduce their environmental impact of carbon dioxide equivalent.	olleco	M&A
Feb-23	viation Fuel Joint Venture (Sa	ZAF	Operator of sustainable aviation fuel plants intended to reduce carbon footprint. The company specializes in the production and distribution of sustainable aviation fuel made from non-petroleum materials such as agricultural waste and non-fossil feedstock, utilizing green hydrogen, sustainable sources of carbon dioxide and biomass, thereby enabling the aviation industry with a fuel substitute that has similar properties to conventional jet fuel but significantly lower carbon traces.	TOPSOE; sasol	JV
Feb-23	TARONIS	USA	Taronis Fuels Inc is a renewable fuel and power generation company. It is a holding company of various gas and welding supply companies. It supplies industrial gases and welding equipment and services to the retail and wholesale metalworking and manufacturing industries. The company also sells and distributes a synthetic gas namely, MagneGas which is a renewable alternative cutting fuel. It has retail locations located throughout California, Texas, Louisiana and Florida.	MERITUS; HARVEY; AEA	Buyout/LBC
Feb-23	aircela	USA	Developer of small solar-powered direct air capture (DAC) units intended to address the need to drive without changing the climate. The company creates household-scale direct air capture (DAC) units that can be used domestically by releasing the carbon from the salts (potassium hydroxide) and producing hydrogen from water, allowing industries to convert ambient carbon dioxide for producing carbon-neutral eco-fuel (e-fuel).	rsen, Jeffrey Ubben, Maersk	VC
Feb-23	almagest nature.spirit.energy	BGR	Producer of bioethanol intended to be used as a substitute to the gasoline fuel in internal combustion engines. The company engages in the production of bioethanol used as a substitute for gasoline fuel in ICE vehicles and also offers potable ethanol (used in beverages), distilled dried grains with soluble (animal feed component), neutral dehydrated ethanol and denatured ethanol.	AGRIA GROUP HOLDING JSC	M&A
Feb-23	LanzaTech	USA	LanzaTech Global Inc is a nature-based carbon refining company that transforms waste carbon into the chemical building blocks for consumer goods such as sustainable fuels, fabrics, and packaging that people use in their daily lives. The company's goal is to reduce the need for virgin fossil fuels by challenging and striving to change the way the world uses carbon.	AMCI Acquisition Corp. II	SPAC
Feb-23	LanzaTech	USA	LanzaTech Global Inc is a nature-based carbon refining company that transforms waste carbon into the chemical building blocks for consumer goods such as sustainable fuels, fabrics, and packaging that people use in their daily lives. The company's goal is to reduce the need for virgin fossil fuels by challenging and striving to change the way the world uses carbon.	BASF	PIPE
Feb-23	VISION BIOENERGY OILSEEDS	USA	Developer of plant genetics intended for oil seed crops as feedstocks for biofuel production. The company engages in developing oilseeds species including camelina from which oil and meal can be extracted for future processing into bioproducts such as animal feed and biofuels.	EQUILON; S&W	JV
Feb-23	uren Biogas Società Agricol	ITA	Operator of a biogas platform serving across Germany and Italy. The company operates biogas projects which provide biomethane and power to local energy companies, industrial companies and energy traders comprising five operational plants in Germany and a pipeline of development projects located across Italy.	HELIOS Energy Investments	Buyout/LBC
Feb-23	independent inspection services	SWE	Provider of testing and inspection services intended for the energy and agricultural sectors. The company specializes in laboratory analysis services of liquid fuels such as petroleum, biofuel and gas and also minerals, agriculture and chemicals, thereby enabling companies with sustainable strategies to meet the demand for fuel business.	AmSpec	Buyout/LBC
Feb-23	Jet Zero	AUS	Developer of a sustainable resource designed to reduce the use of aviation fuel. The company is developing the jet fuel (ATJ) facility, taking surplus ethanol production, and creating the replacement of aviation fuel, enabling the aviation industry with zero emissions and reducing the carbon footprint.	QANTAS; AUDACY VENTURES; AIRBUS GROUP	VC

Source: Stifel IRIS, Pitchbook*

FIG 112: TRANSACTIONS FROM THE LAST 18 MONTHS (10/10)

Feb-23	Tower Energy	USA	Provider of propane fuel delivery services intended to serve residential and light commercial across Northwestern Connecticut. The company delivers propane, heating oil, biofuel and complete HVAC (heating, ventilation and air conditioning) services, thereby enabling clients to have access to professional services at affordable price.	Prodos Capital; SailEnergy	Buyout/LBO
Jan-23	NXTCLEAN FUELS	USA	NXTCLEAN Fuels Inc is a developer and future operator of advanced biofuel refineries with a focus on renewable fuel. It is currently developing renewable fuel production projects at two locations in the State of Oregon. Through its wholly-owned subsidiary, NXT is in the process of permitting its first proposed refinery located at Port Westward, Oregon to produce renewable fuel.	Texas Ventures; United Airlines Ventures	VC
Jan-23	atvos	BRA	Producer and seller of ethanol, very high polarity (VHP) sugar and electricity based in Sao Paulo, Brazil. The company uses sugarcane and biomass to make products including anhydrous ethanol, hydrous ethanol and electricity, providing clients with sustainable, renewable and responsible energy.	Mubadala; Novonor; RK Partners	M&A
Jan-23	INERATEC	DEU	Operator of sustainable fuels (e-fuels) and chemical product manufacturers are intended to use the power-to-X or gas-to-X process. The company's technology produces hydrogen from renewable electricity converted with greenhouse gases such as CO2 into e-kerosene by CO2-neutral diesel, synthetic waxes, methanol or SNG allows dynamic, safe, and efficient operation of exothermic and endothermic chemical reactions such as methanol synthesis, methanation, and synthesis gas generation via catalytic partial oxidation, thereby enabling chemical plant operators to have integration of the entire chemical plant in transportable containers.	Engie; MPC; Planet A; Safran	VC
Jan-23	Maastank	NLD	Owner and operator of a tank terminal for edible oils and high-value petrochemical products. The company's tank terminal consists of 37 tanks with a total capacity of 30,000 cubic meters along with two jetties, a larger one for seagoing vessels and a smaller one for inland barges, thereby enabling companies to import and export a large volume of vegetable oils and petrochemicals.	Koole Terminals; J.P.Morgan Asset Management	Buyout/LBO
Jan-23	Precision	USA	Operator of a testing laboratory based in Toms River, New Jersey. The company specializes in groundwater and soil testing as well as provides services such as petroleum hydrocarbon, raw material, chemical composition, contamination analysis, quality control testing and biodiesel analysis.	TerraNova Partners; York	Buyout/LBO
Jan-23	CYANOCAPTURE Scalable carbon capture technology	GBR	Developer of carbon capture technology intended to provide affordable industrial-scale carbon capture. The company provides affordable, long-term carbon capture on an industrial scale by harnessing genetically modified cyanobacteria, enabling industries for rapid scale-up which current mechanical and chemical capture technologies fail to deliver.		Seed
Jan-23	phycobloom	GBR	Producer of algae-based oil intended to create carbon-neutral biofuels. The company uses synthetic biology to create novel strains of algae that will use atmospheric carbon dioxide to create affordable and sustainable hydrocarbons, enabling clients to get a viable alternative to fossil fuels.	Milad Alucozai	VC
Jan-23	TROVANT	ESP	Developer of environmental technologies intended to connect the energy and waste treatment sectors. The company focuses on the production of biomethane from biogas at a small scale and specializes in the scale-up of sustainable technology which is based on biological and natural processes and specifically designed for small-scale and distributed biomethane generation, enabling businesses to produce energy through sustainability.	Enagas Emprende; Facsa; Repsol; Invierte	VC
Jan-23	Seaweed Solutions	NOR	Operator of an alternative energy company intended to enable large-scale ocean farming of seaweed. The company engages in the sustainable offshore cultivation of seaweed for renewable energy such as biogas and bio-ethanol, enabling clients to cultivate seaweed on an industrial scale that is essential for creating the biomass required for the production of biofuels, without consuming scarce resources such as fresh water and arable land.	WWF World Wildlife Fund	VC
Jan-23	Circular Carbon Chemistry	DEU	Developer of homogeneous catalysis designed for the production of methanol. The company's methanol production chemistry consists of a new catalyst system, working at significantly lower pressures and temperatures where the catalyst is deployed in a cutting-edge reactor, designed specifically for green feedstocks, enabling clients to use renewable feedstocks to produce green methanol.	Maersk	VC
Jan-23	ecoceres	HKG	Developer and provider of biomass utilization solutions intended to attain carbon neutrality. With biomass technology to convert waste-base biomass into a spectrum of high-value products with an important decarbonization impact. The company includes businesses of Bio-Grease Utilization and Agricultural Waste Utilization, the company's main product converts waste oil into high-value biodiesel, enabling industry users to reduce carbon emission and improve energy efficiency.	BainCapital	VC
Jan-23	perator (Envien International	IND	Operator of a biofuel distillery intended to to increase the capacity of its existing 100 KLPD molasses/sugarcane juice-based facility to 125 KLPD of sugancane juice. The company's distillery will be able to change the product mix and produce Extra Neutral Alcohol (ENA) or any other acceptable product based on market demand and sell it to Oil Marketing Companies (OMCs) to satisfy their blending needs.	Zuari; Envien International	JV
Jan-23	Blue Blade Energy	USA	Provider of sustainable aviation fuel intended for the airline industry. The company develops and offers ethanol-based aviation fuel which uses non-petroleum feedstock and is a low-carbon alternative to traditional jet fuel that offers up to 85% lower lifecycle greenhouse gas emissions, thereby helping clients to reduce carbon emissions.	Green Plains; United Airlines Ventures; Tallgrass	JV
Jan-23	Arcadia eFuels	USA	Producer of eFuels intended to protect the environment and produce power. The company's fuels include diesel and jet fuels that are produced using renewable electricity and water to produce Green Hydrogen and combine with captured carbon using proven technology, thereby enabling energy industries to transition to no carbon emissions and meet market demands.	SWEN Capital Partners	PE Growth
Jan-23	EPCON	NOR	Manufacturer of evaporation machines intended for biomarine, biofuel, food and process industries. The company developed unique energy-efficient technical solutions and products such as falling film, forced circulation, combined, flash coolers and compact evaporators for several separation and purification processes, thereby helping industries in separating different types of fluids or fluids from solid material.	Vilokan Group	M&A
Jan-23	HYCO1	USA	Operator of a carbon conversion and utilization company intended to turn CO2 emissions into high-value, sustainable products. The company works with commercial and industrial point-source emitters to cost-effectively convert waste into purity streams of building-block chemical gases and later convert them into low-carbon chemicals, enabling clients to reduce their emissions and get benefits from the processed products.	Undisclosed	VC
Jan-23	LiquidPiston	USA	Manufacturer of advanced rotary internal combustion engines intended for unmanned aerial vehicles and the automotive industry. The company's technology has different thermodynamic cycles, architecture, and operations that make engines smaller and lighter than traditional diesel engines, providing customers with compact, efficient, low-vibration, and multi-fuel capable combustion engines.	RSVP; IRE Investment	VC
Jan-23	OORJA	IND	Operator of farming as a service company intended to power rural livelihoods in emerging markets. The company finances, installs, operates, and maintains solar energy systems, provide irrigation facilities, and also produces biofuel from agricultural plant waste and powers off-grid villages in rural India, enabling consumers to displace fossil fuels, reducing carbon emissions, and improving the lives of people.	elea Foundation for Ethics in Globalization	VC
Jan-23	hinheung (Energy Productio	KOR	Manufacturer of bio-oil, sustainable aviation fuel, biodiesel, and bio-heavy oil based in Seoul, South Korea.	Enzychem	M&A
Jan-23	WOn	BGR	Provider of waste oil collection and recycling services based in Sofia, Bulgaria. The company offers a collection of used cooking oil of vegetable origin, recycling of waste and its conversion into biofuel and electrical energy and trading raw materials for the production of green energy.	Münzer	Corporate

Source: Stifel IRIS, Pitchbook*

CONCLUSION

Although the bulk of existing biofuels are derived from agri-sugars or oil crops, the focus is shifting on to the use of biogenic waste, residues, non-food crops and non-biological feedstocks. However, many of these alternatives require advanced biofuel production technologies that are currently in the early stages of commercialisation, usually with challenging economics that relate either to the level of initial investment needed or the availability of certified feedstocks. Nonetheless, given the region- and country-specific nature of biofuel options, the industry has a material investment phase ahead. In Europe, the ReFuel EU initiative has set binding targets for heavy-duty transport, requiring a shift from a 9% renewable energy mix in transport to at least 29% by 2030. This is further reinforced by sub-segment mandates for aviation and maritime, with a standardised approach to RFNBOs, simultaneously able to scale process industries' decarbonisation and sustainable fuelling as it requires less land and water access compared to traditional biofuels, but heavily relies on additionality for upstream renewable electricity.

The pace of scale is a pressing issue, given that demand for renewable power and potential end uses are expanding faster than infrastructures and power grids can support. Energy storage, whether through batteries or chemical conversion, will be a crucial solution to smooth out supply-demand fluctuations, effectively integrating renewables and enhancing grid resilience while extracting the most from renewable power.

Alternative fuels and chemicals face widespread challenges with in the making feedstock shortages and rising geosourcing competition, exacerbated by traceability issues, especially on Asian imports. Therefore, while new capacity will be needed, driven by regulatory initiatives, growing offtake bids and increasing developers asks, innovative solutions to answer up/midstream requirements and enhance downstream production economics will also be required, either enlarging addressable markets or answering overlooked challenges. This ultimately calls for effective carbon-price frameworks and penalties, providing developers with offtakers willing to pay «green premiums" for sustainable fuels and chemicals, which comes as a prerequisite for the greenest alternatives to attract both strategic and growth infrastructure capital.

Mature players tend so far to continue to wait for regulation, support frameworks and technologies to evolve. Quotas can only serve as a first step in moving the market forward, with regulation and support stability, but also clarity needed to crystallise the value of renewable fuels; increasingly displacing the cursor from cost-only to LCA-also. Gradually stepping from crops to waste and e-synthesis will rely on cost-competitivity and emission reduction arbitrage. Ultimately, this would result in optimised capital flows to scalable solutions from feedstock to power and downstream logistics requirements.

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