

Investments in Sustainable Biofuels

Meeting fuel demand, energy security
and decarbonization goals

JANUARY 2026





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Executive Summary

The global energy transition depends on the rapid scaling of low-carbon molecules. Biofuels- both liquid and gaseous - represent the most immediately deployable and scalable pathway for hard-to-abate sectors including road transport, aviation, shipping, industry, and power. Despite accounting **for less than 2% of global fuel consumption** (nearly 198 Mtpa) today, biofuels already deliver material emissions reductions, enhance energy security, and generate rural economic value, particularly across emerging and developing economies.

Global biofuel demand is set to increase by **2-2.5x by 2035**, driven by tightening mandates, technology and infrastructure maturity, and rising energy security priorities in import dependent regions. Under an accelerated outlook, total demand across liquid and gaseous biofuels could reach nearly **470-520 Mtpa by 2035**. Mature biofuels like Bioethanol and Biodiesel anchor the current market, but will face headwinds from road transport electrification and technical blending walls, particularly beyond 2030, unless demand from new sectors like maritime, aviation, and bio-chemicals/polymers picks up significantly. Growth is increasingly concentrated in Sustainable Aviation Fuel (SAF), Renewable Diesel, Biogases (Biogas and Biomethane), and Biomethanol, reflecting regulatory momentum, technology maturity and the limited availability of scalable alternatives in aviation, maritime, heavy transport, and others.

This growth trajectory will require the **development, validation, and scale-up of new feedstocks and conversion pathways**. Existing lipid-based feedstocks are inherently constrained by availability and sustainability limits, creating a binding ceiling on the long-term growth of Biodiesel, Renewable Diesel, and Hydrotreated Esters and Fatty Acids (HEFA)-based SAF. Scaling biofuels beyond the early 2030s hinges on two complementary pathways: either sustainably expanding today's feedstock pools through higher collection rates, non-food energy, and rotational crops

(NVOs) and improved utilization of sugar and starch-based biomass or by pivoting toward structurally larger but less mature feedstocks such as lignocellulosic residues and industrial and municipal wastes, which require further technological and commercial unlocking. In practice, achieving durable scale is likely to require a combination of both approaches. Pathways such as Alcohol-to-Jet (AtJ), gasification-to-fuels (GFT), and others are critical to unlocking larger biofuel volumes, reducing lifecycle carbon intensity, and mitigating food-versus-fuel concerns, enabling biofuels to scale in line with tightening sustainability criteria and long-term decarbonization targets.

A defining feature of the next phase of biofuels growth is the emergence of the Global South as both a supply powerhouse and a demand center. Historically, abundant feedstock availability and structurally competitive economics positioned many Global South markets as export-oriented producers due to lack of local policy-stimulated demand. Increasingly, domestic mandates, infrastructure development, and fuel-substitution policies are unlocking local demand at scale across biofuels, with Bioethanol and Biodiesel being more established but SAF mandates emerging in select regions, e.g., Asia Pacific.

Meeting the growing demand for biofuels requires a step-change in capital deployment. Cumulative investment will reach **\$420-500 billion in a base case scenario and \$630-740 billion under an accelerated case scenario, by 2035**, implying a **4-7x increase in annual capital flows** compared to historical levels. Capital intensity varies sharply across fuel types: Biogases represent the largest absolute investment pool, while SAF and Renewable Diesel drive the fastest growth in incremental investment as markets scale from a low base. Beyond 2030, advanced biofuels and non-HEFA pathways become increasingly critical to sustain demand growth as sustainability constraints tighten on first-generation feedstocks.

All biofuels remain fundamentally policy-anchored assets with mandates, incentives, subsidies, and sustainability frameworks providing the revenue visibility required for bankability. Within this envelope, mature pathways such as Bioethanol, Biodiesel, Biomethane, as well as HEFA-based SAF and HVO-based Renewable Diesel have established execution track records and repeatable financing structures, enabling access to project finance in supportive markets. In contrast, emerging pathways - including non-HEFA SAF, second-generation Bioethanol, and Biomethanol - face structural financing gaps driven by technology risk, limited operating history, and infrastructure and supply-chain immaturity. This requires concessional capital, guarantees, and risk-sharing platforms to bridge the transition from demonstration to bankable scale.

Unlocking the full potential of biofuels requires harmonized policy and standards, accelerated feedstock and technology innovation, enabling infrastructure and supply chains, and targeted concessional finance for the Global South. When policy ambition is converted into durable, bankable revenue frameworks, biofuels scale quickly and efficiently; when it is not, progress remains fragmented despite strong fundamentals.



01

Introduction: Biofuels and their Role in the Global Energy System

Biofuels, both liquid and gaseous, currently contribute **just under 2% of global fuel consumption**. Yet they remain one of the most immediately scalable pathways to decarbonize transport and hard-to-abate sectors. As countries and industries seek reliable replacements for fossil fuels, biofuels offer a critical solution that complements electrification, efficiency measures, and e-fuels.

Today, the road transportation sector represents the most mature end-use for biofuels, driven primarily by Bioethanol and Biodiesel, contributing to **~4% of total oil demand (~160 Mtpa of liquid biofuels)**. Demand for biofuels in other sectors remains small but is growing: SAF stands at **~0.6% of global jet fuel consumption (~1.9 Mtpa)**, while biofuel uptake is about **0.3% (<1 Mtpa) of energy use** in shipping.

For gaseous biofuels, globally, just under half of Biogas use goes to **power generation (50%, ~27 bcme)**, making it the largest use case today. **Buildings** are the second-largest use at **about 25% (~14 bcme)**, mainly for heating and cooking. **Industry** accounts for roughly

8% (~4 bcme), while a share of roughly **17% (~10 bcme)** is upgraded to Biomethane, reflecting the increasing allocation of Biogases to higher-value uses such as a **transport fuel or gas grid injection**.

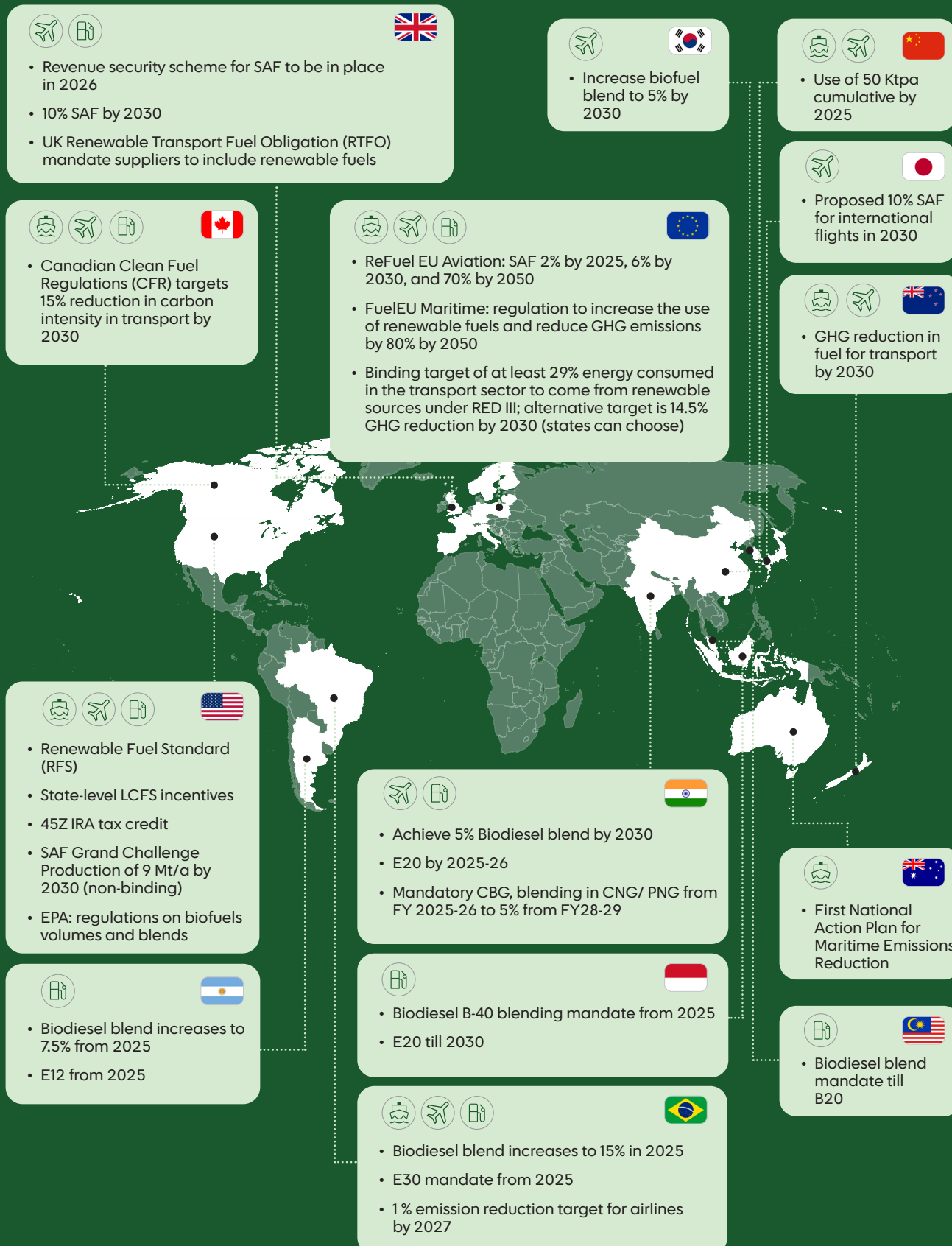
Financing patterns in biofuels reflect how markets are forming across sectors and end uses. Demand evolution, shaped by **regulatory frameworks** (see exhibit 1) and underpinned by technological progress, provides clear signals on the pace and direction of market growth. Interpreting these signals is critical to assessing project bankability and the long-term scalability of biofuel supply.

This paper covers **six biofuels** making up the majority of the industry including Bioethanol, Bio-based Diesel (Biodiesel, Renewable Diesel), SAF, Biomethanol, and Biogases (Biogas, Biomethane).



Europe, North America, and Asia are leading the development of biofuels policies through quotas and economic incentives for production

Not exhaustive



Policy Sectors:



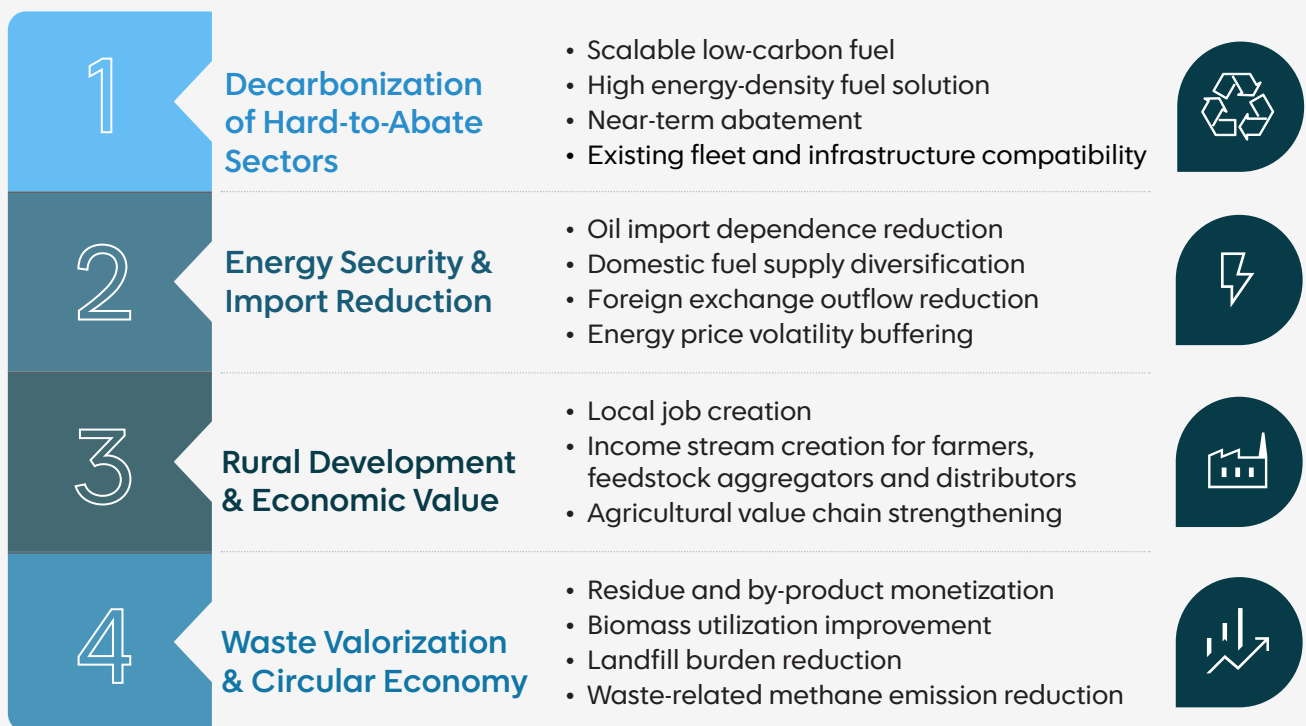
Source: ICAO, Argus, European Commission, ACI, IEA Eurocontrol, Biomass Magazine, S&P Global, Press search

1.1 Why are biofuels critical in the future energy system?

Biofuels play a critical role in global energy transition, offering a scalable, low-carbon alternative for sectors such as road transport, aviation, shipping, and potentially in chemicals manufacturing, as feedstock for biochemicals and bioplastics (e.g., polyolefins) production. Their benefits extend well beyond emissions reduction and contribute to strengthening energy security and sovereignty, creating rural economic development opportunities and enabling a circular economy.

These advantages are particularly pronounced in the Global South (e.g., India, Brazil, Southeast Asia, etc.), where abundant biomass resources, large agricultural economies, and high oil import dependence create a structurally attractive environment for scaling biofuels.

EXHIBIT 02 | Advantages of biofuels driving demand



1.1.1 Decarbonization across hard-to-abate sectors

The heavy transport sector faces immense decarbonization challenges due to its high energy intensity and limited viable low-carbon alternatives. **Road transport** consumes the highest volumes, **2,100-2,200 Mtpa** of oil, with **trucks alone accounting for 650-700 Mtpa**, while **aviation uses 310-320 Mtpa** and **shipping 320-340 Mtpa** of fossil fuels each year.

These high consumption levels translate into a substantial emissions footprint—**aviation and shipping together** emit around **1.9 Gt CO₂ per year** (~5% of global emissions), while road transport contributes to ~ **6 Gt CO₂** (~16% of global emissions), out of which heavy-duty trucks emit ~**2 Gt CO₂ per year** (~5% of global emissions).

These numbers are expected to increase significantly over the coming decades driven by population growth, rising incomes, accelerating urbanization, expanding global trade, and the continued growth of international travel, compounding the decarbonization challenge.

Liquid biofuels have nearly **160 Mtpa** of global production capacity and the potential to deliver high **GHG emissions reductions** per unit of fuel on a lifecycle. They currently represent the main low-carbon option available at meaningful commercial scale for aviation and shipping and a cost-effective complement to electric mobility in road transports. Alternate pathways such as low-carbon electrofuels (e-methanol, e-methane, e-diesel) and zero carbon-emission fuels (green hydrogen, green ammonia) are still struggling to scale due to regulatory uncertainty, complex economics, and limited infrastructure maturity.

1.1.2 Energy security, supply diversification, and foreign exchange saving

Biofuels enhance energy security by reducing reliance on globally traded crude oil markets. International Energy Agency (IEA) projections indicate that emerging Asian economies will absorb **around 60% of internationally traded oil and gas by 2035**, reflecting rising import dependence and growing concentration in global oil markets. Biofuels can be domestically produced in many regions, particularly in the Global South, reducing exposure to volatile global oil markets and enhancing energy sovereignty and security. Against this backdrop, India's Ethanol program achieved almost 20% blending and substituted an overall **~26 million tonnes of crude** that would otherwise be imported, resulting in foreign exchange savings of **~\$19.3 billion**.

1.1.3 Rural development and value creation

Feedstock cultivation, residue collection, and biorefinery operations create **local employment opportunities**, stimulate agricultural productivity, and support waste-to-value markets. For emerging economies, biofuels present a pathway to **industrialization and inclusive growth**. In India, farmers and agro-industries received **~\$15 billion** in payment for feedstocks used in Ethanol production. This infusion of income helped **eliminate sugarcane payment arrears** to farmers and improved the viability of crops like maize by creating new demand. According to IEA, under conditions of strong expansion, **employment in sustainable liquid and gaseous fuels could reach nearly 2 million direct jobs by 2035**, across the full value chain.

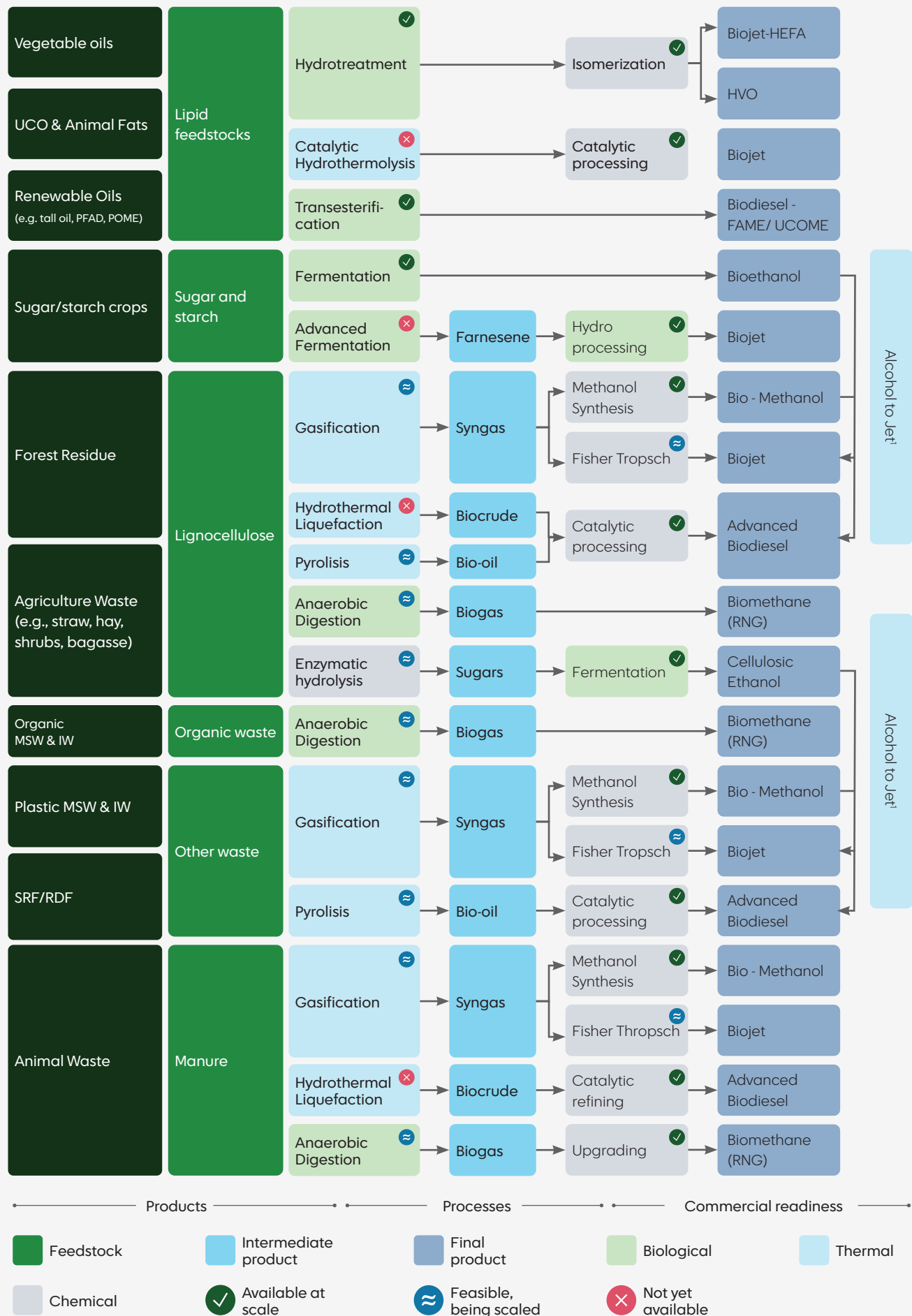
1.1.4 Waste management and circular economy benefits

Globally, **over 2 billion tonnes of municipal solid waste** is generated each year, with the associated economic cost (including waste management expenditures and environmental, health, and climate externalities) estimated at around **\$361 billion annually** according to United Nations Environment Programme (UNEP). Along with this, agricultural and forestry residue waste also poses multiple disposal challenges to farmers. In many regions, farmers often resort to open burning of residues or stubble, contributing to local air pollution, a major health concern for governments and citizens, particularly in South and Southeast Asia. This presents a huge opportunity for biofuels, particularly those of the second generation. Biofuels foster the deployment of a circular economy by valorizing wastes and biomass into fuels for transport applications through technologies like gasification, hydrolysis and fermentation, pyrolysis, etc. In the IEA Net Zero Emissions scenario, the share of liquid biofuels derived from advanced (waste) feedstocks rises from **12% in 2022 to 40% in 2030 and 55% by 2035**, reflecting a strong shift toward waste and residue-based biofuel production, which allows further scalability of biofuels and higher environmental benefits.

8 1.2 Overview of key biofuel types

Biofuels serve as a substitute for or alternative to conventional fossil fuels, but they differ in terms of technology maturity, feedstock availability, sustainability/carbon-intensity, and compatibility with existing infrastructure. Depending on the pathway and type, biofuels can play multiple roles, ranging from low-blend applications (e.g., Bioethanol or Biodiesel), and direct fuel substitution or drop-in replacements of incumbent fossil fuels compatible with existing propulsion systems and infrastructure (e.g., HVO/Renewable Diesel, SAF, Bio-LNG/-methane), to alternative fuel options that can displace fossil fuels consumption but require new solutions (e.g., Biomethanol for shipping). The exhibit 3 below showcases the different types of production pathways and the commercial readiness of these pathways.

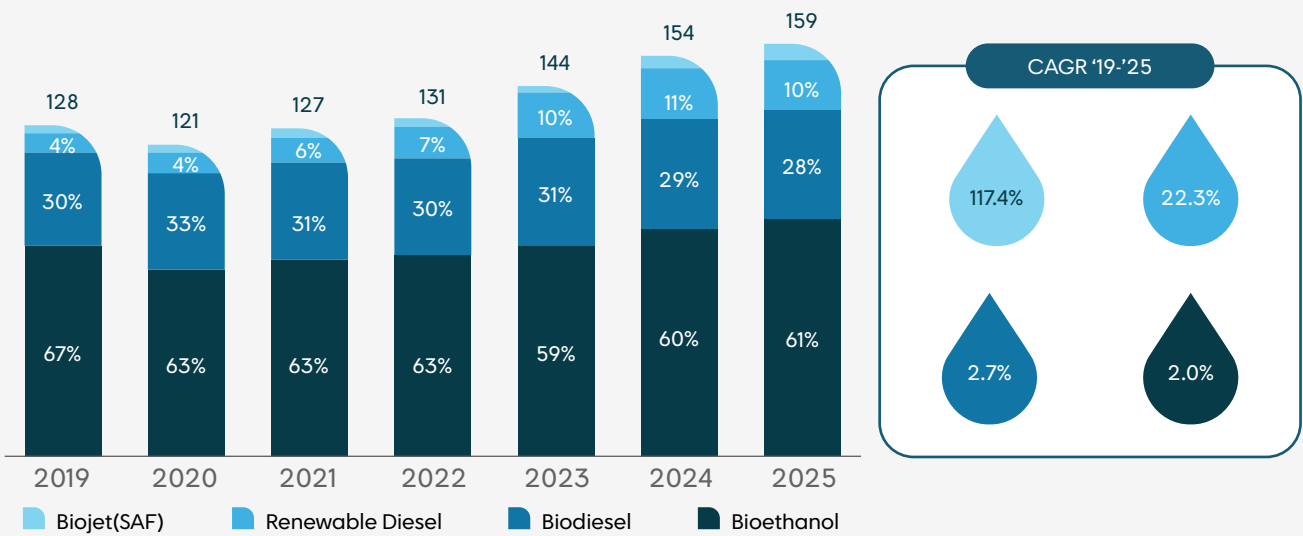
EXHIBIT 03 | Detailed overview of biofuel feedstock and production



1. Alcohol-to-jet process includes Dehydration, Oligomerization, Hydrogenation

Historically, global biofuel consumption has steadily increased, as mature markets (North America, Latin America, EU) have shown steady demand, especially for particular categories, while Asia-Pacific has grown quickly over the last few years, as shown in exhibits 4 and 5.

EXHIBIT 04 | Historical consumption trends for liquid biofuels (by fuel type)



Key Insights

01 Bioethanol has the highest market share and slowest growth rate

Worldwide, the growth of its consumption has been estimated at +2.0% CAGR between 2019 and 2025

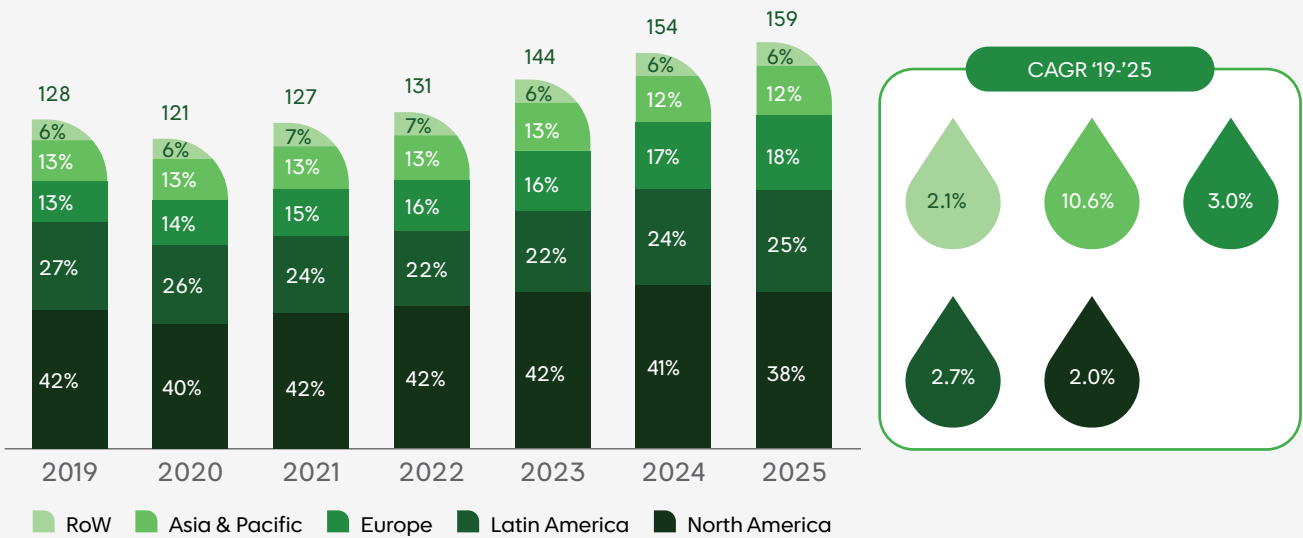
02 Renewable Diesel continues gaining market share vs. 2019

Global consumption has grown at ~22%. Trend expected to continue driven by better engine compatibility and lower CI scores vs. Biodiesel

03 SAF has the strongest growth rate

SAF, with >100% CAGR, is the fastest growing biofuel driven by aviation decarbonization mandates across Europe and NAMR

EXHIBIT 05 | Historical consumption trends for liquid biofuels (by region)



Key Insights

01 LATAM shows stable but mature biofuel demand

Recorded 2.7% CAGR over the period due to established biofuel markets. The next wave of growth is likely to come from emerging fuels like SAF and Biomethane

02 APAC emerging as a growth engine for biofuels

Fast growing biofuel market, driven by India's aggressive Bioethanol push, Indonesia's B40 mandate, and Chinese efforts in SAF and Biogas

1. Biofuels include Biodiesel, Biojet (SAF), Bioethanol, Renewable Diesel
Source: IEA

8 1.3 Deep dive on different biofuels

1.3.1 Bioethanol

1G Ethanol is a mature biofuel with an annual demand of **~96 Mtpa**, with **roughly 80% of demand** concentrated in **US (~40 Mtpa)**, **Brazil (~27 Mtpa)**, and **India (~7.5 Mtpa)**, and 80-90% production capacity also concentrated in these geographies. From an industrial lens however, it is a fragmented market with **<15% total capacity covered by top 10 producers**; including key players like Green Plains, ADM, POET, Valero, Pacific Ethanol (US), and Raizen (Brazil) among others. It primarily utilizes first generation (1G) sugar/starch based agricultural crops, e.g., corn and sugarcane, to produce the biofuel through fermentation. Its main application is as a blending component for gasoline and to help reduce road transport emissions and fossil fuel dependency. While future biofuel capacity growth may be constrained by shrinking gasoline demand (due to the electrification of road transport), meaningful upside remains driven by higher blending mandates in key markets and new emerging applications. For example, Brazil has recently increased its Bioethanol content in gasoline to around 30%, reflecting its long-standing flex-fuel programme and Indonesia is targeting a mandatory E10 ethanol blend by 2027-28 to reduce fuel import dependence. Bioethanol also sees emerging potential applications in aviation (Ethanol-to-Jet, e.g., LanzaJet, Gevo, UOP Honeywell, etc.) and chemicals (poly-olefins, e.g., Braskem, PTT, etc.), which are expected to pick up in the mid and long-term. In this context, second-generation (2G) Bioethanol represents a critical pathway to unlocking the long-term scalability and sustainability of Bioethanol as it enables production via the hydrolysis and fermentation of lignocellulosic feedstocks, particularly agricultural residue streams. Few projects in Brazil and India are operational or in advanced development stages - nevertheless, to date, 2G Bioethanol has seen limited commercial deployment, reflecting operational challenges, significantly higher production costs, and a still-limited track record of large-scale project deployments.

1.3.2 Bio-based Diesel

There are mainly two types of Bio-based Diesel alternatives: Biodiesel, an Ester-based

molecule that can be blended in diesel up to 10-20% (non drop-in) and Renewable Diesel which can fully substitute Diesel as a drop-in solution. Biodiesel or Fatty Acid Methyl Esters (FAME) and Renewable Diesel (Hydrotreated Vegetable Oil or HVO) are closely linked through their reliance on overlapping feedstock pools and conversion pathways but serve different end-use markets. Biodiesel and Renewable Diesel are produced primarily from lipid-based feedstocks such as vegetable oils, used cooking oil, and animal fats with Biodiesel manufactured via transesterification into FAME and Renewable Diesel produced through hydrotreatment to yield drop-in hydrocarbons (HVO). These same lipid/oily feedstocks also underpin HEFA-based SAF, which shares a similar production process with HVO. Oily feedstock supply constraints are driving interest in novel vegetable oil feedstocks (NVOs) from energy or rotational crops, including emerging non-edible/rotational oilseed crops such as Camelina, Carinata, and Jatropha to help expand the availability of biolipids supply.

Within Bio-based Diesel, Biodiesel (FAME) has an annual demand of **~45 Mtpa**, concentrated in **Indonesia (~12 Mtpa)**, **Brazil (~9 Mtpa)**, and **the EU (~7 Mtpa)** due to supportive mandates and abundant feedstock. From a private sector lens, the market is mildly concentrated with **40% total capacity covered by top 10 producers** including Avril, Musim Mas, ADM, Bunge, and Cargill. The market has seen limited growth because of the blending walls required due to the oxygenated non-drop-in nature of this fuel. Biodiesel faces compatibility challenges with logistics, refueling infrastructure and engines, and limited valorization of by-products such as glycerin, it is still expected to grow over time. Growth is expected in SEA and Brazil with targets of B40 in Indonesia, B20 in Brazil, and B5 in India by 2030, putting further pressure on the supply of oily feedstocks. The use in maritime to comply with Fuel Maritime EU and eventually IMO regulations is also expected to grow Biodiesel demand.

Renewable Diesel, with demand surging to **~16 Mt per year**, primarily concentrated in the **US (~11 Mtpa)**, has seen continued growth in road transport, driven by incentives in the US (e.g., RINs and LCFS) and mandates



in the EU. Given its process synergies with HEFA-based SAF production, this pathway allows producers to flexibly adjust product slates, shifting between Renewable Diesel and SAF to respond to market dynamics. At the same time, the EU has introduced sustainability criteria that limit high-iLUC-risk (Indirect Land Use Changes) feedstocks like Palm Oil. This has accelerated the shift toward 2G feedstocks, primarily Used Cooking Oil (UCO) for now, though limited scalability of UCO feedstock will require new solutions. Consequently, global trade balances may shift. As China and Southeast Asian countries expand domestic SAF and Renewable Diesel production, a growing share of feedstocks that were previously exported to the EU is likely to be retained for domestic use.

1.3.3 Sustainable Aviation Fuels

SAF is a small but growing market today with a demand of **~1.9 Mtpa primarily** concentrated in the US, EU, and UK and increasing demand outlook reflecting new and emerging blending mandates beyond the EU and UK, e.g., Singapore, Thailand, South Korea, Japan, etc. The market is highly concentrated with **80% capacity covered by top 10 producers** including Neste, Darling-Valero, Enilive, P66, and EcoCeres. Global blending mandates (e.g., 2% SAF by 2025 in EU, 6% by 2030, 70% by 2050, 2% in 2025 to 10% by 2030 in UK) and related compliance penalties, in addition to incentives like LCFS

and IRA's 45Z tax credits in the US are expected to result in high demand growth through 2050. HEFA is the only commercially mature technology to date, representing the majority of SAF produced today (full-processing and co-processing plants). This pathway is expected to dominate over the next decade, but scaling beyond 2030-35 will require diversification into novel, non-food vegetable oils from energy/rotational crops, as the current dominant feedstock availability tightens (e.g., Used Cooking Oil). In parallel, emerging pathways such as AtJ, MtJ, GFT and pyrolysis could unlock the potential of sustainable and abundant 2G waste and cellulosic feedstocks, though these technologies still require significant cost reductions (through further scale up and R&D) to gain significant market shares and complement HEFA production.



1.3.4 Biogases

Biogas is produced through anaerobic digestion of organic matter, typically agricultural residues, animal manure, biogenic fraction of Municipal Solid Waste (MSW), industrial wastes, and wastewater. A significant amount of Biogas is also produced through rotational energy crops, which is sub-optimal from a sustainability perspective. While Biogas today remains a highly fragmented market primarily used for on-site power and heat, Biomethane (produced through the upgrade of Biogas by removing impurities and CO₂) represents a fast-growing drop-in solution and substitute for natural gas (Bio-CNG for mobility, e.g., in India, EU, Thailand, or Bio-LNG for shipping, e.g., EU, USA, Singapore). Combined, they have a demand of **~40 Mtpa** (~55 bcme). Biomethane demand today is **~15 Mtpa** (~10 bcme) **the EU and the US** as the most developed markets. Asia represents a new potential frontier for Biomethane infrastructure investments given strong feedstock potential, emerging policies, and relevance for these markets. Demand is driven mainly by decarbonization and energy security related policies and regulations with focus on gas grid injection and CNG mobility, with emerging upside in maritime fuels (as Bio-LNG) under FuelEU Maritime and (eventually) IMO frameworks. The market in the EU/US remains fragmented with the **top 10 producers accounting for <20% of capacity in the EU and ~50% in the US**. Key industry players include Nature Energy (Shell), Archaea Energy (BP), Vanguard Renewables, Verdalia, and BioCirc. Its growth potential is significant, particularly in mobility and fossil gas substitution in grids, with emerging markets such as **India and China** expected to scale as policy frameworks evolve, e.g., India's SATAT scheme for Compressed Biogas (CBG).

1.3.5 Biomethanol

Biomethanol can be produced through several pathways and from various types of feedstocks. The two main routes include Biomethane reforming and biomass gasification, both followed by Methanol synthesis from the syngas intermediate. This is a nascent fuel and market, with limited production capacity as of today. The technology faces common challenges related to complex design and operations and economics of biomass gasification facilities. Some commercial-scale projects are under development globally, particularly in

China (e.g., CIMC Enric's 50 Ktpa plan now operational in Guangdong Province, but also projects that are under development by Envision and Goldwin) and US (**500 Ktpa Beaver Lake Renewable Energy** project in pre-FID phase, Louisiana USA, by SunGas Renewables in partnership with C2X Global), typically based on gasification of waste feedstocks such as agricultural and forestry residues or MSW. The strength of Biomethanol lies in the ability to decarbonize the current global fossil Methanol production (**~90 Mtpa**) and potential upside from new and emerging markets like shipping, aviation, and chemicals where Biomethanol could help drive decarbonization. There are **40+** Methanol-capable dual-fuel vessels currently in operation, with **300+ additional vessels** on order globally, highlighting the rapid momentum behind Methanol as a marine fuel. In addition to shipping, chemicals (Methanol to olefins) and aviation (as a precursor for MtJ SAF plants) can also offer demand upside, with several SAF-MtJ projects already announced between the EU and US, while licensors complete the last steps of the ASTM-D7566 certification for the MtJ process.







02

Demand and Capacity Outlook

2.1 Demand growth by fuel type

Biofuels are poised for significant growth over the next decade, however the scale of that expansion depends heavily on whether global markets follow a standard **base-line path** or move toward an **accelerated scenario**.

Methodology and references used to determine the outlook

Our biofuels demand analysis integrates authoritative forecasts including liquid biofuel demand from IEA's Renewables 2025 and Biogases demand from the IEA Outlook for Biogas and Biomethane 2040, apportioned across fuel categories and technologies. This allocation is informed by multiple factors like biofuels project pipeline, regional market dynamics, and the expected technological mix. The projected demand is contingent on the availability of an enabling financing and incentive framework. The demand outlook assumes that appropriate financial instruments and policy support are in place to mobilize investment and support timely capacity deployment. For each biofuel type, we assume a nominal investment cost per unit of production capacity, based on benchmarks from multiple sources (including IRENA, CORSIA, IEA). The nominal investment cost, incorporating technology learning curves to adjust the capital costs over time, along with estimated capacity, define our total capital investment requirements in biofuels.

Base case: The base case reflects the average trajectory implied by current policy frameworks and market conditions. This scenario is anchored on existing commitments and mandates but no major new policy push is considered. Biofuel expansion keeps pace with incremental policy support and organic market uptake, without exceeding the levels consistent with policies already in place or those which are firmly planned.

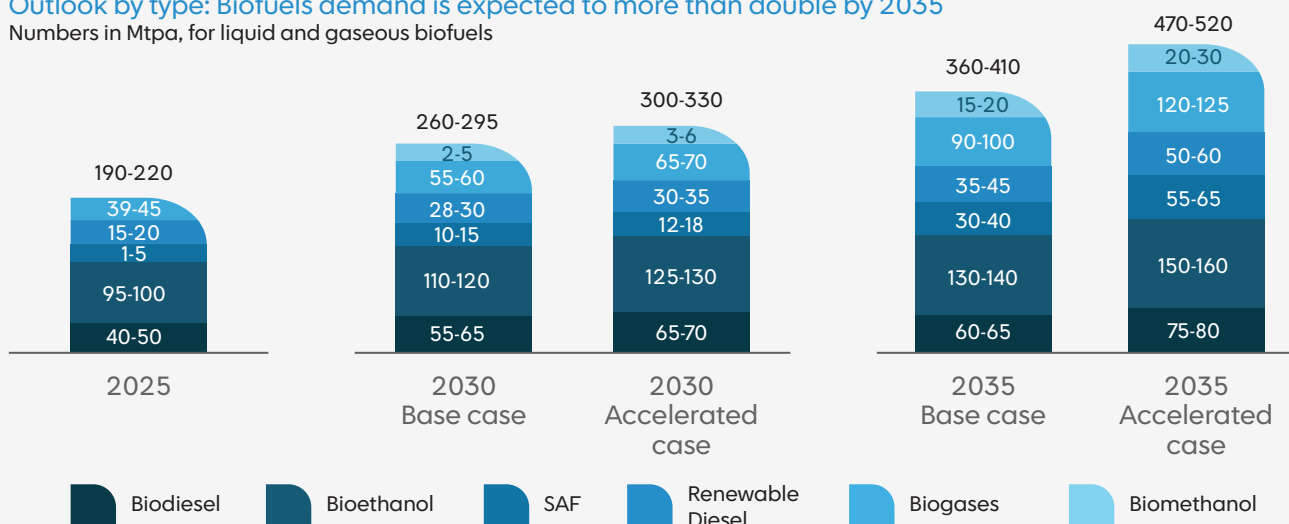
Accelerated case: The accelerated case assumes planned policies are fully legislated, market barriers are broken down, and ample new production capacity is added to meet rising demand. This assumes that targeted shifts in policy and market design occur to boost biofuel beyond the base trend. Additionally, all major announced commitments are delivered on schedule. This accelerated scenario reflects a world where ambitious policies and innovation enable biofuels to play a much larger role in the energy mix, in line with stringent climate goals. The accelerated case is similar to the IEA announced pledge scenario, wherein all aspirational climate targets announced by governments are achieved in full and on time.

The overall demand for biofuels is expected to increase by **2-2.5 times globally by 2035 as compared to 2025 levels**, largely driven by tightening policy mandates across transport and industry, expanding drop-in applications enabled by technology maturity, and energy-security demand in import-dependent regions. A breakdown by fuel types, regions, and applications/sectors follows below.

EXHIBIT 06 | Present and forecasted demand by fuel type for base case and accelerated case scenarios in 2030 and 2035

Outlook by type: Biofuels demand is expected to more than double by 2035

Numbers in Mtpa, for liquid and gaseous biofuels



Note: Multiple sources leveraged to determine expected demand for biofuels in 2035 including IEA Renewables 2025, IEA Biogas and Biomethane Outlook 2025

2.1.1 Bioethanol

Bioethanol is expected to remain the largest biofuel by demand through 2035, with global volumes projected to increase by roughly **1.5 times (reaching 135-154 Mtpa)** over the next decade. While Bioethanol demand has expanded steadily over the past five decades, the pace of growth has slowed down significantly in recent years and is expected to ease further going forward. This slow down reflects the plateauing of the global fleet of internal combustion engine vehicles (due to increasing penetration of battery electric vehicles), higher engine efficiencies that reduce overall fuel consumption, and reaching blending wall limits in mature gasoline markets. These headwinds for Bioethanol are partly mitigated by emerging demand sources beyond road transport. They are further balanced by growing markets where either current Bioethanol use is low (e.g., SEA) or where there's potential for above-blend-wall mixes (e.g., E85, E100 in Brazil or India). These markets are expected to offset the slow decline in more stable markets.

Bioethanol is increasingly positioned as a feedstock for SAF via the AtJ pathway and is also seeing early adoption in maritime applications, e.g., blending trials in marine fuels. Taken together, these segments are expected to generate incremental demand as gasoline blending in road transports growth slows over the next decade.

While **1G Bioethanol** continues to dominate current supply, **2G Bioethanol** is poised to scale post 2030, driven by increasingly stringent sustainability standards, e.g., ReFuelEU Aviation excludes food-crop fuels, and requires 2G Bioethanol for compliance. Despite initial

technical hurdles and delays that have slowed near-term momentum, 2G Bioethanol is expected to scale as technologies advance and production costs improve. One recent success story comes from **LanzaTech, which successfully achieved Guaranteed Performance at the SEKISUI's pilot plant in Japan**, demonstrating reliable performance of their waste-to-ethanol process, which converts unsorted mixed non-recyclable waste into 2G Bioethanol.

2.1.2 Biodiesel

Biodiesel or FAME is the second-largest biofuel by demand today, with volumes expected to increase by around **1.5 to 1.7 times (63-78 Mtpa)** over the next decade, reinforced by higher blending mandates in key markets, e.g., B40 in 2025 in Indonesia and B20 by 2030 in Brazil. This growth trajectory is supported by sustained diesel demand, reflecting slower efficiency gains and limited availability of near-term alternatives, particularly for heavy-duty and long-haul transport. From the 2030s onward, growth is expected to taper as feedstock constraints intensify and Renewable Diesel and SAF increasingly compete for the same constrained oily feedstock pool. At the same time, policy emphasis is expected to shift from volume expansion toward reducing lifecycle greenhouse gas intensity, particularly for the non-UCO based portion of FAME. Even so, Biodiesel is likely to remain an enduring element of the fuel mix for road transport, supported by its technological maturity, established infrastructure, and ability to remain cost competitive with fossil diesel in several markets. There is also potential for new demand for Biodiesel coming from maritime due to engine's compatibility and favorable economics in terms of C-abatement costs, which make it a suitable



fuel to comply with Fuel Maritime EU and, eventually, IMO standards.

2.1.3 Renewable Diesel

Renewable Diesel is expected to be among the faster-growing biofuels, with demand projected to increase by around **2.5 to 3.5 times (41-56 Mtpa)** over the next decade. Growth is strongest in the near term, supported by enabling policy frameworks in the US and under the EU RED III, as well as Renewable Diesel's seamless integration with existing diesel engines and infrastructure (as drop-in solution). Demand is rooted in segments where electrification is slower to scale, such as long-haul heavy-duty trucking, with maritime demand potentially and gradually emerging over the next decade.

Beyond 2030, as traditional oily feedstock constraints emerge, Renewable Diesel growth can be enabled by the potential scale up of NVOs, the next frontier of energy and rotational crops that do not create food vs. fuel competition and can support further scaling of Bio-based Diesel and HEFA-SAF. This pressure can also be partly offset by the gradual scale-up of alternative Renewable Diesel pathways (e.g., the AtJ process for SAF also produces RD, starting from non-oily feedstocks like starch and sugars or other 2G inputs for Ethanol synthesis).

2.1.4 Sustainable aviation fuel (SAF)

SAF is a nascent industry and is forecasted to be the fastest-scaling biofuel, with demand increasing by **20-30x (36-60 Mtpa)** over the next decade as it plays a leading role in aviation decarbonization. This demand is shaped by rising policy momentum, with global frameworks such as CORSIA, regional mandates including ReFuelEU, and national targets such as UK's 10% target, Brazil's aim to reduce emissions by 10% using SAF, Japan's 10% blending mandate plans, Singapore and Thailand's 1% firm mandates started in January 2026. While the HEFA pathway is expected to continue dominating over the next 5-10 years, growth is expected to pivot in the longer term as non-HEFA pathways emerge, reflecting the scale-up of proven technologies supported by expanding capacity buildout (e.g., AtJ, GFT, MtJ).

2.1.5 Biogases

Biogases are expected to scale **2-3x (96-121 Mtpa)** by 2035. While most of the current production is concentrated in the EU and the US, nearly 80% of untapped sustainable potential lies in emerging and developing economies. Asia-Pacific and South America are expected to be the primary growth regions, offering the highest feedstock concentrations and the potential for the lowest production costs globally. This expansion is expected to be supported by energy security priorities reflected in supportive policies, improved feedstock capture, and the build-out of grid-injection infrastructure that allows Biomethane to serve as a direct drop-in substitute for Natural Gas. Carbon markets will also play a key role in supporting the growth of Biomethane in the Global South, e.g., enabled by Article 6, Book and Claim schemes for shipping, or frameworks such as the International Maritime Organization (IMO) and the EU's FuelEU Maritime (Bio-LNG is the most promising decarbonization opportunity in shipping). Collectively, they create globally applicable decarbonization signals, enabling low-carbon marine fuels to scale across international fleets rather than being confined to regional markets. Policy momentum has strengthened globally since 2020, with the introduction of more than 50 new support measures, including blending mandates, grid access rules, and certification frameworks. This has catalyzed demand visibility, project bankability and consequently production capacity and infrastructure scale-up.

2.1.6 Biomethanol

Biomethanol is an industry in early stages of development but exhibits potential to scale rapidly, reaching **2-2.5 Mtpa** by 2030 and **20-23 Mtpa** by 2035, as technology matures and production costs become increasingly competitive. Further expansion is supported by Biomethanol's flexibility and engine compatibility, particularly across marine applications where dual-fuel Methanol vessels are gaining traction. It is also expected to serve as a building block for decarbonizing chemicals like formaldehyde and acetic acid. Industry momentum is already evident through an active project pipeline, including multiple commercial-scale developments in China, Europe and the US.

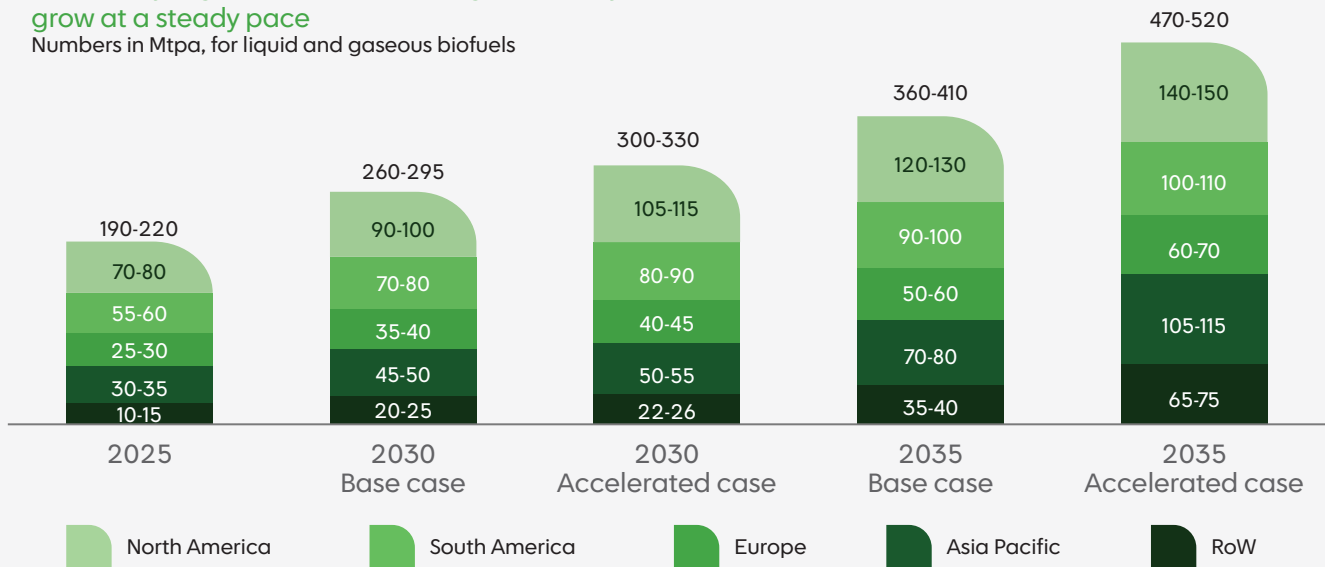
2.2 Demand outlook by region

Biofuel consumption follows divergent regional paths shaped by policy drivers, feedstock access, infrastructure development, financial support, and general market pull. While global demand rises across scenarios, the mix and pace of growth vary materially by region.

EXHIBIT 07 | Biofuels demand forecast by region

Outlook by region: APAC and EU to grow rapidly, while LATAM and NAMR continue to grow at a steady pace

Numbers in Mtpa, for liquid and gaseous biofuels

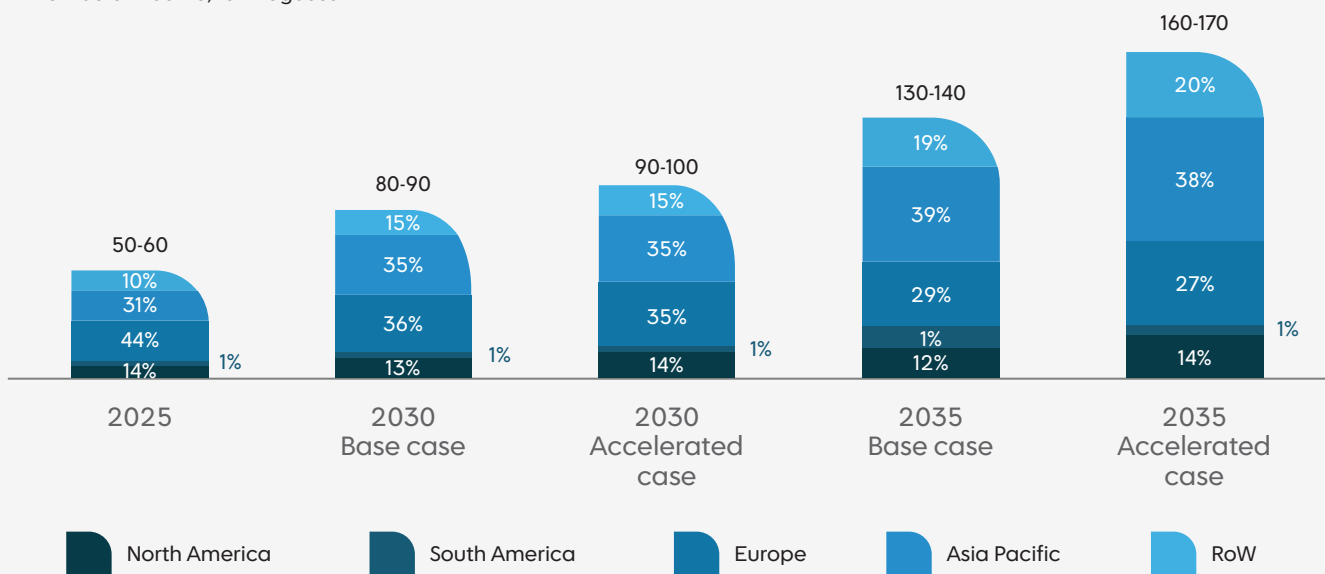


Note: Multiple sources leveraged to determine expected demand for biofuels in 2035 including IEA Renewables 2025 and IEA Biogas and Biomethane Outlook 2025.

EXHIBIT 08 | Biofuels demand forecast by region

Outlook by region: Growth in Biogas and Biomethane will continue to be driven by EU and APAC

Numbers in bcme, for Biogases



Note: Multiple sources leveraged to determine expected demand for biofuels in 2035 including IEA Renewables 2025, IEA Biogas and Biomethane Outlook 2025.

2.2.1 North America remains the largest market for liquid biofuels but becomes less dominant over time

The region continues to be the largest market in absolute terms for liquid biofuels, but its share declines from 39% in 2025 to around 25% by 2035 in the accelerated case as the region is already “built out” with mature 1G Bioethanol and Biodiesel ecosystems and may face marginal impact from electrification in transport. At the same time, policy uncertainty is expected to temper demand growth, for instance in the US, following One Big Beautiful Bill Act (OBBBA) updates to the 45Z clean fuel production credit, which eliminate SAF’s higher tier incentive starting from 2026 (likely to be modified further). By 2035, growth is expected to be led by SAF and Biogas, while Bioethanol and Biodiesel demand remain broadly steady with a gradual shift towards Renewable Diesel.

2.2.2 South America continues to cement its status as a biofuel hub

South America is expected to scale significantly across scenarios and play a strategic role in balancing global supplies. Strong feedstock availability and established infrastructure support are expected to raise the regional share of exports, particularly for Bioethanol. In the accelerated case, Brazil is positioned to meet mandate targets and increase Renewable Diesel blending along with SAF blending, while Bioethanol and Biodiesel blending is expected to rise in Colombia and Argentina.

2.2.3 Europe can see a substantial rise in imports

Europe’s liquid biofuel demand is expected to rise steadily at **8-10% per year across scenarios** driven by policy and compliance requirements. Under RED III and ReFuelEU, incremental demand is primarily dependent on Renewable Diesel, SAF and Biomethane. Fuel Maritime EU regulation will drive uptakes of Bio-LNG, Bioethanol, Bio-Based Diesel and, in the longer term, Biomethanol (and e-ammonia). ReFuel EU will drive demand for SAF, with REDIII driving further demand for road transports. The demand for Biogas is expected to nearly double by 2035, while Bioethanol blending is expected to rise selectively in few regions such as France, Spain, and Nordic countries. In contrast, Biodiesel demand is expected to stagnate in markets such as Sweden, Austria, Belgium and Denmark among others as Renewable Diesel volumes increase. As countries adopt different strategies in RED III implementation, sustainability criteria are tightening within emerging policy frameworks. Consequently,

food-crop fuels are being progressively phased down in favor of more scalable and sustainable second-generation feedstocks, such as waste and residue streams (agriculture, forestry) or rotational energy crops. However, because domestic supply is unlikely to scale in line with rising demand, this transition will further increase reliance on imports.

2.2.4 Asia Pacific is expected to expand its influence as a global growth engine

Asia Pacific records the fastest growth across regions, with the surge driven by strong policy mandates, access to diverse feedstocks and a growing focus on energy independence. Across scenarios, regional demand is expected to grow at 10–14% annually, lifting Asia Pacific’s share of global biofuel demand from around 15-20% today to roughly 25-30% by 2035. The Asian market is also expected to progressively pivot production to local markets, as domestic policies consolidate and stimulate local demand over time. Bioethanol usage in the region is led by India which has reached nearly 20% Ethanol blending by 2025 (from only 5% in 2018-19). Southeast Asia is expected to sustain high Biodiesel blending led by Indonesia (B40 from 2025), Malaysia (B20 by 2030), South Korea (B5 and 3% RD by 2030), Thailand (B10 by 2030) and Philippines (B5 by 2030). The region is also emerging as a SAF hub, supported by blending targets in markets such as Indonesia, Thailand, South Korea, and Singapore and with production plants already operational across Singapore (Neste), Thailand (Bangchak), Malaysia (Ecoceres), and China. Biogases represent a major growth vector, with China and India accounting for the majority of incremental demand, growing by roughly 15x and 7x, respectively by 2035.

2.2.5 Rest of the World can become a rewiring factor

In the accelerated scenario, liquid biofuel demand in the rest of the world grows by around 4-5x by 2035. Growth is supported by early-stage mandates targeting Bioethanol and Biodiesel blending, alongside increasing focus on waste-to-energy pathways. Biogases are expected to see substantial scale-up across these markets, with demand projected to increase by an estimated 4-6x by 2035. While volumes remain smaller in absolute terms, these regions play a growing role in diversifying global supply, demand and future project development.

2.3 Demand outlook by sector

Today, sustainable liquid and gaseous biofuels are highly concentrated in **road transport (75%)**, where liquid biofuels dominate. Beside transport, uptake is largely limited to Biogases in **power (14%) and buildings (9%)**. However, by 2030-35, this mix is expected to change as biofuels will find emerging uses across hard-to-abate sectors. We have highlighted below the key sectoral shifts expected as sustainable fuels scale:

2.3.1 Road transport

The road transport sector is expected to remain the largest consumer of sustainable fuels among all modes with growth driven by Bioethanol, Renewable Diesel, and Biodiesel, especially for heavy-duty trucks which account for 60% incremental demand. However, this growth is expected to be outpaced by other applications, with its share expected to drop from 75% to 50-65% by 2035.

2.3.2 Shipping

Shipping is expected to shift from near-total fossil (fuel oils and LNG) dependence today towards sustainable fuel use as we move towards 2035, driven by evolving global and regional regulations. While Biomethane and Bio-based Diesel will contribute to this sector in the early years, Biomethanol and, potentially, Bioethanol, are expected to scale towards/beyond 2030 as a key marine biofuel. The IMO-MEPC83 draft targets 8-21% and 30-63% fuel GHG-intensity reductions by 2030 and 2035 (vs. 2008), but since the policy is still subject to vote (delayed by 1 year to Oct 2026) for formal adoption, there is uncertainty as to how fast and to what extent biofuels adoption in shipping will happen. In contrast, the FuelEU Maritime regulation provides near-term certainty by requiring reduction of ~6% (2030) and ~14.5% (2035) vs. 2020 to support biofuel uptake in this sector, and unlike IMO it targets only EU related traffic and not all global routes/trades.

2.3.3 Aviation

As covered above, SAF use rises driven by policy mandates and compliance penalties and revenue certainty mechanism (e.g., UK, EU), anchoring aviation's decarbonization through the 2030s.

2.3.4 Buildings

Sustainable fuel use in buildings is expected to increase by ~4-5x by 2035, remaining focused primarily on Biogases for cooking and heating, with limited impact on overall energy shares in this sector.

2.3.5 Power sector

Out of the sustainable liquid and gaseous biofuels used in this sector, Biogases contributed almost entirely to it. This will expand steadily and is expected to more than double by 2035. Biogas will continue to lead due to its ability to provide decentralized electricity and heat generation, whereas Biomethane will grow due to its ability to replace natural gas as a low-carbon drop-in solution and also integrate with Renewable Energy, sources similar to solar, wind, etc., leveraging gas grid infrastructure due to its drop-in nature.

8 2.4 Outlook on feedstock

In the near term, biofuels growth is expected to follow two distinct feedstock tracks. Bioethanol supply remains anchored in first-generation sugar and starch-based (corn) crops, with feedstock demand expected to rise, led by Brazil, India, Indonesia, and the US. In markets with high flex-fuel vehicle penetration, such as Brazil and parts of the US, these feedstocks continue to scale, while in other regions, blending limits and capped offtake constrain further expansion.

Oil-based feedstocks are expected to underpin growth in Biodiesel, Renewable Diesel, and HEFA-SAF, particularly in Europe and North America. Demand for vegetable oils in biofuels production is projected to increase from ~40 Mtpa in 2025 to ~75 Mtpa in 2030, with OBBBA reforms expected to continue favoring conventional 1G feedstocks in USA and EU progressively shifting the entire production to second generation (2G) feedstocks. Demand for waste and residue-derived oils such as used cooking oil and tallow, which are critical for achieving low carbon-intensity compliance (e.g., in EU) and to scale production capacity, is expected to rise from ~17 Mtpa to ~45 Mtpa. As these feedstocks are increasingly drawn into multiple transport end uses, supply is expected to tighten toward the end of the decade. Further growth will be possible only with development, scale-up and deployment of novel oily feedstocks (NVOs) and/or novel technology pathways that can valorize waste feedstocks into advanced 2G biofuels, e.g., gasification of biomass (to produce SAF/RD/naphtha or Methanol or Ethanol), hydrolysis and

fermentation to convert lignocellulosic biomass into Ethanol, AtJ technology to convert sugary/starchy feedstocks into SAF and RD, etc.

As sustainability and GHG performance requirements are expected to tighten, regulatory frameworks such as EU RED III, US RFS, and Brazil's RenovaBio are increasingly steering incremental growth toward second-generation feedstocks. In EU, REDIII caps 1G feedstocks (e.g., soybean, sugar beet, maize, wheat, rapeseed, palm oil) to maximum 7% of final energy consumption in road and rail transport, including Palm Oil ban and even potential POME progressive phase-out in some EU countries. In the UK, a declining cap restricts HEFA to just 71% of the total SAF obligation by 2030, forcing the industry to adopt advanced feedstocks and transition to new production pathways such as AtJ and GFT. These include agricultural and forestry residues, municipal solid waste and lignocellulosic biomass. Despite higher costs and lower technology and infrastructure readiness, policy design in certain regions supports these novel pathways through differentiated crediting and sustainability treatment. As a result, continued growth in advanced biofuels is expected to depend on the successful scale-up and diversification of advanced feedstock supply, with appropriate regulatory steering through mandates, bans or incentives for specific feedstocks.







03

Capital Investment Required in Biofuels

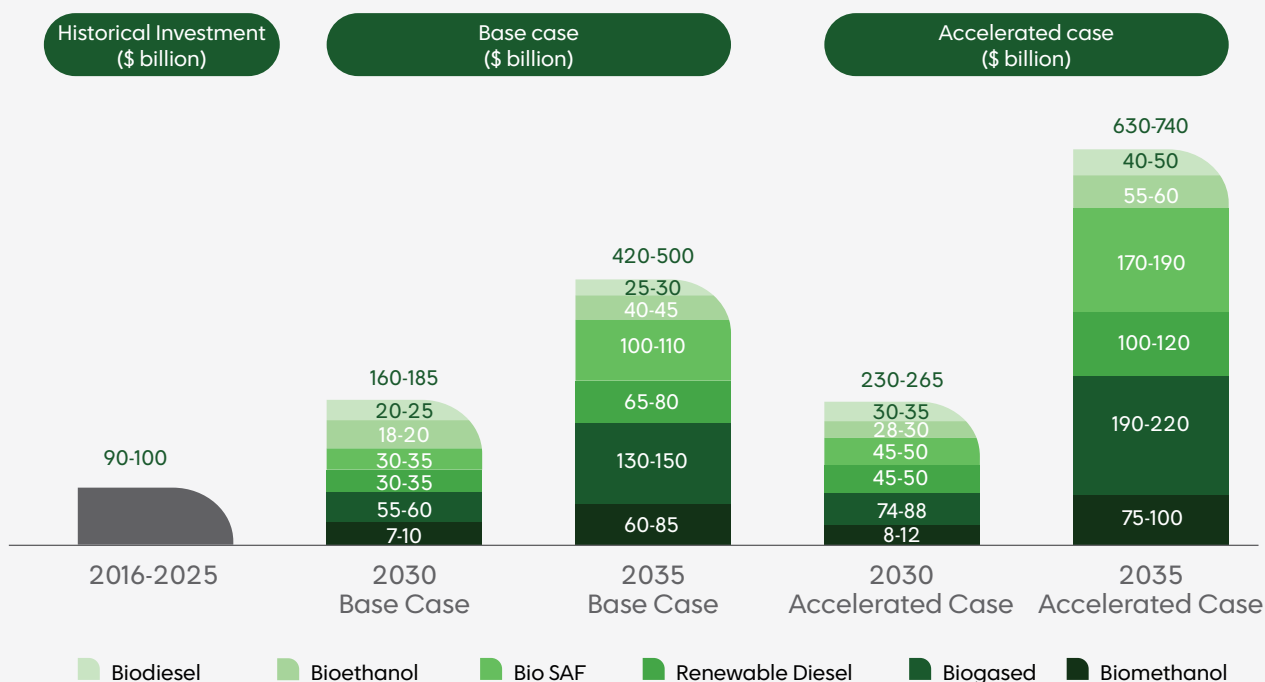
3.1 Investment outlook for biofuels and comparison to historic levels

Historic annual average investment in liquid and gaseous biofuels between 2016-2025 has ranged between **\$9-10 billion**, driven by Bioethanol, Renewable Diesel, and Biodiesel. To achieve sustainable development and meet projected biofuels demand by 2035, significant increase in capital investments is needed across biofuels, feedstocks, and related value chains.

Our analyses suggest that biofuels require **\$630-740 billion** cumulative investment in the **accelerated scenario** and **\$420-500 billion** in the **base scenario** by 2035 to reach liquid and gaseous biofuels projected demand of **470-520 Mtpa in the accelerated scenario and 360-410 Mtpa in the base scenario respectively**. Capital investment should scale **2.5-3x by 2035 as compared to 2030** across scenarios, reflecting the push required for biofuels by 2035 to advance global climate commitments.

EXHIBIT 09 | Capital investment required in biofuels

Global biofuels scale-up demands \$700+ billion in cumulative investment by 2035



Note: The exhibit presents cumulative investment estimates for biofuels under base and accelerated scenarios, based on nominal investment cost assumptions and demand outlook for each fuel type.

Our accelerated scenario is also characterized by strong growth in advanced 2G biofuels post 2030, led by policy direction, climate commitments, and technology advancement. In contrast, 1G fuels will witness moderate growth with an increase in investment of **1.5-2x** of 2030 levels in 2035.

Biofuels must shift from nearly **\$10 billion** annual investments into a major sector, attracting **4-7x** of historical annual average investment levels over the next decade across scenarios. While this seems an unprecedented growth, other energy transition technologies, such as solar energy, saw investments grow **5-6x** between 2019 and 2024 to reach an all time high of **\$500 billion+** in 2024 alone. To meet additional demand by 2030 and 2035, the **annual average investment** needs to scale to **\$40-50 billion per year** and **\$60-70 billion per year**, respectively across our base and accelerated case scenarios.

B 3.2 Capital requirement by fuel types

The investment profile across biofuels shows clear contrasts in both **scale and structure**. Biogases represent the largest pool of capital by 2035, driven by the infrastructure-intensive and distributed nature of Biogas and Biomethane deployment. In contrast, liquid biofuels such as SAF and Renewable Diesel account for a relatively high share of incremental investment growth relative to their current market size, reflecting rapid scale-up from a low base and higher unit capital intensity. Mature fuels such as Bioethanol and conventional Biodiesel absorb capital to sustain growth and optimize existing capacity, resulting in flatter investment trajectories despite their large volumes. Together, these differences shape how capital is deployed across the biofuels landscape in the accelerated scenario.

3.2.1 Bioethanol

Bioethanol is the largest liquid biofuel by volume and the most commercially mature pathway. As a result, it will experience limited step-change growth. In the base case, cumulative investments of \$40-45 billion by 2035 are largely directed toward sustaining output and incremental expansion in emerging markets, with global growth slowing down after 2030. This is driven by headwinds related to regulatory uncertainties in larger markets such as the US, blending wall challenges and electrification trends. In the accelerated case, these headwinds are offset by emerging applications, including Ethanol use in AtJ SAF pathways and potential uptake as an alternative marine fuel leading to higher investment of \$55-60 billion by 2035.

3.2.2 Biodiesel (FAME)

Biodiesel (FAME) from vegetable oil is expected to continue growing through 2035, but will be increasingly outpaced by the expansion of drop-in Renewable Diesel in North America and the EU. This shift reflects emerging blending walls driven by fuel-compatibility constraints, including limitations in existing distribution and storage infrastructure as well as engine and vehicle technology, which restrict higher Biodiesel blend adoption. These dynamics are further reinforced by accelerating electrification in the heavy-duty vehicle segment. In parallel, the EU's increasingly stringent sustainability criteria - particularly its emphasis on waste oils, residues, and non-food crops are expected to slow growth in conventional vegetable-oil-based Biodiesel.



3.2.3 Renewable Diesel

Renewable Diesel also represents a large pool of incremental capital, driven by feedstock diversification and compliance positioning. Renewable Diesel requires a cumulative investment of \$100-120 billion by 2035 in an accelerated case, reflecting its role as a drop-in substitute in markets with tightening diesel standards.

3.2.4 Sustainable Aviation Fuel

SAF represents the fastest-growing investment segment outside Biogases. As mentioned above, HEFA based SAF is expected to dominate production, with non HEFA pathways expected to grow significantly only after 2030 as technologies (e.g., AtJ) mature and scale. Accordingly, investments in HEFA-based SAF from lipid feedstocks are projected to reach \$145-160 billion by 2035 in an accelerated scenario, supported by techno-commercial maturity and established project execution models. In parallel, emerging non-HEFA pathways such as AtJ, Fischer-Tropsch, and Pyrolysis attract \$25-30 billion in the accelerated case by 2035, reflecting the need to diversify beyond constrained lipid-based feedstocks. This rapid scale-up is reinforced by policy frameworks such as HEFA cap in the UK: HEFA can contribute a maximum amount (100%) of SAF demand in 2025 and 2026, decreasing to 71% in 2030 and 35% in 2040.

3.2.5 Biogases

Biogases will account for over 25% of cumulative biofuel investment by 2035, making them the largest investment category in absolute terms. This reflects investment required in the Biomethane value chain, including feedstock collection systems, upgrading units, and grid injection. Strong policy support underpins this scale of investment, particularly in Europe through the REPowerEU non-binding Biomethane target of 35 bcme by 2030. While Europe and North America currently represent more than half of global Biogas demand, Asia is expected to contribute over 30% of incremental growth through 2035, led by China and India, requiring a higher shares of investments in APAC.

3.2.6 Biomethanol

Biomethanol will transition from a nascent to a fast-scaling industry. While investment remains modest in absolute terms by 2030 due to the limited pipeline of mature projects, growth is steep as projects move to early commercial scale.



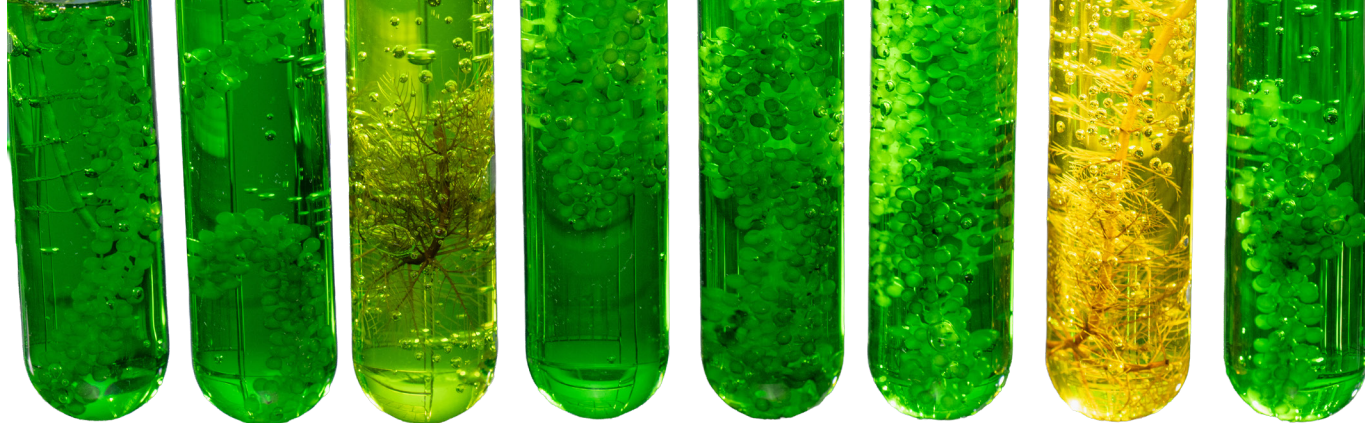
8 3.3 Emergence of Global South

Emerging economies are expected to be **major drivers of biofuel growth** driven by feedstock availability and emerging policy drivers. Recent initiatives like the “Belém 4×10” pledge endorsed by Brazil, India, Italy, Japan, and 23 other nations, explicitly call for quadrupling sustainable fuel output by 2035, with a focus on inclusive, global growth. If successful, by 2035, the biofuels industry will be structurally more balanced with the Global South firmly established as a center of advanced biofuel production, innovation, and feedstock value creation alongside the traditional bioenergy leaders of the Global North. This not only helps achieve global climate goals but also spurs economic development in those regions and particularly across rural areas, making the clean energy transition more equitable.

Over the last few decades, Global South countries like Brazil, India, China, and Indonesia have emerged as strong players in the biofuels industry. Brazil, a pioneer in Ethanol program since the late 70’s, has established a successful Bioethanol market, leveraging locally available feedstock including 1G and 2G Ethanol (Raizen) and derivatives like bio-olefins (Braskem). The Brazilian government plans to build its foothold in the

advanced biofuels ecosystem with its “Fuel of the future” law and is ramping up Biogases and SAF production too. India also embarked on the biofuel transition journey in the last decade and is progressing aggressively, with 20% blending in Bioethanol achieved before the target timeframe. Increased Bioethanol blending is contributing to energy security, foreign exchange savings, and increasing farmer income. India has also diversified its feedstock from sugarcane and corn to bamboo and rice husk. Indonesia has also showcased a steep trajectory with its Biodiesel program, reaching B40 in 2025. Indonesia also introduced regulations to curb exports for UCO and POME to ensure domestic feedstock availability to meet blending mandates. Thailand is also moving towards 1% SAF mandate from 2026, alongside upcoming production capacity from Bangchak SAF plant and PTT Rayong biorefinery with further ambition to expand biofuels production. Through SATAT, India has established mandatory blending targets from 1% in FY26 to 5% by FY29 for CBG (Compressed Biogas) and several subsidy schemes, boosting Biomethane capacity and reaching 170+ plants commissioned to date.





04

Challenges in Financing Biofuels

Biofuels cannot be approached as a single, homogeneous asset class. Risk profiles, returns, and capital structures vary significantly by fuel type, conversion pathways, and stage of technological and commercial maturity.

As global demand accelerates, the sector must address the need for massive annual capital deployment, while navigating challenges rooted in this heterogeneity. Such complexity requires diversified, fit-for-purpose mechanisms to address financing challenges across fuels, countries, and the entire value chain. These challenges span access to capital and a layered risk profile, ranging from feedstock reliability and demand certainty to financial performance metrics such as profitability and cash-flow generation.

While some barriers are common across the sector, their severity remains highly nuanced. Consequently, this chapter unpacks both system-wide challenges and the more specific constraints that differentiate individual biofuel archetypes.

8 4.1 Common challenges across biofuel types

4.1.1 Policy and standards uncertainty

Global biofuels policy frameworks are often fragmented and evolving, undergoing frequent revisions, reversals or delayed implementation that create uncertainty around bankability. Biofuels require support against fossil-based counterparts due to significantly higher production costs, affecting demand and willingness-to-pay which depend on policies comprising blending mandates, fiscal incentives, penalties, certificate, and credit schemes, etc., making them difficult to scale up on a standalone basis. Hence, supportive policy instruments are going to be critical to create this market. Global and regional sustainability frameworks typically define eligibility through feedstock criteria, carbon-intensity thresholds, and GHG accounting rules. Over the past decade, these standards have recalibrated and have been applied with varying degrees of consistency across jurisdictions, exposing projects to revenue uncertainty. Consequently, developers struggle to fully optimize capital structures or in some cases even secure the capital needed for projects. Lenders and investors require higher equity

buffers, shorter debt tenors, and stronger downside protection unless policy-driven revenue risks are mitigated through bankable long-term offtake agreements, price floors, Contracts for Difference or comparable public-sector support mechanisms.

4.1.2 Evolving technology maturity

Many advanced biofuel pathways such as AtJ, GFT, MtJ, and pyrolysis lack a commercial track record and rely on data from smaller non-commercial pilot and demonstration plants. While some insurers offer Technology Performance Insurance (TPI), coverage is selective and carries significant premiums. Similarly, EPC contractors often lack direct experience with these pathways, leading them to price conservatively the integration risks or avoid lump-sum, turnkey contracts all together. This lack of EPC standardization increases execution risk and capital intensity, raising the levelized cost of fuel production, while also exposing the project to significant development and execution risks. With performance and delivery risks insufficiently transferable, a substantial

share of technical risk remains with developers (which are often also the tech developers during scale-up phases) to validate and push the technology in the market. This creates a structural capital mismatch. Infrastructure and private equity funds target de-risked infrastructure assets with contracted cash flows, while venture capital is not set up to finance first-of-a-kind (Foak) plants with CAPEX in the order of few tens to few hundreds of millions of dollars. Consequently, financing constraints persist and the cost of capital increases, constraining project execution and inflating end-product costs.

4.1.3 Gaps in infrastructure and supply chain scale-up

A lack of shared infrastructure across multiple fuel types and technology pathways, particularly in the Global South, combined with immature supply chains, drives project-level costs higher. Deficiencies in transport and logistics infrastructure, including rural road networks, storage facilities, and aggregation hubs constrain viable feedstock collection radii and escalate logistics costs and potentially carbon-intensity. These operational bottlenecks directly erode unit economics and undermine financing viability. Additionally, downstream infrastructure frequently emerges as a critical bottleneck: for example, Biomethane projects face limited access to gas grid connections and injection systems.

For liquid biofuels, infrastructure constraints are more nuanced. While Bioethanol and Biodiesel benefit from mature downstream blending, distribution, and vehicle compatibility in established markets, downstream limitations persist in many Global South contexts. These constraints typically stem from limited retail and quality-control infrastructure, and vehicle compatibility challenges or where supply chains have historically been oriented toward export markets rather than domestic fuel retail. Constraints are particularly acute for SAF, where a lack of certified blending facilities and segregated storage can impact offtake agreements. Without shared or regulated downstream infrastructure, projects would be forced to finance enabling assets on a standalone basis, thereby increasing capital intensity and execution risk while deterring private capital deployment at scale.

4.1.4 Lack of mature carbon markets

Although biofuels can deliver substantial lifecycle GHG reductions, carbon value remains an upside rather than a bankable core revenue stream. International carbon accounting frameworks under Article 6 of the Paris Agreement are still evolving, with ongoing uncertainty around corresponding adjustments, credit eligibility, and interactions with fuel mandates. In parallel,

carbon and fuel registries remain fragmented and largely non-interoperable, limiting the ability to clearly allocate, transfer, and monetize emissions reductions without double counting. While these mechanisms may eventually support robust cross-border value transfer, they currently offer limited revenue certainty for project financing. Carbon pricing applies in sectors like road transport, aviation, and maritime but resulting price signals generally remain insufficient to close the green premium of biofuels relative to fossil fuels. Current compliance and voluntary carbon prices capture only a fraction of the biofuel-fossil fuel cost differential. These markets often lack the long-term price visibility and liquidity required for lenders to treat them as bankable cash flows. However, encouraging developments are emerging in Europe. The extension of the EU ETS to maritime and aviation is beginning to internalize emissions costs in hard-to-abate sectors. In parallel, the reinvestment of ETS proceeds into programs supporting SAF production and infrastructure signals a transition on how carbon markets are utilized. These initiatives reposition carbon markets as strategic tools for de-risking deployment and accelerating scale rather than just pricing instruments.



4.1.5 Weak contractual and commercial execution

Even where supportive policy frameworks and capital instruments are in place, many biofuel projects struggle to reach financial closure due to weaknesses in commercial execution. Offtake arrangements often fail to provide credible volume or pricing certainty, feedstock strategies can leave projects exposed to margin compression, and key risks such as policy change, demand volatility, or operational underperformance are insufficiently addressed in commercial contracts. These shortcomings undermine cash-flow predictability and lender confidence, forcing greater reliance on sponsor balance sheets and slowing deployment despite favorable policy intent.

4.1.6 Market illiquidity and offtake uncertainty of main and co-products

Outside conventional road transport applications for Biodiesel and Bioethanol, markets for advanced biofuels remain relatively illiquid and lack transparent price benchmarks. Buyers like airlines continue to resist long-tenor offtake commitments at premium prices which can be 2.5-5x the cost of fossil fuels. While these premiums are projected to decline as technologies mature and scale, current offtake agreements are typically limited to 5-10 years. This duration falls short of the tenor generally required for project-financed non-recourse structures. This gap creates a structural barrier to debt financing. Similarly, maritime sector offtake activity remains limited and fragmented because counterparties favor shorter and more flexible arrangements amid evolving regulatory frameworks and fuel standards.

4.1.7 Challenges in the Global South

Biofuel projects in Emerging Markets and Developing Economies (EMDEs), particularly across the Global South, encounter additional structural financing challenges. These are largely driven by inherent market inefficiencies and elevated perceived risks. Risks include higher and more volatile costs of capital, limited availability of long-tenor financing, and shallow domestic capital markets. Investors often apply conservative risk premia to reflect concerns around policy durability, contract enforceability, and counterparty creditworthiness, even where underlying project fundamentals are sound. These challenges are compounded by structural mismatches between the decentralized nature of agricultural feedstock supply and the rigid, asset-heavy financing requirements of large-scale biofuel projects. The aggregation of feedstock from fragmented smallholders introduces ecosystem-level execution and logistics risks that are difficult to underwrite on a project-by-project basis. In parallel, developers are frequently exposed to a currency mismatch, with capital expenditures and debt serviced in hard currency and revenues largely denominated in local currency, increasing vulnerability to exchange-rate volatility and further inflating financing costs. As a result, projects that may be economically viable on a risk-adjusted basis often struggle to reach financial closure without concessional capital, blended-finance structures or first-loss and guarantee mechanisms. Addressing these market failures is therefore critical to lowering the cost of capital and unlocking scalable private investment in biofuels across the Global South.

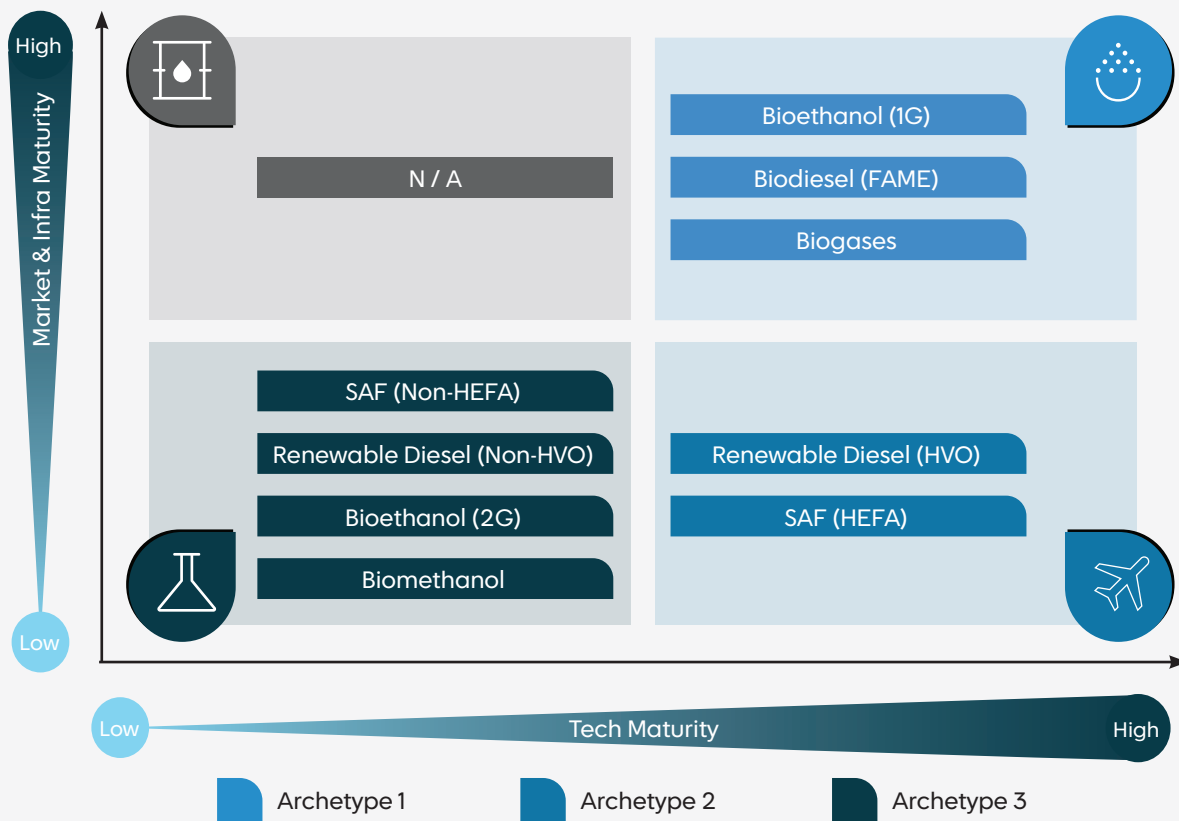
8 4.2 Decoding distinct challenges across archetypes

Meeting future decarbonization targets and hence, biofuels demand, will require a wider range of fuel pathways and feedstocks, implying increased funding needs at different stages of market and technological maturity. As these stages vary, investor risk profiles will also differ.

Overall, financing challenges differ by biofuel archetypes. The rationale for classifying these archetypes is based on **technology maturity**, which measures how proven the fuel conversion process is. Simultaneously, **market maturity** reflects the depth of the commercial system and encompasses established value chains, regulations stability/certainty, infrastructure availability, predictable demand, global footprint, and trading liquidity. This dual-lens approach covers the specific technical and commercial barriers that define each biofuel's path to scale.

As a result (see exhibit below), **Archetype 1** represents mature market bedrocks such as **Bioethanol (1G)**, **Biodiesel** and **Biogases** (the latter particularly in USA and EU), which benefit from established global or regional trade. **Archetype 2** consists of scaling fuels like **HVO Renewable Diesel** and **SAF HEFA** that are technologically mature and commercially proven, but still in the process of expanding market penetration and infrastructure. **Archetype 3** encompasses emerging frontiers, including **SAF (Non-HEFA)**, **RD (Non-HVO)**, **2G Bioethanol** and **Biomethanol**, which currently face lower technical maturity and more significant commercialization and scale-up barriers.

EXHIBIT 10 | Biofuel archetypes by Technology and Market and Infrastructure maturity



This exhibit visualizes the comparative developmental stages of various biofuel archetypes. The positioning is purely illustrative and does not imply strategic superiority or relative market maturity basis stacking. Instead, the quadrants highlight the unique technology and market and infrastructure maturity gaps in each archetype.

4.2.1 Archetype 1 [high tech maturity, high market maturity]

Biofuels like Bioethanol, Biodiesel, and Biogases (particularly Biomethane) have evolved into replicable and increasingly bankable asset classes supported by established technologies and proven operating models. In established markets such as the US, Brazil, and the EU, these assets are often financeable with senior debt because they are supported by policy-backed revenue frameworks like mandates, price floors, and feed-in tariffs. Bankability is often further backstopped by the balance sheets of industry incumbents including oil majors and agribusinesses. However, bankability remains uneven across regions and applications, particularly within EMDEs and in infrastructure intensive uses. In these contexts, financing is more heavily contingent on specific policy support, credit enhancement, and sponsor strength. These biofuels tend to face the following challenges:

- **Feedstock risk dominates cash-flow continuity:** These fuels are exposed to volatile agricultural feedstock prices, weather-driven availability risks, and competing demand from other biofuels. Without long-term supply contracts or

effective hedging, disruptions can impact margins and weaken the ability to service debt on a consistent basis.

- **Working capital intensity is high:** As feedstock procurement is seasonal, inventories must be built up to service plant utilization for the maximum possible duration. This pushes projects toward short-term debt and revolving credit lines, which puts pressure on coverage ratios.
- **Pricing for Biodiesel and Bioethanol remains exposed to both fossil fuel markets and feedstock price dynamics:** Blending mandates help secure volumes but do not insulate revenues from oil and gasoline price cycles. In low fossil fuel price environments, margins can compress and weaken cash flows, particularly when feedstock prices remain elevated. This typically dampens voluntary uptake where buyers are price sensitive and lack regulatory obligation. Conversely, sustained high-price environments can support stronger margins and accelerate capacity additions, increasing the risk of overcapacity over time, especially in Biodiesel markets.

4.2.2 Archetype 2 [high tech maturity, moderate market maturity]

To date, financing for HEFA-based SAF and Renewable Diesel (HVO) has primarily relied on the balance sheets of oil and gas majors, often through joint ventures with feedstock suppliers or offtakers to secure feedstock access and share commercial and execution risks. While these pathways benefit from high technology maturity and proven conversion processes, their market maturity and penetration remains limited. Scale-up has been constrained by structural and market challenges including:

- **Gaps in feedstock bankability:** A key financing challenge is the mismatch between the long tenors required for project finance (typically 10–15 years) and the shorter-duration, less secure feedstock supply arrangements available in competitive lipid markets. HEFA SAF and Renewable Diesel (HVO) projects, in particular, rely on shared pools of waste oils, fats, and other lipids where supply is often contracted on short terms and priced off volatile market indices. From a lender's perspective, this creates unhedged exposure to feedstock price and availability risk, undermining cash-flow predictability and resilience. As a result, projects face higher risk premia, more conservative debt sizing, and lower achievable leverage at financial close.
- **High-cost structures limit margin headroom:** Renewable Diesel (HVO) and HEFA-based SAF projects are often capital-intensive, particularly in greenfield configurations or where significant logistics and blending infrastructure is required. Overall project economics remain sensitive to feedstock costs and policy-linked revenue streams. Margin headroom is highly dependent on feedstock contracting, offtake structures, and policy support. In scenarios where these are weak or short-tenor, adverse movements in input costs, operating performance, or incentive regimes can quickly

translate into pressure on coverage ratios and covenant compliance.

- **Offtake ambition exceeds revenue certainty:** Ambitious decarbonization targets don't consistently translate into the binding, long-tenor offtake agreements required for project finance because policy uncertainty can weaken demand visibility. This instability constrains the willingness of offtakers to commit to long-term premium pricing over long horizons, leaving many SAF/HEFA arrangements without firm volume commitments or enforceable take-or-pay provisions. Without these protections, revenue certainty for lenders is reduced. These factors collectively diminish capital efficiency and increase refinancing risk, leaving the reliability of long-term cash flows as a primary concern for creditors.
- **Price discovery and reset risk:** Limited market liquidity and immature price discovery remain key hurdles for HEFA SAF and Renewable Diesel (HVO). While indicative price assessments exist, these fuels lack deep, transparent, and widely accepted benchmark indices comparable to conventional fossil fuels. As a result, pricing is often established through bespoke contracts with significant reliance on policy-driven components, creating uncertainty around price resets, refinancing, and merchant exposure over the life of the asset. While some policy mechanisms like penalty-backed SAF mandates in the EU framework partially mitigate this, these instruments do not yet constitute fully liquid or hedgeable price signals. Consequently, lenders must rely on cost-plus formulas, bespoke pricing, or policy-driven credit indices, all of which introduce pricing opacity and reset risk. This limited ability to value future cash flows or hedge market exposure forces conventional lenders to apply highly conservative assumptions, resulting in tighter debt sizing and elevated financing costs outside very few mature markets.



- **Competition for internal capital allocation:** Even for projects led by strategic incumbents, HEFA-based SAF and Renewable Diesel investments compete internally for capital against lower-risk opportunities within integrated energy portfolios. This competition can delay Final Investment Decision (FID) timing and favor brownfield retrofits over greenfield projects, ultimately constraining the pace of deployment despite favorable policy signals.

4.2.3 Archetype 3 [low tech maturity, low market maturity]

This archetype, including 2G Bioethanol, Non-HEFA SAF, Non-HVO RD, Biomethanol, and pathways like pyrolysis or hydrothermal liquefaction has relied predominantly on equity-heavy financing complemented by government grants or loan guarantees to mitigate risks. Individual projects which can require up to several hundred million dollars in capital, frequently utilize strategic partnerships between technology providers and offtakers to bridge the ‘valley of death’ between pilot validation and commercial scale. However, bankability remains constrained by residual technology scale-up risks and a structural misalignment between available financing instruments and project risk profiles. Their limited operating track records and integration complexities are compounded by immature demand signals and high green premiums. Collectively, these factors inhibit debt sizing and stall the transition from demonstration to commercial scale, as lenders remain unwilling to credit projected revenues toward debt service. Some of the challenges include:

- **Persisting burden of proof:** Although many of these technologies have progressed beyond pilot or demonstration scale, investors and lenders continue to require evidence of reliable performance at full commercial scale. For financiers, identifying the optimal inflection point to support scale-up remains a significant challenge. This uncertainty often extends feasibility assessments and technical due diligence timelines, while increasing both development and financing costs. Where process validation is incomplete or underfunded, risks frequently surface during early operations, leading to suboptimal performance, extended ramp-up periods or temporary idling - outcomes observed in several Foak projects.
- **Limited assessment capacity and standardization:** The absence of universally accepted technical benchmarks and standardized risk-assessment frameworks constrain lender confidence across this archetype. Unlike mature sectors like solar or wind, most financial institutions lack the in-house expertise to assess competing conversion pathways or realistic performance envelopes for emerging technologies. This benchmarking gap forces a reliance on bespoke expert opinions rather than repeatable analytical models, driving conservative underwriting and elevated transaction costs.
- **Capital requirements exceed traditional financier appetite:** The ticket size for Foak and early commercial plants often exceeds the appetite of any single investor and the assets remain insufficiently de-risked for traditional bank lending. Consequently, projects must rely on complex financing stacks that combine equity, concessional capital and strategic investment. However, aligning the divergent mandates of different types of investors, who often have conflicting priorities regarding risk-adjusted returns or other project requirements introduces significant coordination risk.
- **Construction and development risk:** Foak projects typically lack a proven EPC delivery track record, resulting in contractual structures that fall short of fully wrapped, lump-sum turnkey arrangements. Instead, performance responsibility is often fragmented across multiple contractors and licensors, which obscures liability and increases exposure to cost overruns and interface risks. Without a single point of accountability for cost and schedule, construction risk cannot be effectively transferred away from the project company. From a financing perspective, this fragmentation weakens risk mitigation, forcing lenders to require higher equity buffers, reduced leverage, higher interest rates or delayed participation. Additionally, the high dependence on imported machines by developing countries can significantly raise costs.
- **Operational Performance and Execution Risk:** Achieving stable production yields is challenging, as early facilities require complex integration to run reliably. Foak projects face high ramp-up risk, where initial performance volatility can disrupt cash flows and delay debt service. To mitigate this, lenders often require liquidity cushions to absorb potential shortfalls during these initial periods, which can extend into years. While performance guarantees and insurance improve credit protection, their high costs further weigh on project economics for developers.

8 4.3 Assessing challenges across the value chain

Biofuel risks are not uniform across the value chain. They vary by segment, as different actors face distinct technical, commercial, and regulatory constraints. Understanding these segment-specific risk profiles is critical to designing financing structures that can support scale. The Biomethane value chain illustrates these dynamics clearly:

- **Feedstock collectors and providers:** Feedstock collection is often undertaken by smallholder farmers or Small and Medium Enterprises (SME) aggregators, for whom the capital required to develop collection hubs or logistics infrastructure can be prohibitive. These entities typically lack formal credit ratings or balance-sheet strength, making it difficult to meet bankability requirements. Additionally, feedstock providers face a contractual deadlock: producers are reluctant to enter into long-term supply agreements without firm demand commitments from downstream buyers, while financiers seek secured feedstock contracts as a precondition for financing.
- **Project developers:** Smaller and independent developers frequently face high upfront permitting and development costs, alongside challenges in monetizing by-products such as digestate, which lenders often discount or exclude due to fragmented markets and regulatory uncertainty. Developers are also exposed to a classic coordination problem: debt financing typically requires signed offtake agreements, while offtakers may delay commitments until projects reach financial close. For larger plants, banks may require corporate-level collateral rather than relying solely on project cash flows, creating an additional barrier for developers without sufficient balance-sheet capacity, which represents the large majority of players.
- **Technology Providers and EPCs:** Many specialized Biomethane technology providers and EPC contractors lack the balance-sheet strength required to offer the performance guarantees, completion bonds, or liquidated damages lenders typically expect. This limitation prevents a full wrap of construction and performance risk, leaving greater residual risk at the project level. Consequently, lack of creditworthy counterparties to back these liabilities reduces overall financeability.
- **Midstream traders:** Midstream traders and aggregators often assume counterparty and volume risk by committing to long-term delivery obligations while sourcing Biomethane from multiple small or mid-scale producers having heterogeneous performance profiles. Under-delivery risks are difficult to hedge, particularly where upstream suppliers lack the balance-sheet capacity or contractual penalties needed to compensate for shortfalls. This exposure weakens the credit quality of aggregated supply contracts and, in turn, reduces the bankability of downstream offtake arrangements.
- **Off-takers:** Offtakers face minimal operational risk, but often face challenges in financing last-mile infrastructure, such as pipeline connections or grid injection facilities, which have limited alternative use if production ceases. This creates stranded asset risk, making it difficult to raise upfront capital for interconnection. In addition, offtakers may struggle to justify the price premiums over fossil gas, particularly where demand relies heavily on subsidies or policy support rather than structural cost competitiveness.
- **Financiers:** High transaction and due diligence costs make small, bespoke Biomethane projects unattractive on a standalone basis. This is especially true for Foak facilities, which have higher unit costs and smaller scales. A lack of standardized structures, combined with policy-dependent revenues and feedstock risks, makes the financing process complex and limits available debt. Furthermore, limited secondary markets and exit options reduce investor interest. Unless projects are aggregated into portfolios to spread risk, financiers prefer larger renewable assets where time and risk involved are more proportionate to the investment size.

8 4.4 Unpacking challenges across the project lifecycle

Financing hurdles for biofuel projects evolve as projects move through successive development stages. This dynamic is particularly pronounced for SAF and advanced biofuels, where projects navigate long and complex development timelines often spanning several years from concept to the Financial Investment Decision (FID), particularly for Foak facilities but also, to a certain extent, for larger scale commercial plants. As risks are progressively revealed, reallocated or amplified across the lifecycle, financing constraints mutate accordingly. This section examines these stage-specific challenges and how they interact with capital availability and lender behavior.

- **Conceptualization and Pre-Feasibility:** Conceptualization and pre-feasibility are the earliest development stages, preceding Front End Engineering Design (FEED) and FID. Developers focus on feedstock mapping, preliminary engineering, and regulatory scoping to assess commercial viability. While capital requirements are modest compared to later FEED and EPC phases, these costs are non-recoverable and spent without bankable assets or contracted revenues. Because this stage is highly uncertain, traditional lenders view it as too speculative for debt, leaving projects reliant on sponsor equity or grants.
- **Front-End Engineering Design:** Risks often intensify during the FEED phase as capital commitments increase and uncertainties begin to crystallize into defined cost, schedule, and execution exposures. For emerging pathways, this is driven by uncertainty around process scale-up, integration, and performance. For mature commercial pathways, risk concentrates on execution factors like feedstock logistics, permitting, and CapEx accuracy. Lenders typically respond by applying conservative assumptions to cost and schedule, requiring higher equity buffers to protect against delivery risks. Insufficient investment in rigorous FEED or independent technical and cost validations can undermine downstream bankability, as weaknesses often surface during later stages. Simultaneously, milestones such as independent engineer reviews, firm contractor selections, and counterpart commitments become critical. At this stage, any delays or incomplete documentation can significantly increase lender hesitation.
- **Final Investment Decision:** FID represents the principal bankability gate where risks crystallize around a project's resilience under downside scenarios for pricing, feedstock costs, and operating performance. Access to non-recourse debt at commercial scale remains highly constrained without creditworthy offtake agreements that provide sufficient revenue certainty. In SAF in particular, lenders often require firm and long-tenor volume commitments and take-or-pay structures to bridge the green premium relative to fossil jet fuel. Partial offtake coverage that leaves material exposure to merchant pricing typically fails to satisfy lender requirements, limiting leverage or delaying financial close.
- **Construction and Implementation:** Execution risk peaks during construction, especially for FoaK or early-scale plants. The absence of standardized engineering templates and repeatable delivery models increases exposure to cost overruns, schedule slippage and interface risk. Where construction risk is insufficiently wrapped or shared, overruns and delays are absorbed primarily by the sponsor's balance sheet. This can heighten liquidity pressure and, in some cases, threaten project completion before revenue generation begins.
- **Commissioning and Operations:** Early operations are a fragile phase because debt service and covenant compliance rely on hitting performance targets and stable throughput almost immediately. This leaves little room for error as technical issues during the ramp-up can easily disrupt cash flows and delay the transition to steady-state operations. Such disruptions are often compounded by high maintenance costs for specialized equipment which further strain liquidity and reinforce lender caution toward FoaK assets. These risks are heightened by the need for specialized O&M skillsets during ramp-up.
- **Decommissioning:** The end-of-life phase introduces long-tail liabilities like site remediation and waste handling that require early financial planning. These obligations create a lingering credit risk if they are not clearly defined or funded because they can weaken sponsor balance sheets and limit future borrowing. As a result, lenders tend to scrutinize decommissioning provisions even during the earliest stages of development.



05

Financing Biofuels at Scale: Matching Capital, Risk, and Policy

As discussed in the previous chapter, financing needs across biofuel pathways vary primarily because of **technology maturity, country/state level policy designs, and allocation of risks across the value chain**. In combination with prevailing market conditions, these factors determine how reliably future revenues can be converted into bankable cash flows.

Building on the archetypes defined in Chapter 4, this chapter examines how financing solutions must be tailored to different combinations of technology and market maturity. For Archetype 1 pathways, characterized by high technology and market maturity, financing is typically anchored in conventional debt, refinancing, and infrastructure-style capital. Archetype 2 pathways, involving mature technologies scaling into expanding or less established markets, require a combination of strategic equity, risk-sharing instruments, and policy-backed revenue certainty to bridge scale-up risk. Archetype 3 pathways, defined by emerging technologies and low market maturity, rely most heavily on grants, concessional capital, guarantees, and platform-based approaches to reach early commercial viability. Across all archetypes, the effectiveness of these financing approaches ultimately depends on strong commercial execution, as only credible offtake, resilient feedstock strategies, and well-defined risk allocation allow policy support and capital instruments to translate into bankable cash flows.

Accordingly, this chapter examines financing through four lenses: where capital comes from, who absorbs risk, how scale can be achieved through structuring and platforms, and how policy frameworks help make revenues bankable, showing how capital stacks evolve across archetypes as projects move from Foak to scalable deployment.

In that context, five major categories of financing approaches occur, mentioned in the exhibit below:

EXHIBIT 11 | Financial instruments discussed in this chapter

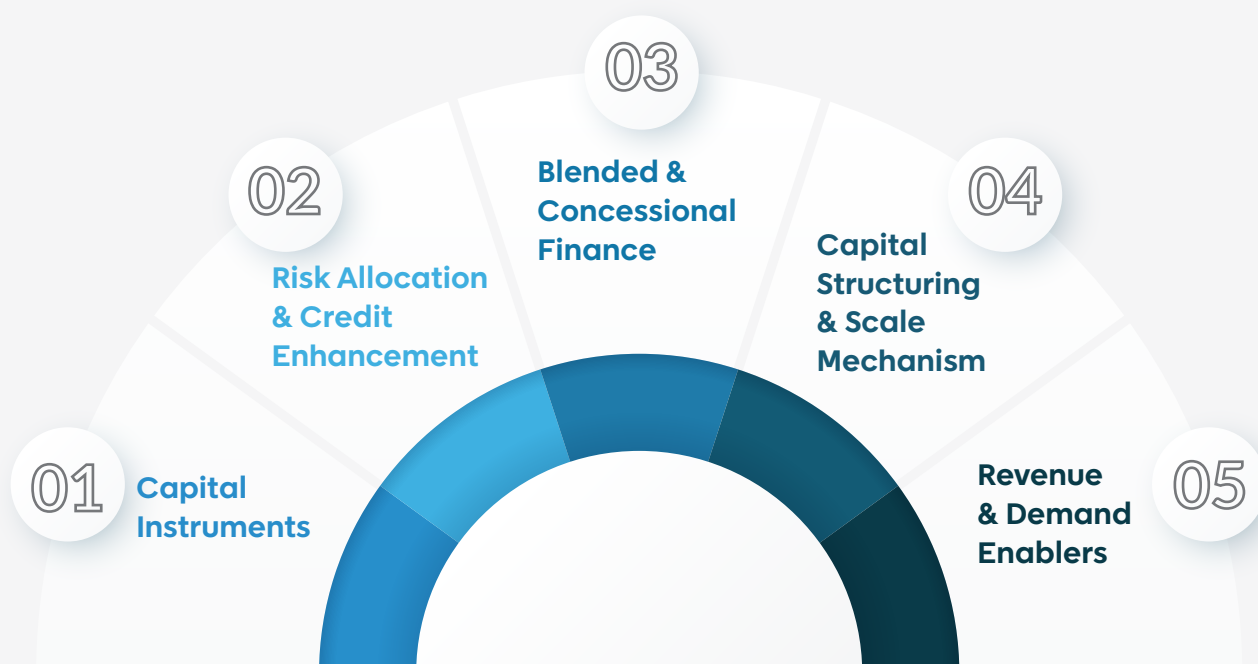


EXHIBIT 12 | Financial instruments discussed in this chapter

 Category	 Instrument / Mechanism	 Brief Description
Capital Instruments	Corporate balance-sheet equity / JV equity	Equity capital deployed directly by sponsors or strategic partners to fund project development and construction, typically supported by corporate balance sheets rather than project cash flows
	Venture & growth equity	Equity investment used to support technology development, for Foak facilities, or early commercial scale-up, typically at the corporate or platform level and bearing higher technology and execution risk
	Project finance (limited/non-recourse debt)	Asset-level debt raised at the project/SPV level and repaid primarily from project cash flows, with limited or no recourse to sponsor balance sheets
	Infrastructure debt / infrastructure funds	Long-tenor debt or equity provided by banks, institutional investors, or infrastructure funds targeting de-risked, operational assets with stable and predictable cash flows
	Green bonds / sustainability-linked bonds	Capital markets instruments issued by corporates or projects where proceeds or pricing are linked to environmental objectives or sustainability performance metrics
	Working capital & trade finance	Short-term financing facilities used to fund feedstock procurement, inventory, receivables, and other operational liquidity needs during ongoing operations
	Grants (R&D, FEED, demo, CAPEX)	Non-repayable public funding provided to support R&D, front-end engineering, demonstration projects, or capital expenditures for early-stage and FOAK activities
	Subsidies (CAPEX & OPEX)	Direct financial support mechanisms that reduce upfront capital costs or ongoing operating costs, including investment grants, tax incentives, or per-unit production support
Risk Allocation & Credit Enhancement	Results-based finance (RBF)	Payments disbursed upon the verification of predefined outputs or performance outcomes (e.g., volumes produced, emissions reduced), shifting delivery risk to the project while rewarding achieved results
	Loan guarantees / public credit support	Public, multilateral, or export credit guarantees that partially or fully cover debt service in defined downside scenarios, reducing lender risk and improving debt terms
	First-loss / subordinated capital	Junior capital that absorbs initial losses ahead of senior debt or equity, enhancing the risk profile and creditworthiness of senior investors
Blended & Concessional Finance	Insurance (political, Forex, performance/ feedstock)	Risk transfer products that protect against non-commercial risks (e.g. political events, currency inconvertibility), as well as selected technical, performance, or supply risks, improving bankability
	Blended / concessional finance (structuring approach)	Financing structures that combine public, philanthropic, or concessional capital with commercial investment to improve risk–return profiles and crowd in private capital



Category

Instrument /
Mechanism

Brief Description

Capital Structuring & Scale Mechanisms

Platform investments / aggregation finance

Portfolio-level investment structures that pool multiple assets or projects to diversify risk, reduce transaction costs, and enable more efficient capital deployment

Refinancing (post-COD repricing)

Replacement of higher-cost or shorter-tenor construction or early-stage capital with lower-cost, longer-tenor financing once assets are operational and hence de-risked

Revenue & Demand Enablers

Mandates / blending obligations

Regulatory requirements that compel minimum use or blending of low-carbon fuels, creating non-discretionary demand and underpinning market formation

Compliance credit revenues (e.g. LCFS, ETS effects)

Revenues derived from tradable regulatory credits linked to verified emissions reductions or fuel attributes, supplementing core fuel revenues

Revenue certainty schemes (CfDs, strike prices)

Policy or contractual mechanisms that stabilize revenues by compensating for deviations between market prices and pre-defined reference prices over a fixed period

Long-term offtake contracts

Binding purchase agreements with creditworthy counterparties that provide volume, pricing, and tenor certainty, forming the foundation for project bankability



8 5.1 Capital Instruments across the biofuels lifecycle

Scaling and commercializing biofuels depends not only on technological readiness and policy frameworks, but on a **financial architecture** in which different instruments apportion risk across the project, in line with asset maturity. Financing is most efficient when instruments are matched to specific use cases, showcased below:

EXHIBIT 13 | Financing instruments suitable for varying biofuel archetypes

Instrument/ Approach Category	Financing Instrument/ Approach	Archetype 1	Archetype 2	Archetype 3
		Mature and mass deployed	Mature tech, expanding markets	Emerging tech in nascent markets
 Capital Instruments	Corporate balance-sheet equity / JV equity			
	Venture & growth equity			
	Project finance (limited/ non-recourse debt)			
	Infrastructure debt / infrastructure funds			
	Green bonds / sustainability-linked bonds			
	Working capital & trade finance			
	Grants (R&D, FEED, demo, CAPEX)			
	Subsidies (CAPEX & OPEX)			
 Risk Allocation & Credit Enhancement	Results-based finance (output-linked)			
	Loan guarantees / public credit support			
	First-loss / subordinated capital			
 Blended & Concessional Finance	Insurance (political, FX, per- formance/feedstock)			
	Layered public-private capital stacks			
 Capital Structuring & Scale Mechanisms	Platform investments / ag- gregation finance			
	Refinancing (post-COD risk re-assessment)			
 Policy-linked Revenues & Carbon Market Enablers	Mandates / blending obligations			
	Compliance credit revenues (e.g. LCFS, ETS effects)			
	Revenue certainty schemes (CfDs, strike prices)			
	Long-term offtake contracts			

Widely applicable/typically bankable
given current maturity

Conditional (depends on offtake,
policy, sponsor strength, or structure)

Generally not viable as a primary
instrument today

5.1.1 Green Bonds

Green bonds have emerged as a core financing instrument for Renewable Energy, including bioenergy projects which qualify through verified emissions-reduction and climate mitigation benefits. For biofuel developers with mature technologies and stable cash flows, such as Bioethanol plants or Renewable Diesel refineries, green bonds can lower the cost of capital through competitive interest rates. Their suitability is highest where feedstock supply, technology, and offtake are already de-risked through long-term contracts and stable policy frameworks, making them particularly effective for second-plant, brownfield, or modular investments with established operating histories.

For instance, in 2023, **BURN Manufacturing** issued sub-Saharan Africa's first green bond, raising \$10 million to expand clean cooking stove production in Kenya. The proceeds increased biomass and Biogas cookstove manufacturing from 400K to 600K units per year.

Despite cumulative issuances surpassing \$3 trillion and annual issuance crossing \$577 billion in 2024, green bonds still account for just 3% of the global bond

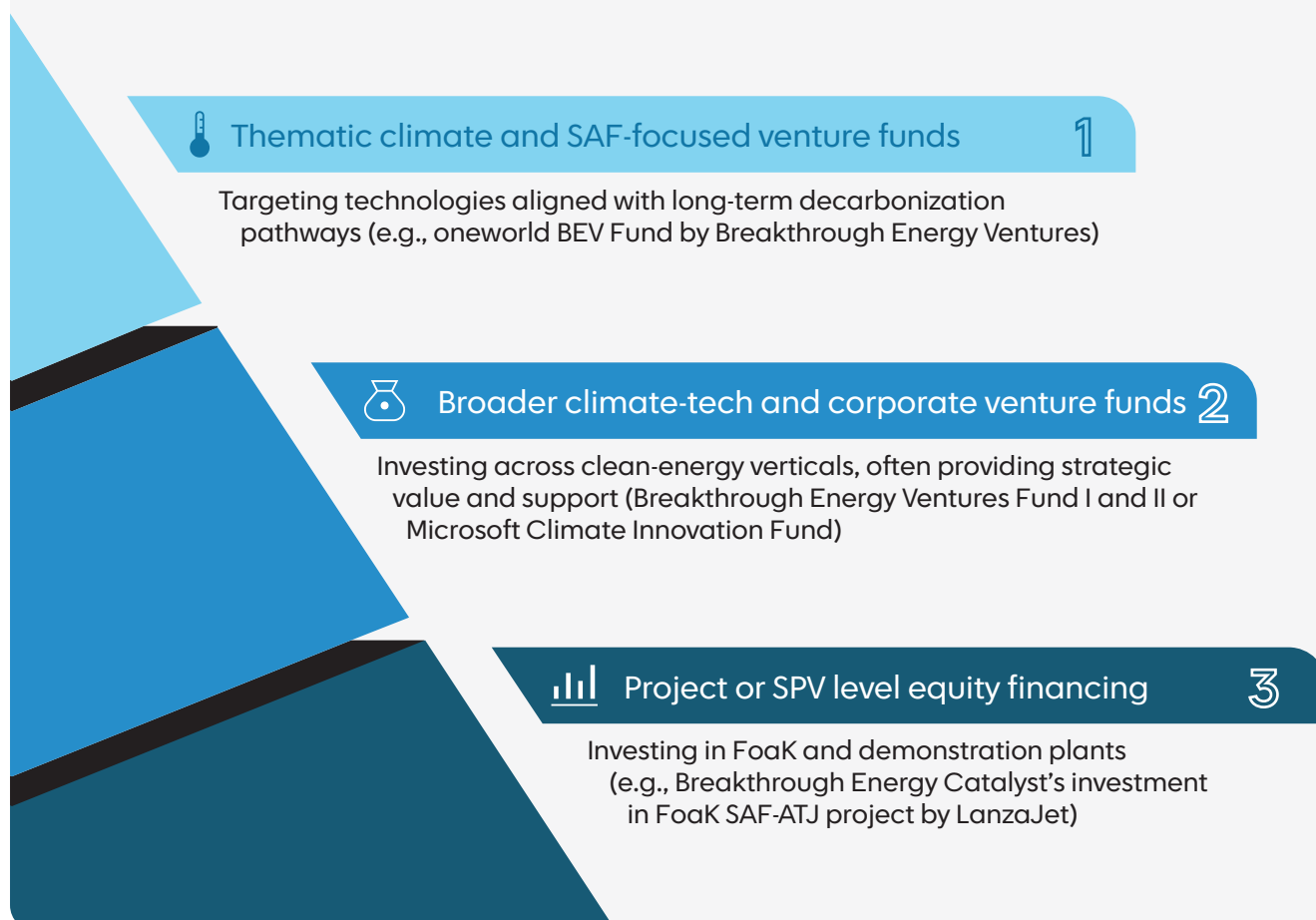
market. Their expansion is hindered by regulatory complexities, high issuance costs, greenwashing, disappearing green premiums, and inconsistencies in green definitions across jurisdictions. Their impact is maximized when paired with clear policy signals and robust governance frameworks.

5.1.2 Venture and Growth Equity

Venture capital plays a critical role in supporting emerging and pre-commercial technologies by underwriting technology development and early scale-up risk in exchange for long-term growth potential and strategic positioning. VC participation in advanced biofuels generally falls into three categories, as covered in exhibit 14, with the first two accounting for the vast majority of activity to date, while direct project-level participation remains the exception rather than the norm.

A useful illustration is provided by **LanzaJet**, a US-based SAF developer, which demonstrates how venture capital, strategic equity, grants, and project-level finance can be combined to support Foak deployment. Over the early 2020s, the company raised significant

EXHIBIT 14 | Broad categories of VC participation in advanced biofuels



equity capital from a mix of venture investors and strategic partners including climate-focused funds, airlines, OEMs, and energy companies to advance and commercialize its Alcohol-to-Jet technology. For its Freedom Pines FoaK facility, this equity was complemented by a blended capital stack that included grant support from Breakthrough Energy Catalyst, alongside other forms of public and strategic financing. This combination and stacking of equity, grant funding and concessional capital, enabled the delivery of a pre-commercial scale FoaK SAF-AtJ plant. This project provided the technical and financial validation needed to underpin subsequent scale-up efforts and projects bankability, potentially unlocking subsequent investments for the future pipeline of commercial AtJ plants globally.

5.1.3 Grants, Subsidies and Results-Based Finance (RBF)

Grants, subsidies, and RBF are catalytic instruments, forms of public or quasi-public capital, used primarily to support R&D, early deployment, and FoaK or early commercial biofuel projects that are not yet financeable on purely commercial terms. While these instruments differ in their disbursement mechanics, ranging from upfront, ex-ante support to performance-linked payments, they serve a common function: absorbing early-stage technology, execution, and market risks that private capital is typically unwilling to assume.

Grants, particularly those targeted at R&D, engineering, and early scale-up, play a critical role in de-risking innovation by funding activities such as laboratory research, pilot plants, FEED and early project development. Many governments have established dedicated grant programs for advanced biofuels. For example, the US DOE's Bioenergy Technologies Office (BETO) provided a funding opportunity of up to \$30.3 million, specifically for **"Scale-up of Biotechnologies"** to fund projects ranging from TRL 3 to 7.

The EU Innovation Fund, financed through proceeds from EU Emissions Trading System (EU-ETS), has similarly supported FoaK advanced fuels projects at scale, with the Innovation fund mobilizing billions of Euros over 2020-2030. **BIOZIN in Norway** received €75 million to develop a commercial lignocellulosic drop-in biofuels

facility using Shell's IH2® technology, converting forestry residues into jet fuel, diesel and gasoline. **LanzaTech** secured a €40 million EU Innovation Fund grant for FoaK integrated Carbon capture, Utilization and Storage (CCUS) to 2G Bioethanol project in Norway.

Beyond grants, **capital and production subsidies** are deployed in some jurisdictions to reduce delivered fuel costs and support early market formation. These mechanisms can include upfront CAPEX support (e.g., US IRA's Investment Tax Credit), operating subsidies/incentives (US IRA-45Z), per-unit production incentives, or infrastructure funding. The **US IRA Section 45Z Clean Fuel Production Credit**, is a technology-neutral, performance-based tax credit that rewards the production of low-carbon transportation fuels based on their lifecycle carbon intensity relative to a fossil baseline, providing per-unit support to help close the cost gap during early market formation.

Under **India's SATAT initiative**, the government provides price assurance and offtake guarantees through public Oil Marketing Companies (OMCs), complemented by capital subsidies for CBG plants and support for gas distribution infrastructure upgrades/extensions, already supporting **177 operational projects** as of end-2025.

Results-based finance is another useful tool with disbursements explicitly linked to the achievement of predefined and independently verified outcomes such as volumes of biofuel produced, capacity commissioned or the number of systems installed. This creates incentives for delivery and operational performance. A recent example is the Modern Cooking Facility for Africa (MCFA), a results-based financing program supported by European and Nordic donors. In 2024, MCFA awarded a €2 million **performance-based grant to Home Biogas in Kenya**, with payments linked to verified household biodigester installations. The program targets the deployment of around 34K systems by 2028, reaching approximately 170K smallholder farmers and catalyzing private co-financing, which is expected to at least double the total capital invested.

8 5.2 Risk Allocation Approaches and Credit Enhancement Instruments

Public credit enhancement mechanisms also play a critical role in enabling Foak and early-stage projects. In addition, Export Credit Agencies (ECAs) play a critical role in credit enhancement for biofuel projects by providing guarantees, direct loans, or insurance linked to the export of equipment, technology, and engineering services. In some cases, ECA support can also be anchored to long-term offtake arrangements with buyers in the ECA's home market, indirectly strengthening project bankability. ECAs and institutions driving export credit enhancement such as Denmark's EKF, Sweden's EKN, and Germany's Euler Hermes are involved in capital-intensive biofuel and bioenergy projects, particularly in emerging markets.

5.2.1 Loan Guarantees

Loan guarantees are a credit-enhancement instrument that reduce lender risk by partially transferring default or performance exposure to another entity, potentially public or multilateral. In the biofuels sector, they are particularly effective in enabling senior debt for Foak and early commercial projects where policy frameworks and demand signals are credible, but operating, scale-up, or integration risks remain elevated.

In the US, the **Department of Energy's Loan Programs Office** has deployed loan guarantees and direct loans to support advanced biofuel and SAF facilities, particularly those involving novel technologies and Foak deployment, by improving debt tenor, pricing and lender confidence. Similarly, in Kazakhstan, the **European Bank for Reconstruction and Development (EBRD)** de-risked a SAF project through feasibility studies, late-stage equity and guarantees.

In the European Union, the **European Investment Bank (EIB)** plays a central role in providing long-tenor, policy-aligned debt and risk-sharing support for First-of-a-Kind and early commercial clean energy projects, including advanced biofuels and renewable fuels. By lending alongside commercial banks or through EU risk-sharing facilities, the EIB helps lower financing costs, extend maturities and crowd in private capital for CAPEX-intensive biorefineries that would otherwise face prohibitively high weighted average costs of capital. Recent examples illustrate this catalytic role: the **EIB agreed upon a €285 million loan with Cepsa** to finance a second-generation biofuels plant in Andalusia producing SAF and Renewable Diesel from organic waste, underpinned by circular-economy feedstocks.

Bilateral public finance institutions also play a complementary role. In 2025, the **Japan Bank for International Cooperation (JBIC)** signed a **\$408 million loan agreement with Power Finance Corporation Limited** to support renewable and next-generation energy projects in India, including a bamboo-based second-generation Bioethanol facility in Assam. JBIC committed approximately \$244 million

of the total financing and provided guarantees to mobilize private co-financing, thereby reducing credit risk and improving bankability for a 2G biofuel project aligned with India's Ethanol-blending objectives.

5.2.2 Insurance-based derisking products

Insurance products can play an important role in strengthening the bankability of biofuel projects by reallocating selected risks away from lenders and investors, covering both non-market and technical exposures. While insurance is not a substitute for sound project fundamentals, it can materially improve risk allocation when deployed in a targeted and disciplined manner. On the non-market side, political risk insurance, provided by institutions such as the **Multilateral Investment Guarantee Agency (MIGA)**, has been used to support Bioethanol, Biodiesel, and Biogas projects in EMDEs, protecting investors and lenders against risks such as expropriation, breach of contract, currency inconvertibility and political violence.

In these contexts, **political risk coverage** has enabled foreign equity participation and longer-tenor debt financing where sovereign and regulatory risks would otherwise prevent financial close. In parallel, **technical and operational insurance products** have been applied across several biofuel pathways to address performance- and feedstock-related risks. In agricultural biofuels such as corn and sugarcane ethanol, producers routinely rely on **crop insurance and weather-linked risk products** to mitigate feedstock availability and cost volatility arising from droughts and other climate events. Similar approaches have been extended to energy-crop-based Biogas projects, where biomass supply reliability is a critical determinant of operating performance.

For Biogas and Biomethane plants, lenders frequently **require performance guarantees**, often provided by technology suppliers and, in some cases, backstopped by insurers, covering minimum gas yields, methane concentration and plant availability during the early operating period. These guarantees can partially substitute for higher equity buffers by reducing downside risk during ramp-up and stabilizing early cash flows.

In more advanced and Foak biofuel pathways, including 2G Bioethanol and non-HEFA SAF, a limited number of insurers have begun offering Technology Performance Insurance (TPI) to cover defined underperformance risks relative to predefined output or efficiency thresholds. While such coverage remains selective, narrowly scoped, time-limited, and relatively expensive, it has been deployed alongside public guarantees, sponsor support, and concessional capital to help bridge lender confidence gaps where EPC wraps and operating track records are incomplete.

Separately, construction and Delay-in-Start-Up (DSU) insurance is widely used in large Bioethanol, HVO, SAF, and integrated biorefinery projects, particularly

where bespoke equipment and long lead-time components increase schedule risk. These policies protect debt service during insured construction delays and are a standard component of bankable risk-management packages.

Taken together, these biofuel-specific insurance solutions demonstrate how risk transfer mechanisms, when appropriately structured, can complement public support and sponsor equity, improving bankability across a range of biofuel technologies while recognizing the inherent limits of insurability for technology and market risk.



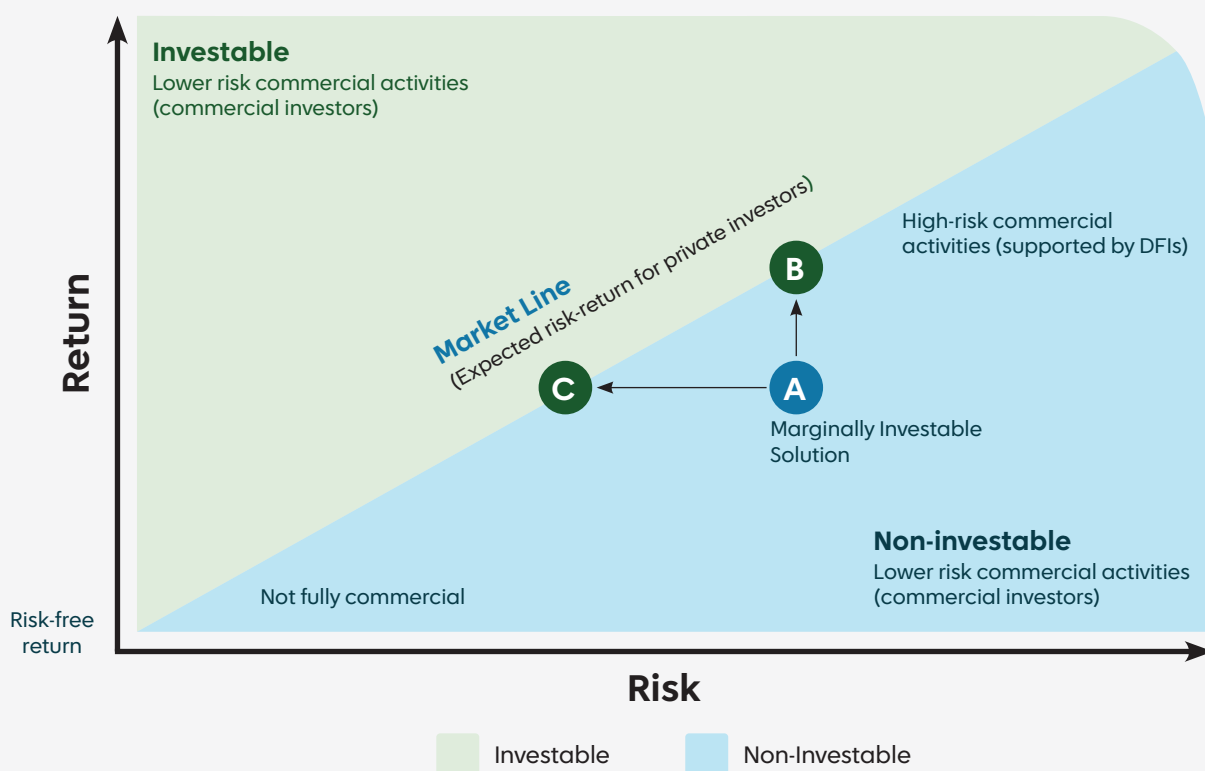
5.3 Blended and concessional financing approaches

In cases where policy, regulatory, or market conditions are not conducive to attracting private sector investments, alternative financing mechanisms like concessional and blended finance can play a targeted role in mobilizing private capital for climate-aligned projects. **Concessional finance** provides public or philanthropic capital on preferential terms through pricing, tenor or risk absorption to address specific market failures, while **blended finance** strategically combines concessional and commercial capital to improve risk-return profiles without permanently subsidizing project economics.

These approaches are particularly suited to early-stage or higher-risk biofuel projects, using mechanisms such as guarantees, first-loss tranches, and concessional debt to mitigate downside risk or improve cash-flow certainty. Critically, these first-loss and blended structures are most effective when applied selectively and at scale, targeting clearly defined market failures rather than individual projects in isolation. When deployed programmatically, across multiple projects, technologies, or geographies, they can reduce transaction costs, improve learning effects and create a pathway toward fully commercial financing over time.

EXHIBIT 15 | Blended finance in a nutshell

Illustrative



Blended finance is deployed through a set of **well-established instruments** that address different stages of project development and risk spectrum. Early in the project lifecycle, grants and technical assistance support preparation activities such as FEED studies and ESG assessments, often delivering high leverage by converting concepts into bankable opportunities. As projects advance, concessional debt with instruments like first-loss capital improve credit quality and protect senior investors. At later stages, guarantees and insurance instruments such as political risk insurance and foreign-exchange hedging help unlock long-tenor commercial debt, particularly in emerging markets.

In practice, the most catalytic form of blended finance for biofuels, particularly in early commercial and emerging-market contexts, has been the deployment of risk-absorbing capital and first-loss capital provided by Multilateral Development Banks (MDBs), Development Finance Institutions (DFIs) and philanthropic investors. Rather than subsidizing project economics on a permanent basis, these structures are designed to absorb early downside risk, improve the seniority profile of commercial capital and unlock debt and equity that would otherwise remain sidelined due to technology, policy, or execution uncertainty.

First-loss capital is a concessional instrument whereby an investor agrees to absorb initial losses in the event of underperformance, thereby protecting senior capital and improving the overall risk–return profile for private investors. A prominent example is **Climate Investor One**, launched in 2015, which has mobilized more than **\$850 million across 15+ countries** through blended-finance structures to enable large-scale renewable energy projects in markets perceived as higher risk. While first-loss structures remain relatively underutilized in the biofuels sector, recent analysis by the World Economic Forum and Climate Investor One highlights their potential relevance for SAF and advanced biofuels. In these segments, where commercial lenders are deterred, targeted first-loss capital could play a key role in attracting private investment and enabling early commercial deployment.

Philanthropic capital has played a growing role in this context by funding first-loss tranches, grants, or concessional layers explicitly targeted at Foak and early scale-up biofuel projects. For example, Breakthrough Energy Catalyst has deployed grant and concessional capital to absorb Foak risk in SAF and advanced biofuel projects, allowing senior lenders and strategic investors to participate despite unproven operating histories and high green premiums. By taking early downside exposure, such catalytic capital improves project bankability without distorting long-term market pricing.

MDBs and DFIs similarly deploy risk-bearing capital at the project or portfolio level, often combining first-loss positions with policy-backed senior debt to crowd in private finance. Institutions such as the EIB, EBRD and JBIC have supported advanced biofuels through structures that blend long-tenor debt with guarantees, subordinated tranches, or junior risk participation.

Despite its catalytic role, blended finance remains small relative to global climate and SDG financing needs. While total climate finance reached about \$1.9 trillion in 2023, blended finance accounts for only \$17-20 billion per year. Volumes have remained broadly flat, with roughly 70% allocated towards climate-related transactions. In the Asia-Pacific region, blended finance deployment has declined since 2019 despite the development needs of the region. It further remains concentrated in energy and infrastructure, skewed toward a small number of larger economies, with limited reach into smaller markets and declining average ticket sizes. This can constrain its ability to support the balance-sheet scale, tenor, and risk absorption required for capital-intensive biofuel

projects, highlighting the need for more programmatic, scaled deployment.

Scaling blended finance is constrained less by the availability of concessional capital than by the strength of project pipelines, the speed of project preparation and market signaling. Here, project preparation refers to the upstream work required to make projects investment-ready, including FEED, permitting, ESG due diligence and financial modelling. These activities are critical for reducing execution and information risk.

As a result, the challenge is primarily one of deployment rather than supply. In this context, MDBs and DFIs can anchor concessional finance, complemented by climate funds, bilateral agencies, and philanthropic capital that absorb early risk and mobilize commercial investors. Although execution challenges persist, recent platform-based initiatives such as ALTERRA, FAST-P (Singapore) and Project GAIA have announced multi-billion-dollar targets and seek to address deployment frictions through pooled and programmatic approaches.

For biofuels in the Global South, financing constraints are driven less by technology alone than by structurally high WACC, currency risk, policy uncertainty, and fragmented value chains. In this context, concessional and blended finance can play a critical role in reducing overall capital costs for highly CapEx-intensive assets such as biorefineries. Furthermore, these mechanisms also help narrow the gap between production costs and off-takers' willingness to pay, enabling early market formation and a disciplined transition toward fully commercial financing.

Despite their impact, when such risk-absorbing blended-finance deployments remain small relative to the scale of capital required to industrialize biofuels globally, the need for larger, faster, and more coordinated deployment of first-loss capital by MDBs, DFIs, and philanthropic platforms becomes all the more critical to yield impact-driven results. Success stories have emerged using this approach by leveraging and/or combining its instruments such as first-loss capital, loan guarantees, among other things, as evident in the examples seen in this chapter.

8 5.4 Capital structuring and repeatability mechanisms

5.4.1 Green loans and infrastructure debt

Green loans and infrastructure debt are financing instruments that can be used to fund biofuel assets once technology and construction risks are largely resolved and operating performance is demonstrated. They typically provide longer tenors and a broader pool of lenders for repeatable, contracted assets, supporting scale-up and refinancing as projects transition from the development-stage to stable operations. These can also be attracted once operational risk is reduced for biofuel assets, particularly Biogas, Renewable Diesel, and HEFA-SAF. For example, Waga Energy has financed its Biomethane platform using green loans and infrastructure-style debt facilities, reflecting its repeatable asset model and long-term gas offtake contracts.

5.4.2 Strategic Corporate Investment and Offtake-Backed Equity

Corporate off-takers increasingly provide equity linked to long-term purchase agreements, anchoring demand and improving project bankability. Strategic corporate investment and offtake-backed equity play a critical role in anchoring demand and improving the bankability of capital-intensive biofuel projects. In these structures, airlines, fuel buyers, or downstream users provide equity or quasi-equity alongside long-term purchase commitments, aligning incentives across the value chain and reducing demand risk for lenders.

A prominent example is Infinium's Project Roadrunner for producing e-SAF and e-diesel, where long-term SAF offtake agreements with American Airlines, combined with strategic investment by other partners (as well as philanthropic project-level commitments by Breakthrough Energy Catalyst) enabled the financing of a Foak power-to-liquid fuels facility. Similarly, IAG's strategic investment in Twelve, alongside a long-term offtake agreement over 14 years for ~785,000 metric tons of e-SAF, illustrates how airlines are using equity participation at TopCo and SVP/project-level to secure future fuel supply while de-risking early commercial deployment.

5.4.3 Value chain anchor investments

Value-chain anchor investments involve a dominant industrial or commercial player deliberately securing critical links across the biofuel value chain to reduce coordination failures and improve bankability.

On the feedstock and upstream side, several biofuel developers and incumbents have moved beyond spot procurement by actively anchoring

supply. A prominent example is **Eni's East Africa agri-feedstock model**, under which Eni provides long-term buy-back guarantees for oilseed crops (e.g., castor, croton), invests in local aggregation and processing infrastructure and partners with tens of thousands of smallholder farmers through structured contracts, inputs and agronomic training. This model reduces feedstock price volatility, improves traceability and sustainability compliance and converts a fragmented agricultural base into a bankable supply chain for downstream biofuel production.

In sugar-based biofuels, vertically integrated players such as **Raizen and São Martinho** combine mill ownership, long-term grower contracts and logistics infrastructure to stabilize sugarcane supply. This integration has been critical in enabling large-scale project finance and refinancing for Ethanol and bioenergy assets in Brazil. In Biogas and Biomethane, upstream anchoring is often led by utilities and infrastructure-backed platforms. Companies such as **Nature Energy and Waga Energy** secure long-term feedstock supply through contracts with municipalities, wastewater utilities, landfills and agro-industrial players, in some cases co-investing in collection, pre-treatment, or upgrading infrastructure. These arrangements reduce counterparty and volume risk and are a key enabler of infrastructure-style financing.

On the demand side, anchor investments take the form of long-tenor offtake commitments, often complemented by strategic equity participation. Airlines such as International Airlines Group (including British Airways) and United Airlines have signed 10-20-year SAF offtake agreements with producers including LanzaJet, Twelve, Neste and Infinium, in some cases alongside minority equity stakes or advance purchase commitments.

Taken together, these explicit anchor investments by named industrial players, upstream through feedstock aggregation and buy-back structures and downstream through equity-backed offtake, are among the most effective mechanisms for overcoming fragmentation, stabilizing and de-risking cash flows and enabling project finance for capital-intensive biofuel assets, particularly in emerging and early-scale markets.

5.4.4 Tax Equity

In some markets, producers combine project finance with tax equity to monetize federal tax credits (e.g. IRA Section 45Z), while separately stacking regulatory credit revenues such as California's Low-Carbon Fuel Standard (LCFS) to strengthen cash flows and debt service coverage; the mechanics of carbon crediting are

discussed in later sections. This layered revenue structure allows projects to improve leverage and reduce WACC by converting policy support into bankable, contractible cash flows. However, reliance on multiple policy instruments also introduces structuring complexity and exposure to regulatory durability, requiring careful alignment of credit tenors, compliance eligibility and offtake arrangements.

5.4.5 Refinancing

Refinancing improves capital efficiency by replacing higher-cost development and construction capital with lower-cost and/or longer-tenor financing once construction risk has been eliminated and operating performance is demonstrated. This transition is critical to reducing WACC, releasing sponsor capital for redeployment, and enabling portfolio-level scale-up.

While biofuel specific refinancing transactions remain relatively limited, adjacent renewable energy sectors offer relevant precedents that illustrate the mechanism. In Uruguay, the **La Jacinta solar project** was refinanced post-commissioning by replacing short-tenor construction-phase bank loans with a long-tenor project bond placed with institutional investors, materially extending maturities and lowering financing margins. In India, the Indian Renewable Energy Development Agency (**IREDA**), **supported by the National Clean Energy Fund**, has implemented a **refinancing scheme** that provides concessional refinancing of a portion of outstanding debt for operational biomass and RE projects, improving debt service coverage and freeing up balance-sheet capacity for new investments.

As biofuel assets and markets mature, particularly in Biogas, Biomethane, Renewable Diesel and HEFA-SAF, similar refinancing pathways are expected to play a growing role in transitioning projects from sponsor-backed or construction-phase financing toward infrastructure-style capital markets solutions (namely, infrastructure or pension funds, yield-oriented investors) once asset performance is validated and revenues stabilized or de-risked.

5.4.6 Platform Investments

As biofuel deployment moves from pilot projects toward multi-asset buildout, platform investments are increasingly used to manage risk and scale capital deployment. Rather than financing individual facilities on a standalone basis, platform models aggregate multiple projects, geographies or value-chain segments within a shared investment and governance framework, reducing transaction costs and limiting exposure to single asset risks. This enables capital providers to move towards replicable and scalable deployment.

A precedent has been seen in clean cooking and Biogas. For example, the **Africa Biogas Partnership Program** operated as a multi-country platform coordinating donors, DFIs, local banks, tech providers and implementers. By aggregating thousands of small digesters under a single framework, it reduced credit risk, standardized implementation and monitoring and mobilized concessional and commercial capital. To date, the programme has installed over 50K biodigesters, benefiting more than 250K households.

Another example is **Verdalia**, a European Biomethane investment platform launched by Goldman Sachs Asset Management with a mandate to deploy over €1 billion into Biomethane projects across Europe. Verdalia has secured substantial equity commitments to build and operate a diversified portfolio of operating and late-stage Biomethane assets, targeting multi-terawatt-hours annual production at scale. The platform aggregates assets under a single ownership and governance structure. As individual projects reach stable operations and secure long-term gas offtake arrangements, Verdalia's model is designed to support project-level debt, refinancing, and capital recycling—progressively lowering the cost of capital and enabling further portfolio expansion.

This platform structure facilitates sequential risk transfer, with early-stage development and scale-up risk absorbed at the platform level before individual projects transition toward project-level debt or infrastructure-style financing as operating performance and contracted cash flows are established. By standardizing project design, contracting structures and execution processes, the Infinium-Brookfield platform aims to reduce transaction costs, accelerate replication and progressively lower the cost of capital as deployment scales.

5.4.7 Joint ventures and project Special Purpose Vehicles (SPVs)

Joint ventures and project SPVs play complementary but distinct roles in biofuel project structuring. Joint ventures with oil majors, utilities, or agribusinesses shift technology, feedstock, and market risk from stand-alone project entities onto stronger balance sheets better able to absorb them, enabling scale through balance sheet financing. This is seen in examples such as Neste and TotalEnergies' JV and strategic equity structures for scaling HVO and SAF capacity by leveraging existing refining infrastructure, or Brazil's Raizen, a 50:50 JV between Shell and Cosan. Project SPVs, by contrast, are used to ring-fence individual assets, allocate risks contractually, and enable non-recourse or limited-recourse project finance once offtake, feedstock, and policy risks are sufficiently mitigated.

8 5.5 Policy-linked revenue and carbon market enablers

Apart from financing instruments, carbon markets and regulatory policies can influence project revenues (and hence, financing) in four distinct ways:

1. **Carbon-intensity-based fuel standards** (e.g., LCFS-type schemes), which monetize verified lifecycle emissions reductions through tradable compliance credits and can generate direct, producer-level revenue
2. **Compliance carbon pricing mechanisms** (e.g., emissions trading systems), which internalize the cost of fossil emissions and improve the relative competitiveness of low-carbon fuels, primarily by raising the reference price faced by off-takers rather than paying producers directly
3. **Voluntary carbon markets**, which can provide supplementary revenue streams or demand aggregation in eligible segments, but typically remain non-bankable and are treated as upside optionality by lenders
4. **Policy levers for financing enablement and pricing certainty**, such as blending mandates, quota systems, penalty-backed funds, or Contracts-for-Difference-type schemes, which create non-discretionary demand and, in some cases, convert regulatory signals into predictable cash flows (that can close the green premiums between green and incumbent molecules) without relying on spot carbon prices.

Taken together, these channels shape revenue certainty, risk allocation, and investor confidence and therefore, play a decisive role in determining whether low-carbon pilot projects can progress from demonstration to commercial deployment.

5.5.1 Carbon-intensity based fuel standards

Low Carbon Fuel Standards (LCFS) are regulatory crediting mechanisms, first implemented in California Low Carbon Fuel Standard in 2011, that support low-carbon fuels by requiring fuel suppliers to progressively reduce the average lifecycle Carbon Intensity (CI) of transportation fuels. Compliance is achieved through the generation and trading of credits linked to verified CI reductions relative to fossil fuel baselines. While most developed in California, LCFS-type programs have since been adopted in modified form in other jurisdictions such as Oregon and Washington, applying similar lifecycle-based crediting approaches across a range of biofuels.

Dairy Biogas-to-renewable natural gas (RNG) projects illustrate the impact of LCFS-type schemes. By capturing methane emissions from manure management and upgrading Biogas to vehicle fuel, these projects can achieve deeply negative lifecycle carbon intensities, resulting in substantial credit generation. Together, these revenue streams materially improve project cash flows and have been central to the bankability of dairy-based RNG in regulated US markets.

The International Maritime Organization's Maritime Environment Protection Committee 83 (not implemented yet, vote delayed by a year to October 2026) proposed a global fuel-intensity standard with tradeable surplus units and penalty mechanisms. In its current form, it regulates vessel operators rather than fuel producers, meaning its impact on project finance

is indirect through off-takers' willingness-to-pay and contract structures, rather than via direct, producer-level credit revenues as under LCFS.

5.5.2 Compliance carbon pricing mechanisms

Compliance carbon pricing mechanisms, such as the EU CO₂ ETS, influence biofuel project finance by internalizing the cost of fossil fuel emissions and thereby improving the relative competitiveness of low-carbon alternatives. Unlike LCFS-type standards, ETS frameworks typically regulate fuel users or emitters, rather than producers, and do not generate direct, project-level credit revenues for biofuel suppliers. Instead, they raise the effective reference price of incumbent fossil fuels, narrowing the green (cost) premiums of biofuels and increasing off-takers' willingness to pay for lower-carbon fuels and supporting demand through market price signals. From a financing perspective, this impact is largely indirect and becomes bankable only where ETS-related costs are credibly passed through into long-term offtake contracts or where complementary policy mechanisms—such as allowance recycling, rebates, or contracts for difference—translate carbon price signals into more predictable cash flows for low-carbon fuel projects.

5.5.3 Voluntary Carbon Markets (VCM)

From a financing perspective, VCMs and adjacent voluntary demand mechanisms can play a supporting, but generally non-core, role for biofuel projects, particularly where mandates, LCFS-type schemes, or compliance carbon pricing are unavailable or

insufficient. In such contexts, voluntary revenues or attribute-based demand signals can improve early project economics, support aggregation platforms, or catalyze first deployments. However, financiers typically treat these revenues as incremental upside rather than debt-supporting cash flow, reflecting price volatility, limited liquidity, methodological uncertainty, and short contract tenors.

Voluntary demand aggregation has also played a catalytic role in early SAF and marine biofuels, particularly prior to the introduction of binding mandates. This has been most clearly demonstrated through Book-and-Claim (B&C) systems or direct voluntary offtake agreements by airlines (before mandates materialized), under which the environmental benefit of a low-carbon fuel is decoupled from physical fuel delivery and contractually allocated to buyers based on verified emissions attributes. In aviation, the Sustainable Aviation Buyers Alliance (SABA) aggregates voluntary SAF demand from airlines and corporate buyers, enabling B&C-based transactions that support early market formation and price discovery.

Similarly, in maritime shipping, the Zero Emission Maritime Buyers Alliance (ZEMBA) aggregates demand from more than 40 freight customers, including Amazon, IKEA, and Nike through competitive tenders for low-emission shipping services, allocating verified emissions reductions via a B&C framework, rather than issuing tradable carbon credits. ZEMBA's inaugural 2024 tender enabled the avoidance of approximately 82,000 tCO₂e through waste-based Biomethane shipping services, while subsequent tenders focused on hydrogen-derived e-fuels are expected to enable avoidance of at least ~120,000 tCO₂e under contracts beginning in 2027. While such coalitions provide credible early demand signals and have supported first commercial transactions, contract tenors have typically been limited to three to five years, constraining their usefulness for long-tenor debt financing of capital-intensive fuel production assets.

Overall, voluntary carbon markets and book-and-claim-based demand aggregation are best viewed as catalytic and transitional tools, which are useful for pilots, aggregation and early market formation but insufficient on their own to support debt-financed, large-scale biofuel deployment. Their greatest value lies in complementing mandates, compliance carbon pricing, or revenue-stabilization mechanisms that translate decarbonization value into predictable, bankable cash flows.

5.5.4 Global Policy Levers for Financing Enablement and Pricing Certainty

Demand-side policies encompass a range of regulatory and market-based tools, including blending mandates, quotas, carbon pricing, compliance credit schemes, and administered offtake mechanisms, designed to create non-discretionary demand and improve revenue visibility for low-carbon fuels.

Demand-side policy can support biofuel deployment by anchoring demand, improving revenue visibility, and enabling more bankable offtake structures with the EU providing a clear illustration. Regulatory developments such as ReFuelEU Aviation have accelerated market formation by establishing binding targets for SAF blending over time. While ReFuelEU does not provide direct financial support, it creates a clear and enforceable demand signal that has stimulated a broad pipeline of announced and developing SAF and advanced biofuel projects across multiple pathways. A significant share of this pipeline remains pre-FID and subject to permitting, feedstock, and financing constraints; nevertheless, the presence of a long-term mandate materially improves producers' ability to negotiate long-tenor offtake agreements, which are a prerequisite for project finance.

A similar demand-anchoring effect is observed in India, where the government mandates Bioethanol blending under the Ethanol Blended Petrol (EBP) Program and public OMCs provide assured offtake at administered, cost-linked prices. Annual price notifications issued by the government create a high degree of pricing predictability, enabling Bioethanol producers to secure financing based on contracted volumes and stable revenues. Although these instruments do not finance projects directly, they materially alter underwriting risk profiles: binding offtake obligations and administered pricing allow lenders to offer longer debt tenors and higher leverage than would otherwise be feasible.

While these measures do not eliminate the green premium, they improve airlines' willingness to contract low-carbon fuels, either to reduce compliance costs or avoid penalties, thereby supporting offtake negotiations and strengthening financing conditions across SAF and adjacent biofuel pathways.

EXHIBIT 16 | Key EU policy mechanisms enabling SAF financing

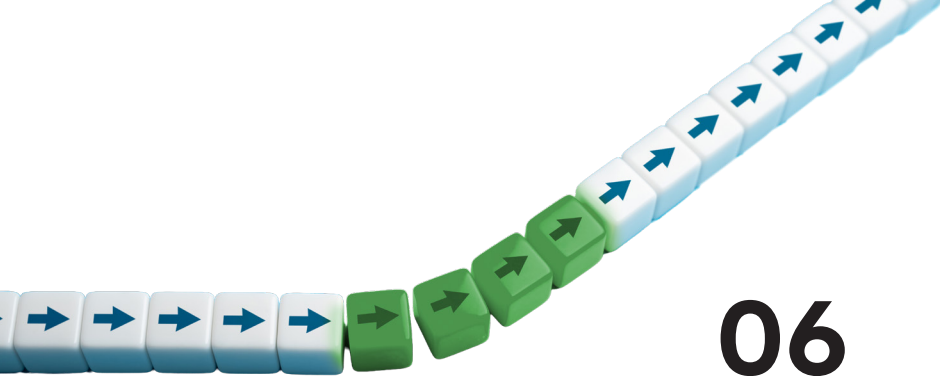
Policy Lever	What it does (financing-relevant)	Brief Overview	Financial Relevance
ReFuelEU Aviation (SAF mandate)	Creates non-discretionary demand for SAF	Mandates SAF blending at EU airports: 2% (2025), 6% (2030), 20% (2035), 70% (2050); synthetic SAF sub-mandate 1.2% by 2030, 35% by 2050	Enables long-term offtake contracts (10–15 yrs) aligned with debt tenors; reduces volume risk
EU ETS (aviation coverage)	Increases opportunity cost of fossil jet fuel	Intra-EU aviation subject to carbon pricing; SAF treated as zero-rated under ETS	Improves airlines' willingness to pay for SAF; strengthens revenue assumptions
EU Sustainable Transport Investment Plan (EU-STIP)	Provides targeted revenue support for SAF uptake	~20 million ETS allowances (2024–2030) earmarked to offset SAF price premium; ~1.3 million allowances (~€100m) allocated in 2024	Narrows green premium; improves near-term DSCR and offtake pricing
Renewable Energy Directive (RED III) + FuelEU Maritime	Ensures long-term eligibility and cross-sector demand	Sets sustainability and GHG thresholds; prioritizes advanced biofuels & RFNBOs; same feedstocks eligible across aviation, maritime, road	Reduces regulatory risk; enables offtake diversification and downside protection

5.6 Conclusion

Based on global trends and case studies, it is evident that scaling biofuels depends on effective risk alignment and the strategic sequencing of investments. Success to date has been driven by adaptive capital stacks that evolve as projects move from early commercialization toward industrial scale, and that are explicitly aligned with biofuel project archetypes-reflecting differences in technology maturity, market maturity, and regional context across developed and emerging markets. By deploying

the right financial tools at the right stage, and by synchronizing public and private roles, stakeholders can convert policy intent into bankable projects. These observed patterns provide the foundation for the targeted interventions required by policymakers, DFIs, corporates, and investors to unlock the next phase of global biofuels scale-up, which is the focus of the next chapter.





06

Call to Action - Unlocking the Next Phase of Biofuels Scale-up

Scaling sustainable biofuels from niche deployment into a durable pillar of the energy system requires a step-change in both the scale and scope of investment. Beyond converting isolated pilots into bankable, repeatable assets, the next phase of growth must also broaden the underlying feedstock and technology base. This expansion will require not only scaling existing infrastructure and production technologies, but also advancing new fuels, diversifying feedstocks, and accelerating novel pathways through investments across the entire value chain.

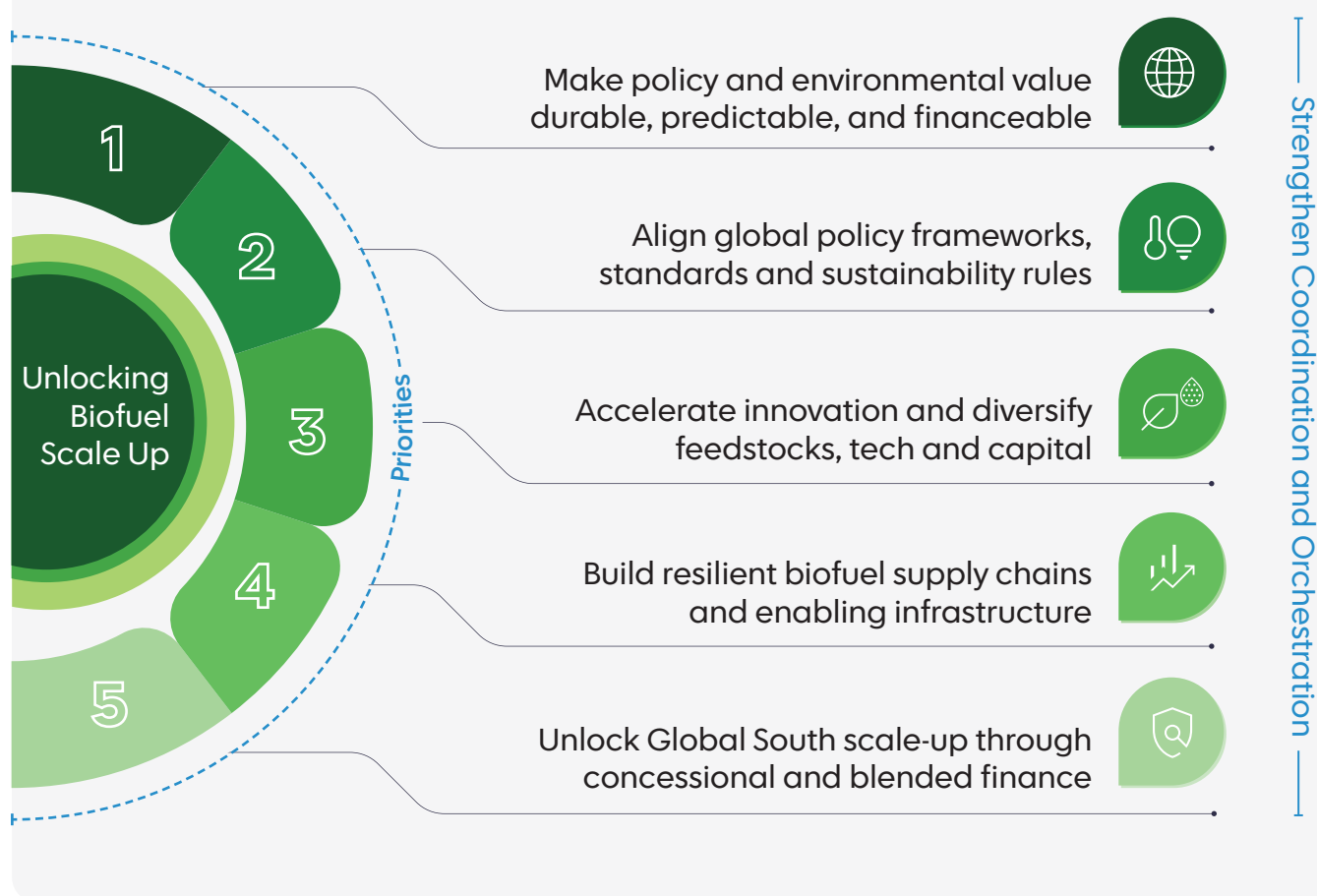
Achieving this transition will require **annual investments of approximately \$420-500 billion in the base case scenario and \$630-740 billion under an accelerated scenario by 2035**, representing an increase of approximately **4-7 times relative to current yearly biofuels investment levels**. Mobilizing capital at this scale will depend less on any single policy or financing instrument and more on coordinated progress across technology de-risking, cost stabilization, and ecosystem readiness. Early-stage and emerging pathways must be systematically supported through the “valley of death” so they can mature into financeable assets, even as capital continues to flow into proven, large-scale deployment.

Policy remains a necessary foundation, but it enables finance most effectively when it translates **into predictable and durable revenue outcomes**. In addition, **fragmentation in sustainability criteria, certification standards, and eligibility rules** across jurisdictions continue to raise transaction costs, constrain cross-border capital flows, and limit the scalability of otherwise bankable biofuel pathways, underscoring the importance of greater global alignment and mutual recognition across policy

frameworks. Successful projects rely on **layered capital structures**, to align cash flows and risks with lender requirements. As projects progress from early deployment toward scale, the central challenge shifts to **risk allocation and sequencing**, where who absorbs downside risk matters as much as the volume of capital deployed.

Strategic corporates are increasingly anchoring selected projects through strategic equity participation and long-term offtake, improving bankability by reducing commercial and execution risk. However, this involvement remains uneven. It is largely concentrated in specific fuels, geographies, and sponsor profiles and has not yet generalized across the sector. As a result, the next phase of scale-up will depend less on bespoke, project-by-project solutions and more on platform structures, aggregation models, and standardization, which can accelerate replication and enable capital to be deployed efficiently across multiple assets and markets. Crucially, these models can only scale in the presence of durable, credible policy frameworks that provide long-term demand visibility and revenue stability. Effective ecosystem coordination across policymakers, developers, financiers, corporates, and intermediaries will therefore be essential to ensure that policy intent, capital instruments, and project pipelines evolve in a mutually reinforcing manner.

Against this backdrop, six priorities emerge as critical to building sustained financier confidence and unlocking the next phase of biofuel scale-up (see exhibit below).



8 6.1 | Priority 1: Make policy and environmental value durable, predictable, and financeable

Policy incentives, carbon value, and avoided-emissions benefits can materially improve biofuel economics, but they rarely function as core collateral unless they are durable, transparent, and contractually enforceable. Scaling biofuels therefore, depends not on the existence of policy or carbon mechanisms alone, but on their translation into financeable cash flows.

- **Generate high-integrity environmental value:** Developers should adopt high-integrity standards (e.g., Core Carbon Principles (CCP)-aligned methodologies where applicable) and robust additionality and permanence criteria. This would ensure that environmental value is credible, defensible, and valued by institutional buyers and lenders.
- **Automate and standardize carbon and emissions accounting:** Producers and technology providers should deploy digital MRV systems that deliver

auditable, verifiable carbon-intensity, and emissions data to reduce verification risk, lower transaction costs, and improve offtaker and lender confidence.

- **Translate policy and environmental value into bankable revenues:** Where project economics rely on policy incentives, carbon value, or avoided-emissions benefits, developers must demonstrate how these are converted into predictable, durable, and enforceable cash flows that lenders can underwrite. This may involve regulated credit monetization, price-stabilization mechanisms, administered pricing or contractually aligned offtake structures, depending on market design.

8 6.2 | Priority 2: Align global policy frameworks, standards, and sustainability rules

Policy fragmentation remains a structural barrier to biofuel investment. Divergent sustainability criteria, certification systems, and GHG accounting rules increase transaction costs, constrain market clearing, and expose projects to regulatory risk.

- **Harmonize sustainability rules to enable market clearing:** Governments, regulators, and international agencies should align sustainability standards, certification regimes, and lifecycle GHG accounting (including iLUC treatment) to improve comparability and reduce revenue uncertainty.
- **Enable policy cross-pollination:** Policymakers, multilaterals, and NGOs should systematically share evidence on policy design and effectiveness, enabling faster adoption of proven approaches across regions.
- **Lock-in clear, long-term targets:** Governments should define durable, long-term targets for advanced biofuels across aviation, shipping, road transport, and industry providing credible demand signals beyond electoral cycles.

8 6.3 | Priority 3: Accelerate innovation and diversification across feedstocks, technologies, and capital

Long-term biofuel scale-up requires sustained innovation across the entire value chain: expanding the range of sustainable feedstocks, advancing multiple conversion pathways for different fuels, and ensuring the continuity of capital from R&D through first commercial replication.

6.3.1 Diversify and industrialize sustainable feedstock supply

- **Enable feedstock innovation and scale validation:** Grants and incentives should support innovation in feedstock supply, including the cultivation of novel oilseeds (e.g., Camelina, Carinata, Jatropha) and the mobilization of lignocellulosic biomass from agricultural residues, forestry residues, and dedicated energy crops, where sustainable. Support should focus on validating yields, sustainability performance, logistics models, and cost structures at scale, generating robust data to de-risk downstream conversion and financing.
- **Support feedstock-conversion innovation:** Governments, DFIs, and philanthropic organizations should fund programs that jointly develop feedstocks and compatible conversion pathways. This co-development reduces integration risk and accelerates progression from pilot concepts to commercially viable configurations.
- **Scale incubators and accelerators for pre-commercial technologies:** Governments and the industry should expand incubators and accelerators that combine early-stage capital with technical assistance, project development, and commercialization support, enabling emerging biofuel technologies to progress from laboratory validation to bankable pilot and demonstration projects.
- **Reduce pathway concentration risk for scalable drop-in fuels:** Scaling SAF and Renewable Diesel at system level will require complementing lipid-based HEFA/HVO routes with alternative conversion pathways such as AtJ, gasification-to-liquids, MtJ and waste-based processes - that deliver the same end-use molecules (e.g., SAF, RD, bio-naphtha, etc.). From a financing perspective, pathway diversification reduces exposure to feedstock bottlenecks, policy reallocation risk, and correlated cost volatility while enabling staged scale-up aligned with technology maturity and infrastructure compatibility.

6.3.2 Expand and de-risk conversion pathway innovation

- **Targeted grants and subsidies across the scale-up continuum:** Public support should span R&D, pilot testing, FEED, and Foak ramp-up to enable the processing of new feedstocks, advance non-incumbent conversion pathways, and improve the performance and cost of existing technologies. By generating validated performance data and reducing upfront capital at risk, these instruments

accelerate the transition from demonstration to early commercial deployment and crowd in private capital.

For example, this priority could be operationalized through a global network of **biofuels Centres of Excellence**, combining R&D labs and physical pilot and demonstration facilities, with virtual coordination platforms covering feedstocks and conversion pathways.

6.3.3 Activate strategic financing vehicles across the scale-up gap

- **Mobilize patient capital for early scale-up:** Strategic corporates, venture and growth equity investors, climate-focused funds, and concessional capital providers play a critical role in financing demonstration, Foak, and early replication projects, where technical and integration risks remain too high for conventional infrastructure capital.
- **Scale collaborative early-stage financing platforms:** Philanthropic and catalytic investors should expand vehicles such as Breakthrough Energy Catalyst that blend grants and equity to finance pre-commercial and first-scale biofuel assets across multiple pathways.

- **Address the growth-stage “missing middle”:** Dedicated biofuel growth equity vehicles are needed to provide capital continuity between Foak deployment and fully bankable commercial assets, preventing projects from stalling after technical validation but before infrastructure-scale financing becomes available.

For example, **dedicated biofuels venture-growth platforms** could be structured to invest across feedstocks, conversion technologies, and enabling platforms at pilot and demonstration stage, while reserving follow-on capital for Foak and first-replication projects via project-level or platform equity.

8 6.4 | Priority 4: Build resilient biofuel supply chains and enabling infrastructure

Infrastructure gaps remain a binding constraint for biofuel scale-up, particularly in feedstock-rich but capital-constrained regions. Beyond asset-level risks, **uncertainty around the pace, location, and composition of biofuel capacity expansion creates coordination challenges across the upstream and downstream value chain.** As a result, financing enabling infrastructure for feedstock production, aggregation, logistics and distribution, pre-treatment and conversion to fuels, and downstream logistics and end-use often proves complex, as these assets depend on multiple projects reaching scale in parallel rather than on a single bankable facility. Addressing these risks requires coordinated investment and risk-sharing across the biofuel ecosystem.

- **Develop regional infrastructure backbones:** Governments and development banks could invest in enabling infrastructure (such as roads, reliable power supply, water access, ports, and grid or pipeline connections) to link remote feedstock sources to processing hubs and export or consumption points. These investments reduce logistics costs, expand viable feedstock catchment areas, and improve project economics.
- **Enable bio-hub development:** DFIs, governments, and project developers should co-invest, where possible, in bio-hubs that aggregate, store, and pre-process residues and wastes. Shared infrastructure for drying, sorting, densification, or upgrading can reduce the duplication of capital expenditure, improve feedstock quality consistency, and lower integration risk for downstream conversion assets.
- **Improve feedstock payment certainty:** Guarantees, escrow mechanisms, and payment-security instruments can reduce upstream counterparty

risk and stabilize participation by farmers, municipalities, and small suppliers. Improving payment certainty is critical for maintaining reliable feedstock supply and avoiding disruptions that directly affect plant utilization and debt service.

- **Strengthen supplier contracting models:** Producers and aggregators should adopt multi-year feedstock contracts with minimum volume commitments, transparent pricing formulas, and clearly defined delivery and quality terms. Where appropriate, contracts can be supported by aggregation platforms or public risk-sharing mechanisms to improve enforceability and bankability.
- **Anchor downstream demand:** Shipping lines, cargo owners, ports, airlines, and other end-users should commit to green corridors and long-term offtake agreements for low-carbon fuels. Anchored demand reduces revenue volatility, supports the financing of conversion assets and justifies parallel investment in downstream infrastructure.
- **Invest in distribution, storage, blending, and bunkering infrastructure:** Port authorities, gas and fuel network operators, and energy suppliers must expand specialized storage, blending, compression, liquefaction, and bunkering infrastructure to enable reliable last-mile delivery of diverse biofuels (e.g., SAF, Biomethane, Renewable Diesel, Biomethanol). While many biofuels are technically drop-in at the point of use, their production locations, volumes, and trade flows may differ materially from fossil fuel supply patterns. This requires reassessment and, in some cases, the development of new logistics, blending and terminal infrastructure. These assets are critical to avoid stranded production capacity and to unlock scale beyond pilot markets.

8 6.5 | Priority 5: Unlock Global South scale-up through concessional and blended finance

MDBs and DFIs play a catalytic role in scaling biofuels by absorbing risks that remain mispriced or unfinanceable for commercial lenders, particularly during early scale-up and first replication. Through concessional capital, guarantees, first-loss tranches, and policy-linked instruments, MDBs and DFIs can de-risk projects and mobilize private capital rather than crowd it out. Critically, their interventions should be designed with clear graduation pathways-allowing risks to be progressively transferred to commercial banks and institutional investors as markets mature, and enabling capital recycling and scale.

In many EMDEs, biofuel financing constraints stem less from technology readiness than from structurally high costs of capital, currency and sovereign risk, policy uncertainty, and fragmented value chains. These factors materially raise WACC and limit access to long-tenor financing, even where project fundamentals are sound. Concessional and blended finance therefore, play a critical role in addressing market failures that private capital alone cannot absorb.

- **Ring-fence capital with explicit sectoral targets:** MDBs, National Development Banks (NDBs), and climate funds should earmark dedicated concessional and blended finance envelopes for biofuels across feedstock systems, conversion assets, and associated logistics and export infrastructure. Treating biofuels as a priority sector with clear allocation targets can improve pipeline visibility and accelerate deployment.
- **Deploy risk-absorbing instruments at scale:** First-loss capital, subordinated debt, and construction and completion guarantees along with political and foreign exchange risk mitigation instruments are essential to crowd in commercial lenders and institutional investors. These tools should be applied selectively to absorb early-stage, country, and execution risk rather than permanently subsidizing project economics.
- **Secure cross-border demand and payment support:** Governments and multilateral institutions can play a catalytic role in facilitating long-term offtake arrangements, buyer aggregation, and payment guarantees, particularly for export-oriented projects supplying SAF, Biomethane, or renewable fuels to international markets. Such mechanisms reduce counterparty risk and enable producers to commit supply with greater revenue certainty.
- **Rebase investor risk frameworks to reflect public support:** Financiers should more systematically incorporate policy backing, administered pricing, guarantees, and concessional layers into credit assessment and risk models. Recognizing the risk-mitigating effect of public support, rather than treating it as ancillary, can lower perceived risk premiums and unlock longer-tenor, lower-cost capital.

For example, MDBs and DFIs could operationalize this approach through a **dedicated biofuels scale-up facility** for the Global South, structured as a multi-window platform covering feedstocks, conversion technologies, and enabling infrastructure.

8 6.6 | Priority 6 (Cross-cutting): Strengthen coordination, sequencing, and ecosystem orchestration

Across all priorities, deployment is often delayed not by absolute capital scarcity, but by coordination failures across actors, risks, and timelines. Misaligned sequencing between policy, infrastructure, technology readiness, and capital deployment increases uncertainty, raises costs, and leads to stranded or underutilized assets. Addressing these failures requires deliberate orchestration across the biofuel ecosystem.

- **Sequence capital and risk intentionally:** Early-stage public, philanthropic, and catalytic capital should absorb technology, integration, and execution risk at different project stages. This enables the orderly entry of commercial lenders and infrastructure investors once risks are sufficiently reduced, improving capital efficiency and accelerating scale-up.
- **Orchestrate value chains, ecosystems, and demand across biofuels (not isolated projects):** Governments, DFIs, corporates, and intermediaries should coordinate across multiple biofuel pathways and their respective value chains - including feedstocks, conversion technologies, enabling infrastructure, logistics, and pooled demand/offtake mechanisms. Demand aggregation across sectors, buyers, and geographies (e.g., anchor offtakers, multi-buyer offtake platforms, mandate-backed pooling) improves bankability, reduces volume and price risk, and ensures that supply, infrastructure and end-use demand mature in parallel-reducing policy misalignment and the risk of stranded assets.
- **Build repeatability and institutional memory:** Standardized tech and project designs, contracting structures, technical specifications, and governance frameworks reduce reliance on bespoke projects, lower transaction costs, and enable faster replication. Institutionalizing lessons learned across fuels and regions is critical to moving from one-off successes to scalable deployment models.



The exhibit below summarizes the impact different stakeholders can have across the above-mentioned key priorities.

EXHIBIT 18 | Stakeholder x Priority impact

Stakeholder	Make Policy & Env. Value Predictable & Financeable	Align Global Frameworks & Standards	Accelerate Innovation & Diversify Feedstock, Tech & Capital	Build Resilient Supply Chains & Enabling Infra	Unlock Global South Scale-up by Concessional & Blended Finance
Polymakers & Regulators	Primary Driver	Primary Driver	Enabler	Enabler	Enabler
Feedstock Providers & Aggregators	Enabler	Enabler	Primary Driver	Primary Driver	Enabler
Tech Developers, Licensors & OEMs	Enabler	Enabler	Primary Driver	Enabler	Enabler
Biofuel Producers & Infra Developers	Enabler	Enabler	Enabler	Primary Driver	Enabler
Certification & Standard Bodies	Enabler	Primary Driver	Enabler	Enabler	Enabler
Strategic & Institutional Investors	Enabler	Enabler	Primary Driver	Primary Driver	Primary Driver
Concessional Finance Providers	Enabler	Enabler	Primary Driver	Primary Driver	Primary Driver
Offtakers	Enabler	Enabler	Enabler	Enabler	Enabler
International Organizations & NGOs	Enabler	Enabler	Enabler	Enabler	Enabler

Primary Driver
Enabler
Low Priority/Indirect Involvement

Note: Priority 6 cuts across the 5 key priorities; this table is directional and is not an exhaustive stakeholder or priority list

Conclusion

Scaling biofuels into a material pillar of energy transition will not be achieved by extending today's approaches incrementally. The challenge is no longer one of technical feasibility or capital availability in isolation, but of coordinating risk, policy, and capital across fundamentally different fuel archetypes, value chains, and geographies.

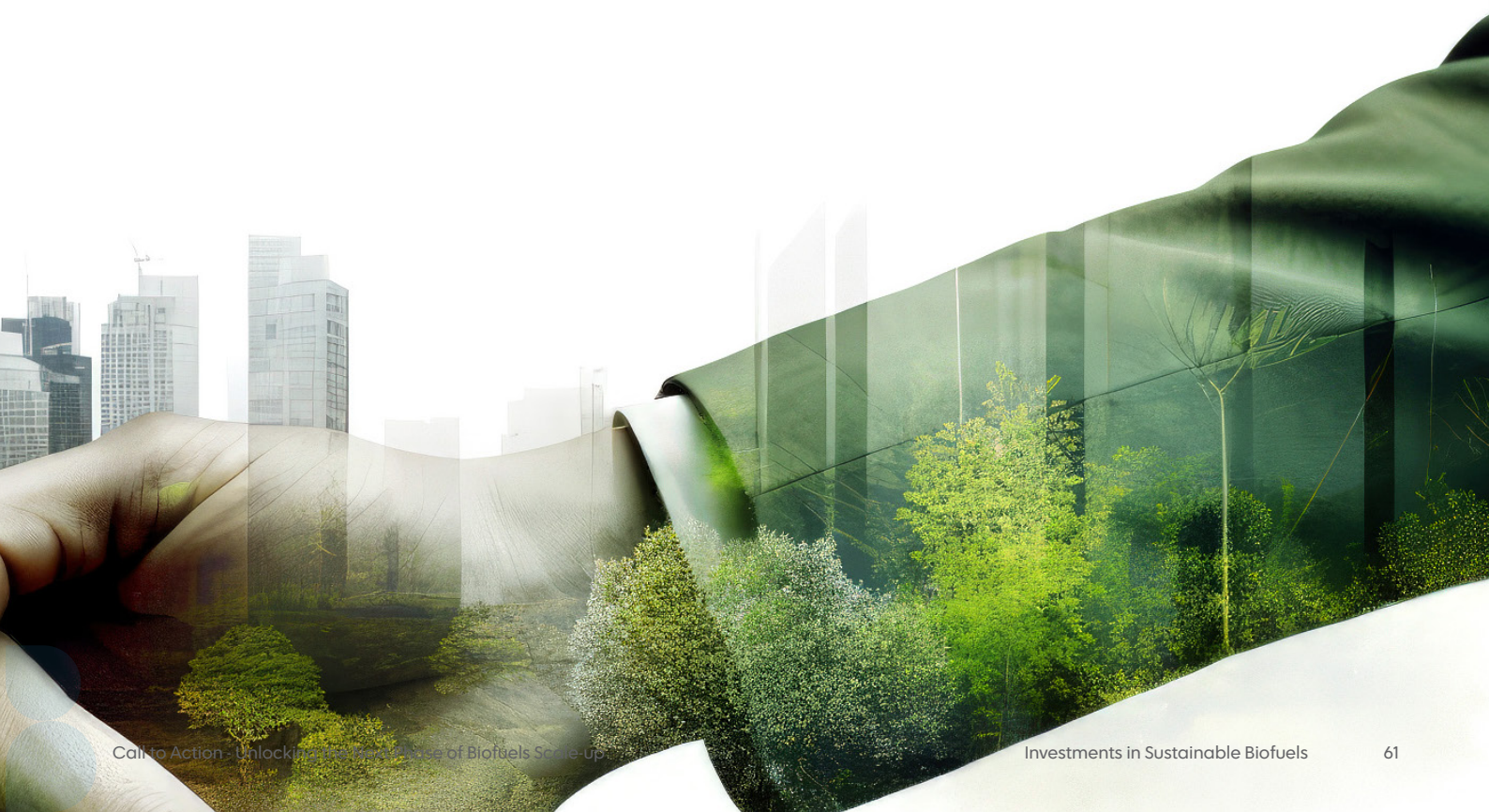
Biofuel financing challenges manifest differently across mature, scaling, and emerging pathways and at different points along the value chain - from feedstocks and conversion to infrastructure and offtake. Across these contexts, constraints consistently emerge where risk allocation is misaligned with investor mandates, policy support is not converted into financeable revenue structures, or investments across the value chain progress unevenly, creating bottlenecks that delay or prevent scale-up.

The next phase of biofuel deployment therefore, requires a deliberate shift: from isolated projects to integrated systems, from single-instrument solutions to layered capital stacks, and from fuel-by-fuel optimization to coordinated deployment across the biofuels ecosystem. This includes accelerating innovation beyond incumbent pathways, expanding sustainable feedstock systems, building enabling infrastructure ahead of demand, and strengthening contractual and

commercial frameworks through standardized offtake structures, robust risk allocation, and bankable pricing mechanisms. Together, these would translate policy and technology progress into predictable cash flows. Notably, public and concessional capital will remain essential to crowd in private investment where risk continues to be mispriced.

Ultimately, unlocking scale is a collective action challenge. Governments, DFIs, corporates, financiers, and developers each hold part of the solution, but impact depends on how these roles connect across archetypes and the biofuels value chain. The priorities set out in this chapter define where action is most needed. Delivering on them, at speed and in concert, is what will determine whether biofuels remain a collection of promising projects, or become a scalable, investable cornerstone of the net-zero transition.

The Global Biofuels Alliance (GBA) is uniquely positioned to act as an orchestrator for this shift by aligning diverse stakeholders across critical priorities. By reducing fragmentation across global geographies and pathways, GBA can help translate high-level policy ambition into coordinated and bankable deployment, which is required to scale up biofuels worldwide, over the course of this transition journey.



07

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