CANDRIAM
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Green innovations series: Biofuels

JUNE 2023

Marketing communication

About the author.

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Marouane joined Candriam in 2022 as Senior Fund Manager in the Thematic Global Equity Team, focusing on climate action and the effort to limit global warming.

He began his career in 2015 at Edmond de Rothschild AM in Paris as an Equity Analyst on environment-related themes. From 2018 to 2022 he co-managed a climate solutions-focused global mandate and an energy evolution fund which focused on the ongoing climate related energy transition. Beginning in 2020 he also became lead manager of the EdR Green New Deal fund, a global equity climate fund.

Marouane holds a Masters in Financial Markets and Risk Evaluation from the Toulouse School of Economics, where he is an external lecturer on Sustainable Finance and ESG analysis. He became a CFA Charterholder in 2018.

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Green innovations series: Biofuels.

The Russian invasion of Ukraine has been yet another wake-up call for our need for energy independence. While Europe's reliance on Russian gas was evident, Russia is also one of the largest oil producers, exporting half of its production to Europe before February 2022.

More than 40%[1] of global oil production is supplied by the 'OPEC +' nations. The risks of a market in which supply is controlled by a few sellers and demand is inelastic are obvious, and geopolitics merely adds to those. Within the European Union, almost 60%[2] of oil demand is consumed by transportation, making decarbonization and energy sovereignty top priorities. While electrification is a significant lever for the energy transition, biofuels are another important, albeit rarely-discussed, lever.

While electrification is arguably the best option for light-duty vehicles over the longer term, ***biofuels*** can provide a low-carbon solution for ***heavy-duty trucks, ships, and aircraft*** -- which have fewer viable medium-term decarbonization options.[3]

But how are biofuels produced? What types are available? What are the challenges? What areas of the market are the most attractive?

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B7
Voertuigmotor afzetten
Roken en vuur verboden
Slang afnemen en tanken
Slang ophangen
Pompnummer onthouden en bij kassa afrekenen
diesel
B7
Voertuigmotor afzetten
Roken en vuur verboden
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Vergeet uw bon niet
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excellium DIESEL
SPAAR ZACHT bij Total
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E5

What are biofuels?

Biofuels are derived from biological materials such as plants or organic waste, and are already widely used in our daily lives. When you refuel at a gas station, you are probably purchasing a mixture of diesel and biodiesel (the European B7 diesel contains 7% biodiesel) or gasoline and ethanol (The E10 gasoline contains up to 10% ethanol).[4]

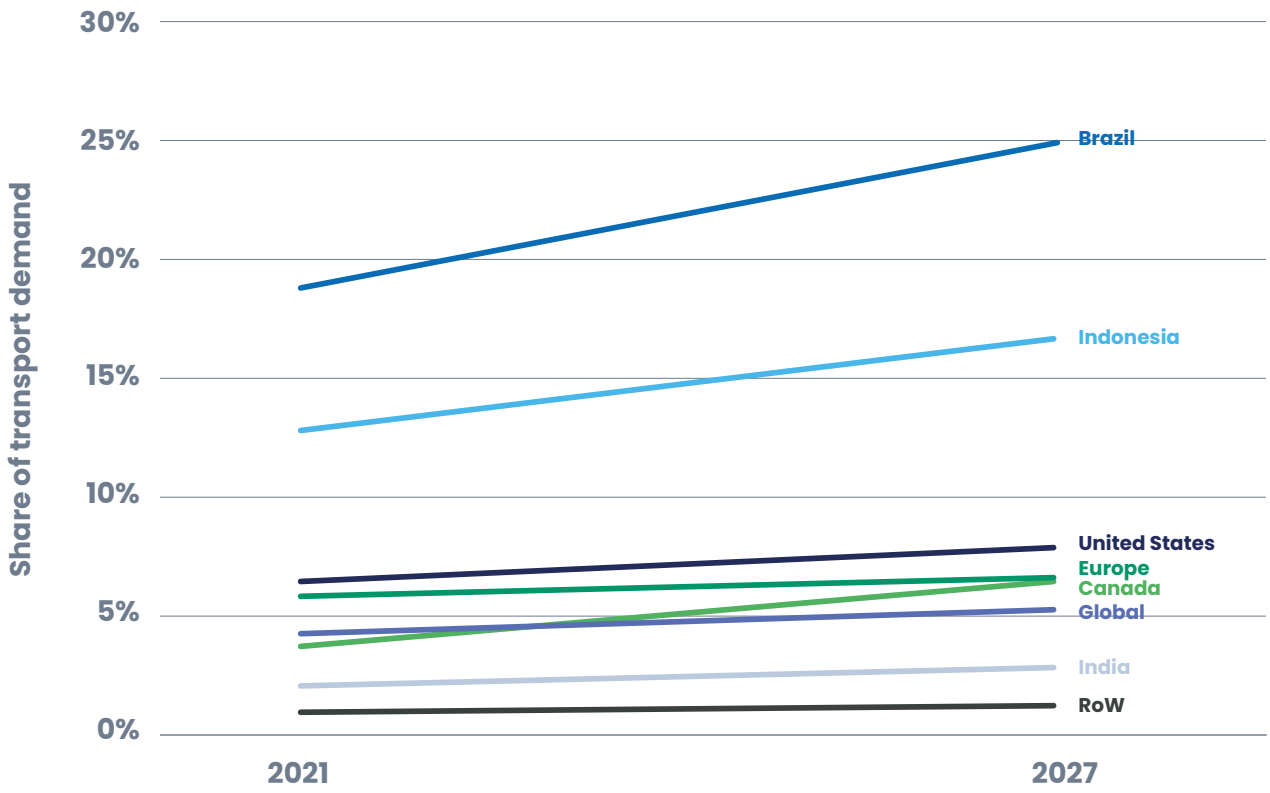
Growth potential

Biofuels date to the early days of the automobile. Indeed, Rudolf Diesel's engine was initially designed to run on peanut oil! Three decades later and on the other side of the Atlantic, Henry Ford proclaimed that ethanol produced from agricultural crops would be 'the fuel of the future.' However, due to the abundance and low cost of petroleum, biofuels were largely ignored in favour of fossil fuels during the 20th century. It was not until the oil crises of the 1970s that the desire to reduce dependency on oil imports sparked renewed interest in biofuels.

The market is already significant. Biofuels represent 6.8%[5] of the 2020 fuel consumption for road transportation in Europe. In the US it is already 10% of gasoline consumption. In California, thanks to the LCFS program, or Low Carbon Fuel Standard, renewable diesel now makes up 20% of total diesel demand.

The IEA, or International Energy Agency, expects biofuel consumption to grow by 20%[6] per year over the next five years, driven by policies such as the EU's target of 14% biofuel utilization in transport by 2030. The US offers incentives linked to the 2022 'Inflation Reduction Act' designed to drive higher penetration, while China has committed to "actively promote the use of advanced biofuels." Brazil, Indonesia, and India are also notable growth markets with ambitious mandates, and the IEA estimates that biofuels could contribute as much as 15% of global transport energy use by 2030.

Figure 1:
Projected biofuel share of transport demand, selected countries



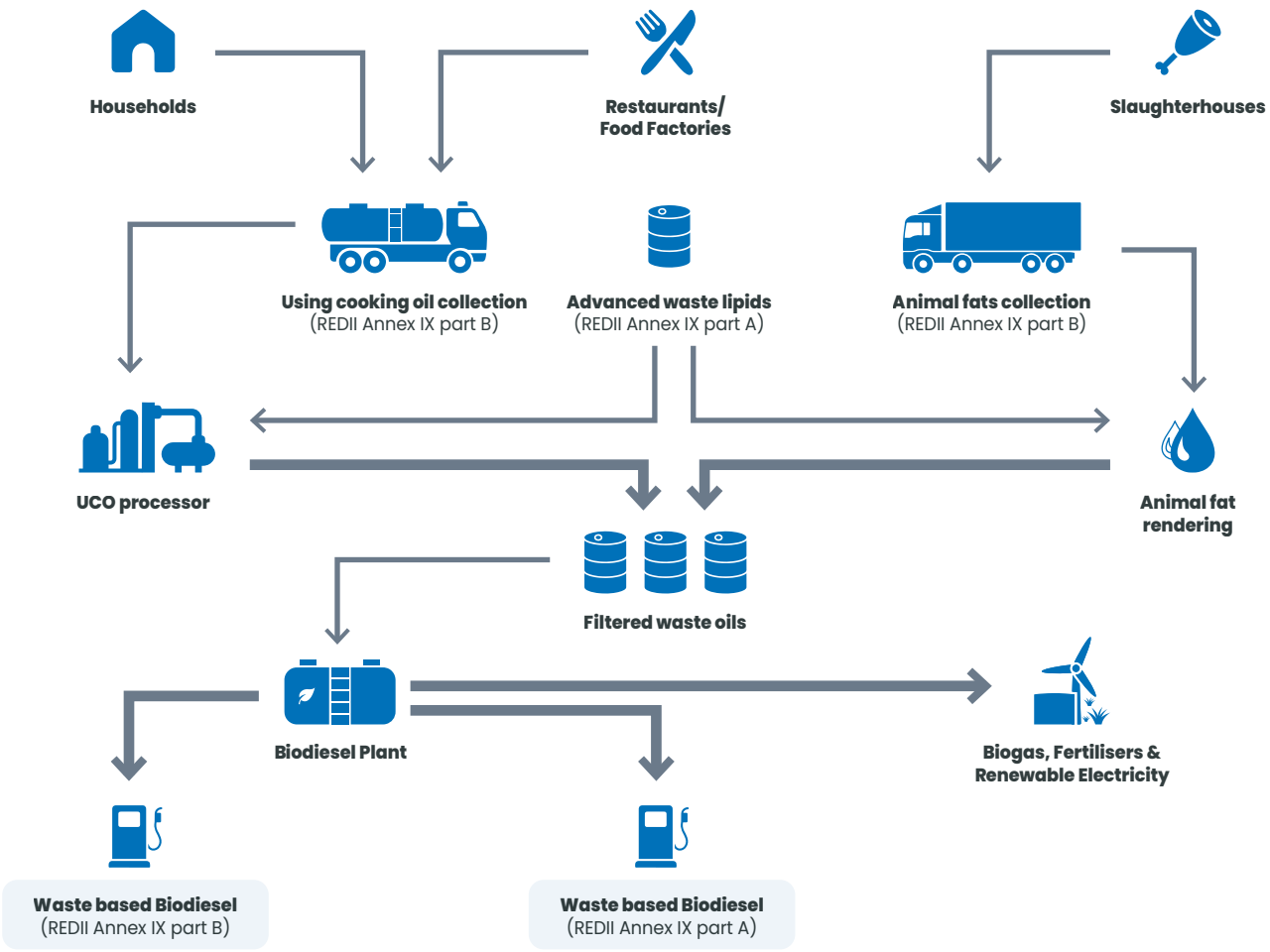
Source: IEA, Paris. *Renewables 2022, Analysis and forecast to 2027*, https://iea.blob.core.windows.net/assets/ada7af90-e280-46c4-a577-df2e4fb44254/Renewables2022.pdf, accessed 22 May, 2023. Used under Creative Commons license, format adapted.

The three ages of biofuels

Biofuels can be classified into three generations, based on the feedstock and the production technology used:

- **First-generation biofuels**: Produced from food crops rich in sugar, starch, or oil, these biofuels are the most widely adopted and commercially viable. Their production has raised concerns about competition with food production, and over land-use change. The two main fuels are biodiesel and bioethanol.
    - **Biodiesel** is produced mainly from vegetable oils including soybean, rapeseed/canola, or palm oil. Biodiesel can be used in diesel engines without any modification and is often blended with petroleum diesel.
    - **Bioethanol** is an alcohol fuel produced by fermenting sugars such as sugarcane, corn, and sugar beets. Bioethanol can be blended with gasoline or used as a standalone fuel in flex-fuel vehicles such as those in Brazil.
- **Second-generation biofuels** use feedstocks which are more abundant and have less impact on food production, but the production processes are more complex. They use non-edible crops and biomass waste such as food waste, agricultural waste and forestry waste.
- **Third generation biofuels** use feedstocks with no food value, high yields with virtually no land requirement, and relatively low-cost production requirements. The main feedstock explored to date is algae, but production is not yet commercially viable.

Figure 2:
Conversion path of FOG feedstocks into bio-based fuels



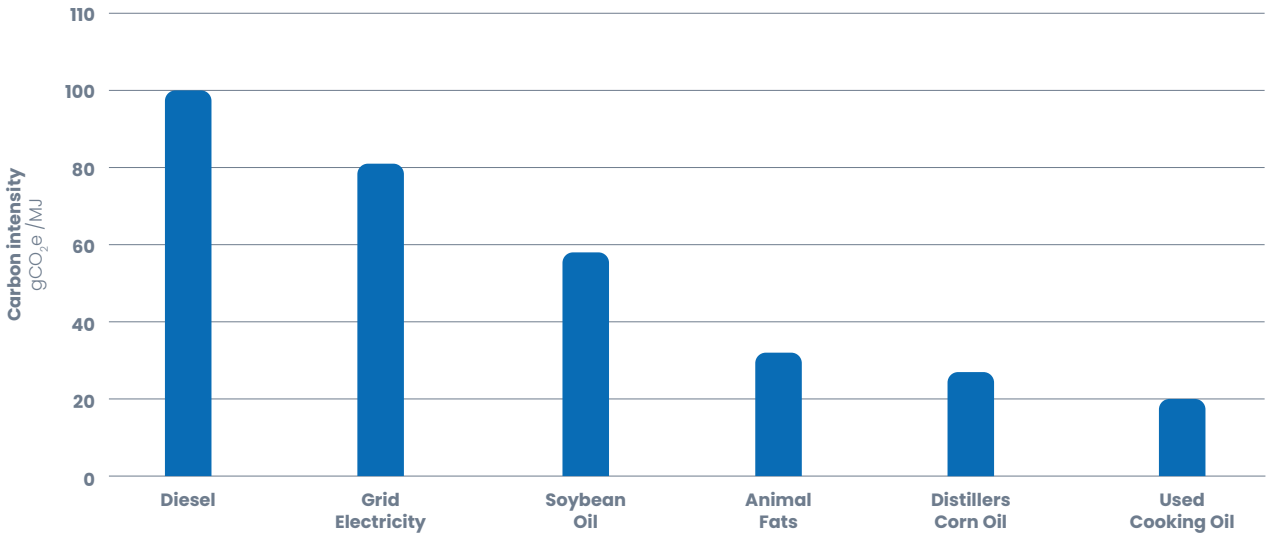
Source: European Waste-based & Advanced Biofuels Association, December 2022, and Candriam.
FOG = fat, oil, and grease

Third-generation biofuels are exciting for the energy transition but less of a focus for investors given their early stage. Previously, companies such as the Dutch DSM chemicals firm or Exxon Mobil in the US had invested in the development of algae-based biofuels, but left this area due to the difficulty in scaling to sufficiently high yields. There is still intense R&D activity in this segment, but commercial scale production is not on the horizon.

The array of second-generation biofuels utilizing animal fats, used cooking oil, and non-edible vegetable oils to produce renewable diesel (RD) or Biojet (for blending with jet fuel) is currently one of the most exciting areas for decarbonization of transportation. The production of these **second-generation biofuels helps to decarbonize two of the most challenging segments in transportation, heavy-road transport and aviation.**

Renewable diesel provides several advantages over biodiesel, particularly because its chemical similarity to petroleum diesel allows it to be blended and used interchangeably with diesel. Depending on the feedstock, this carbon intensity reduction can be significant. For example, Diamond Green Diesel, a US renewable diesel producer, estimates an 80% reduction in carbon intensity compared to fossil fuel diesel when utilizing used cooking oil, and a 68% reduction when using animal fats.[7]

Figure 3:
Feedstock Carbon Intensity



Source: Diamond Green Diesel/Group Valero, Copyright © Valero Marketing and Supply Company 2001-2002. All rights reserved. Incorporates 2022 LCFS data from California Carbon Fuel Standard, assuming $200 per metric ton carbon price. $1/gallon is equivalent to €0.25/litre at 31 Dec 2022 rate of $1.07/Euro

The *food vs fuel* debate

The availability of feedstocks has become a limiting factor for new entrants. The growth of renewable diesel (RD) in the US, driven both by regulations in California and by Federal tax credits, has been significant, with capacity expanding by 44% in 2022[8]. Many producers are unable to access waste feedstocks or lack the capacity to treat them, resulting in the use of vegetable oils such as soybean or palm oil. This has led the US and Europe to strengthen feedstock requirements in an effort to reduce competition with food production for arable land.

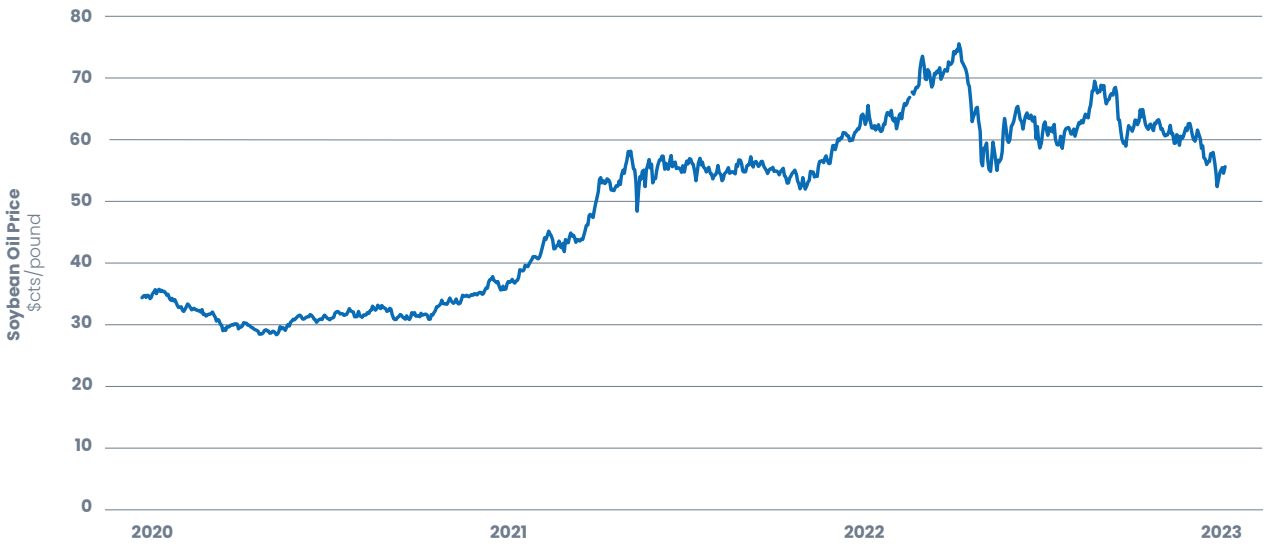
While the renewable energy label is a positive factor, this alone is not sufficient. It is important to also consider the environmental impact of different types of biofuels and their production processes when evaluating their potential as an alternative to conventional fossil fuels. Certain first-generation biofuels have been directly linked to deforestation, land-use change, and negative impacts on local communities in some regions, which has pushed some regulators such as those in Europe to limit their use

Although these concerns are valid and require monitoring, according to the International Energy Agency (IEA), 70% of renewable diesel in 2021 was derived from wastes and residues. Thus, incentives must continue to develop growth in this area while capping the production of first-generation biofuels.

In advanced economies, production of first-generation biofuel is already declining. However, this decline is offset by growth in emerging economies like Indonesia and India.

At Candriam, as responsible investors, we have a strict policy on palm oil requiring that companies in which we invest demonstrate that their sourcing is sustainable, usually RSPO certified (Roundtable on Sustainable Palm Oil), and with a clear policy in place against deforestation.[9]

Figure 4:
Soybean oil price



Source: Bloomberg, CBOT prices

To space and beyond?

The renewable diesel (RD) market has experienced a healthy correction during 2022, with some projects being delayed or cancelled. The market is dominated by two players: Finnish refiner Neste and US-based Diamond Green Diesel (a joint venture between Valero and Darling). Several oil companies, such as Eni and Total, are also present in the market -- typically entering by converting refineries. Chevron entered the RD category in 2022 through its $3 billion acquisition of US-based Renewable Energy Group. Incumbents such as Neste and Diamond Green Diesel usually have better access to waste residues for feedstock, while new players and oil companies find themselves more reliant on vegetable oils.

'Biojet', or Sustainable Aviation Fuel (SAF), is seen as the future growth area for the industry. Aviation currently contributes 2.5%[10] of global CO2 emissions, and aviation emissions continue to grow. Electric and hydrogen solutions are still far in the future for aviation, leaving SAF as the only viable medium-term solution, besides reducing air traffic. SAF has been certified under the ASTM standards for global aviation, for up to 50% of the aviation fuel blend.

The SAF market is still in an early stage. In 2021, the US produced only 19 million gallons of SAF, which pales in comparison to the 20 billion gallon annual consumption of US airlines before the pandemic. This fuel consumption is forecast to *double* by 2050. Thankfully, the incentives in place are driving exponential growth in the SAF market:

- The Biden administration in the US aims to produce 3 billion gallons of SAF by 2030 and has introduced a tax credit as an incentive.
- In Europe, regulation requires SAF blending to reach 2% by 2025 and 5% by 2030.
- The global airlines industry has agreed on a voluntary plan called CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation) to stabilize the industry's CO2 emissions.

SAF is currently two to three times more expensive than traditional jet fuel, but the market opportunity is attracting a number of new entrants. Over the next five years, the supply of SAF is expected to compound at a 54% annual rate, compared to just 19% for renewable diesel.[11]

World Energy, a US refiner, was the first to the market in 2016 and is currently expanding its production through a partnership with Air Products, targeting 340 million gallons per year. Neste, the Finnish refiner, is already the biggest player in renewable diesel and is on track to also become the biggest producer of SAF thanks to the planned expansion this year of its SAF production to 1.5Mt (≈450M gallons) per year.

Most SAF producers are using a production process similar to that for renewable diesel, but some start-ups are exploring different methods:

- Gevo and LanzaJet are two companies exploring the alcohol-to-jet pathway, to convert ethanol into jet fuel.
- Ineratec, a German start-up, is focusing on power-to-liquids, converting energy from renewable sources into liquid fuel.
- BayouFuels is planning a 35 million gallons-per-year pilot plant in the US to produce SAF from forestry waste.
- Amyris, Evolva, and other start-ups are exploring synthetic biology metabolic modification of bacteria, yeast, or algae to produce specific biofuels.

Given the present market conditions and government incentives, whether regulatory or financial, our analysis suggests that the second-generation biofuels are likely to make the greatest contribution to carbon reduction in aviation power. Feedstock constraints, due to environmental concerns in particular, are likely to limit the contribution of first-generation technologies. Within the second-generation players, those producing SAF fuels may be able to make the greater impact on emissions, as supply is still lagging the regulatory-driven demand. The need and demand are there for them to expand. Beyond environmental concerns, one risk to the expansion of this carbon solution is the volatility of feedstock prices. The second-generation technologies are likely to solve this problem through vertical integration to increase the predictability of access to and prices of feedstocks.

Because of the potential growth of the biofuels market, investors may wish to position part of their portfolio in this market. It is therefore essential to make a precise assessment of these players, the technologies they use, the environmental benefits and risks associated with their biofuel technologies and their potential growth, beforehand. At Candriam, because we've been considering “green energy” in our sustainable portfolios for over 25 years, we have the knowledge and vision to help you make the transition to biofuels.

Although we recommend to peddle your bicycle or take the train, the next time you fly, consider blending some SAF, Neste already serves 50 airlines.

Notes & References.

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2 Eurostat, as of 2021. Oil and petroleum products - a statistical overview - Statistics Explained. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Oil_and_petroleum_products_-_a_statistical_overview&oldid=315177#Consumption_in_sectors, Accessed April, 2023.

3 Hydrogen, which we will discuss in another edition of this series, is a long way off.

4 "Much of petroleum diesel fuel sold in the United States actually contains up to 1% biodiesel because of biodiesel's lubrication qualities." U.S. Energy Information Administration, 29 June, 2022. Biofuels explained - use and supply. https://www.eia.gov/energyexplained/biofuels/biodiesel-rd-other-use-supply.php#:~:text=Much%20of%20petroleum%20diesel%20fuel,tanker%20trucks%20for%20local%20distribution, Accessed 22 May, 2023.

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7 Valero, Basics of refining and renewable diesel. https://s23.q4cdn.com/587626645/files/doc_presentations/2023/02/basics-of-refining-and-renewable-diesel-2023.pdf, page 24. Accessed April, 2023.

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9 The Candriam Exclusion Policy is available on our website at https://www.candriam.com/en-be/professional/insight-overview/publications/#sri-publications

10 Global Carbon Budget 2019, aviation only. https://www.globalcarbonproject.org/carbonbudget/ Accessed April, 2023.

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€139 B

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600

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+ 25 years

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*As of 31/12/2022, Candriam changed the Assets Under Management (AUM) calculation methodology, and AUM now includes certain assets, such as non-discretionary AUM, external fund selection, overlay services, including ESG screening services, [advisory consulting] services, white labeling services, and model portfolio delivery services that do not qualify as Regulatory Assets Under Management, as defined in the SEC's Form ADV. AUM is reported in USD. AUM not denominated in USD is converted at the spot rate as of 31/12/2022.

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