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Asian Insights SparX

Industry & Sustainability | Group Research

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Food-for-Fuel:
Fuelling, without Hungering, the World

Opportunities in Asia

01 Introduction & Summary

Introduction & Summary

This report deck serves as a primer and provides an overview of the current state and future prospects of biofuels as a renewable energy source- **Food-for-Fuel: Fuelling, without Hungering, the World**. With increasing focus for the world to achieve *Net Zero* (Paris Agreement)* and increasing global demand for sustainable and clean energy solutions, biofuels has gained significant attention. We touched on the challenges and potential environmental impacts associated with biofuel production. Understanding the current trends and advancements in biofuel technology is crucial for investors and stakeholders in shaping a greener energy future.

There are three main sections to this deck. First, we provide an **understanding of biofuel** – what is it, types of feed stock, uses, markets and regulations, uses and considerations. This, while may seem basic to some, serves to provide a basis, context and commonality of terms and references used. In addition, we believe this could be helpful for those who are relatively new to this topic.

Secondly, with transportation contributing to ~16% of GHG emissions (according to Climate Watch, Ourworldindata.com), we delve into three broad **modes of transport – Land, Air and Sea** and briefly discuss the uses and potential of biofuel within the various modes. In Land Transportation, our observation is that biofuel have a *transition* role to play even though the likely way forward is electrification. On the other hand, biofuel should play a more critical role for the aviation industry as the industry aims to achieve net zero emissions by 2050. For the marine industry, use of biofuel and regulatory mandates looks to be nascent at current point in time.

Following on, we explore **possible investment opportunities**. Our current initial assessment suggest that for biofuel use to succeed, one of the key criteria, amongst others, is on the use sustainable feedstock and waste products (Type II). We touched on **Used Cooking Oil (UCO)** and the potential for it. The obvious benefit to this is on the reduction of competing uses of feedstock, for instance, food crops – Type I. In addition, the use of sustainable feedstock such as waste materials (UCO), helps in ***upcycling*** and promote the drive towards a ***circular economy***.

We acknowledge and note that the topic of biofuel is far reaching, wide and one has to consider numerous factors and implications that comes along with the interplay of all the above as well as others, such as technological advancements. We are unable to cover all issues and opportunities; and, are aware that there are many other related points or areas to consider and are not discussed here. For instance, the development of biofuel and usage depends on regulation, pricing of traditional fuels, availability and pricing of feedstock, technological advancement, and so on. We also recognise that in the transition to sustainable biofuel, the use of traditional feedstock (eg corn, sugar cane, vegetable oils) will still remain relevant and important. Nonetheless, this deck serves as a **primer and an initial discussion** of the thematic angles impacting the longer-term investment thesis.

We view this as an ongoing conversation rather than a one-off treatise on the topic, invite **feedback**, and **welcome follow on questions worthy of closer examination**.

Thank You!

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**Note: Based on UN Climate Action, net zero means cutting greenhouse gas emissions to as close to zero as possible, with any remaining emissions re-absorbed from the atmosphere, by oceans and forests for instance. The Paris Agreement has called to keep global warming to 1.5 degree Celsius, and emissions need to be reduced by 45% by 2030 to reach net zero by 2050.*

Content

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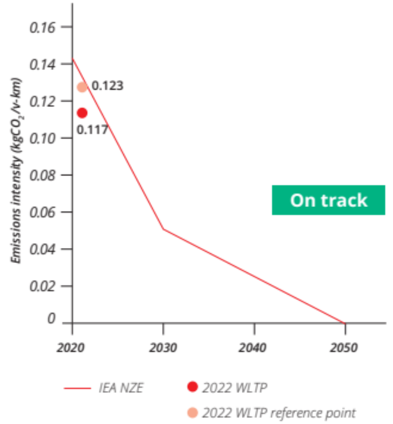
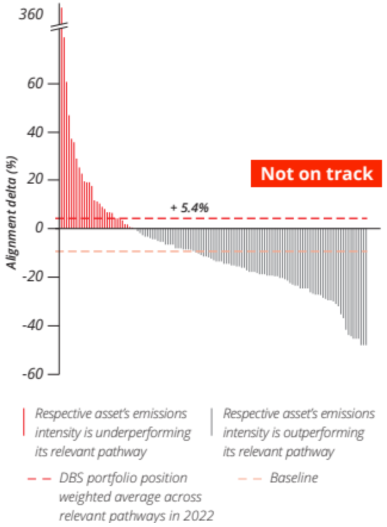
DBS is committed to net-zero as part of our sustainability initiative

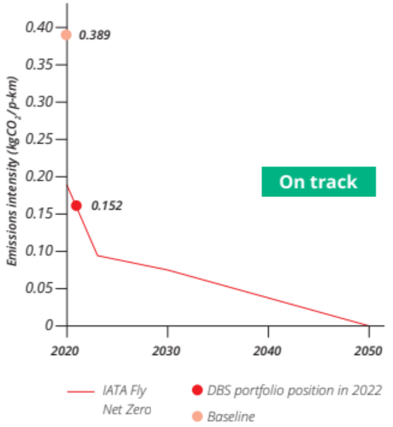
Automotive
kgCO$_2$/vehicle-km



Shipping
Alignment delta (%)



Aviation
kgCO$_2$/p-km



- DBS Bank is a signatory to the industry-led, UN-convened Net-Zero Banking Alliance (NZBA), which aims to **reinforce, accelerate and support the implementation of decarbonisation strategies**
- We have set ambitious targets to drastically reduce emissions from **transportation sector, which accounts for ~16% of greenhouse gas emissions**
- **Automotive:** Focus on light passenger vehicles and aim to reduce pipe emissions down to zero
- **Aviation:** Supporting the growth and adoption of sustainable aviation fuel (SAF)
- **Shipping:** Focus on reducing emissions intensity of vessels

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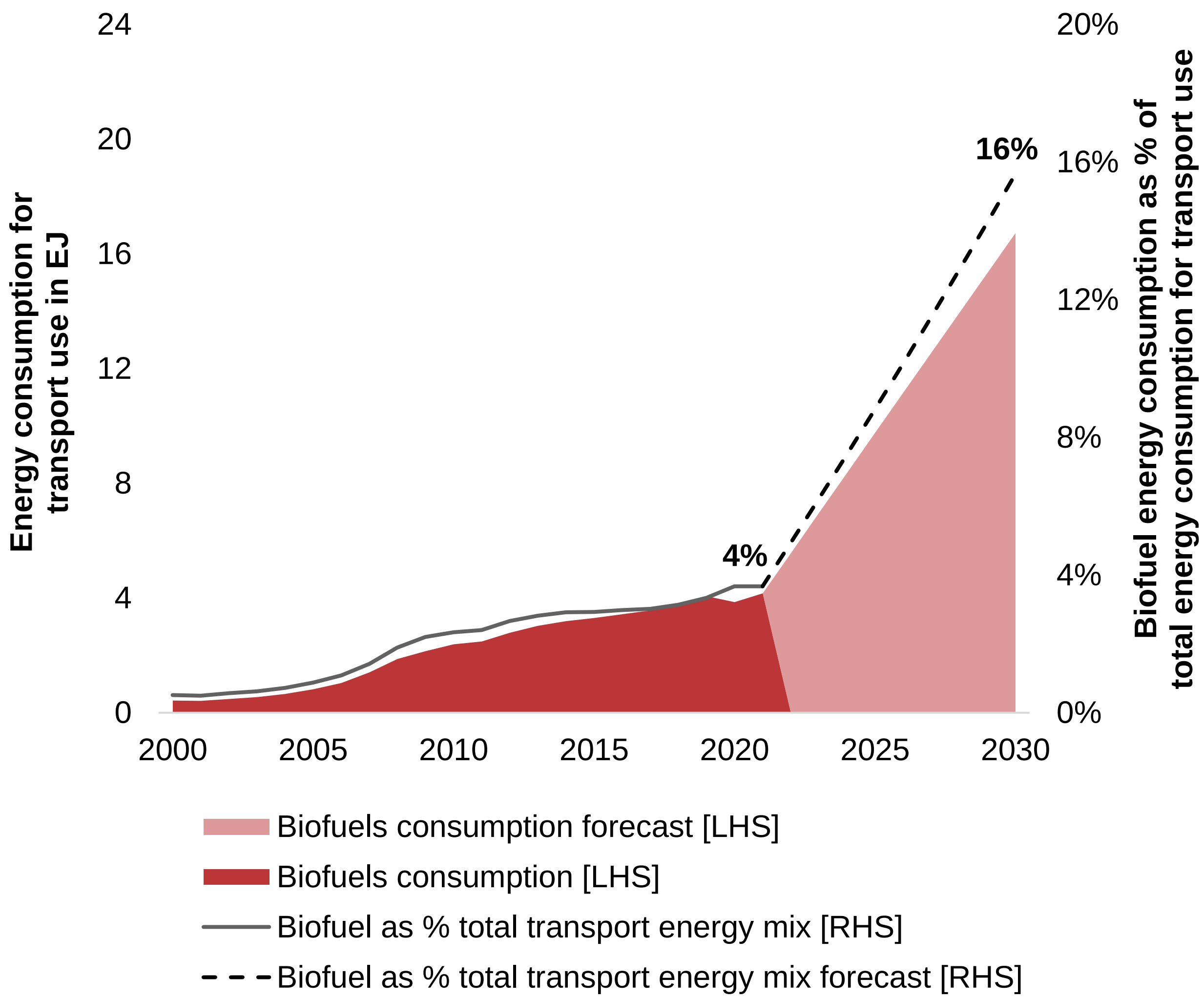
Source: DBS Bank (Note: IEA NZE refers to International Energy Agency's Net Zero Emissions by 2050 Scenario; WLTP refers to Worldwide Harmonised Light Vehicle Test Procedure, which is the global standard adopted in measuring fuel consumption and emissions from cars; IATA Fly Net Zero refers to International Air Transport Association's net zero forecast starts from 2020 based off IEA's starting point)

Biofuel expected to play a critical role in net zero transition



- Biofuel is expected to play a critical role in **net zero transition for transportation segment**
- Based on IEA NZE*, a **4-fold increase in biofuel consumption as part of global transportation fuel mix** is required in 2030 to remain on track for net zero by 2050
- Increased use of biofuel and electricity is expected to **reduce reliance on oil and natural gas** as part of transportation fuel mix from 95% in 2021 to 76% by 2030
- Shift to biofuel is expected to be **more effective than electrification in the short/medium term** in reducing carbon emissions given the cost barrier and infrastructure needs of electric vehicles especially in less developed countries

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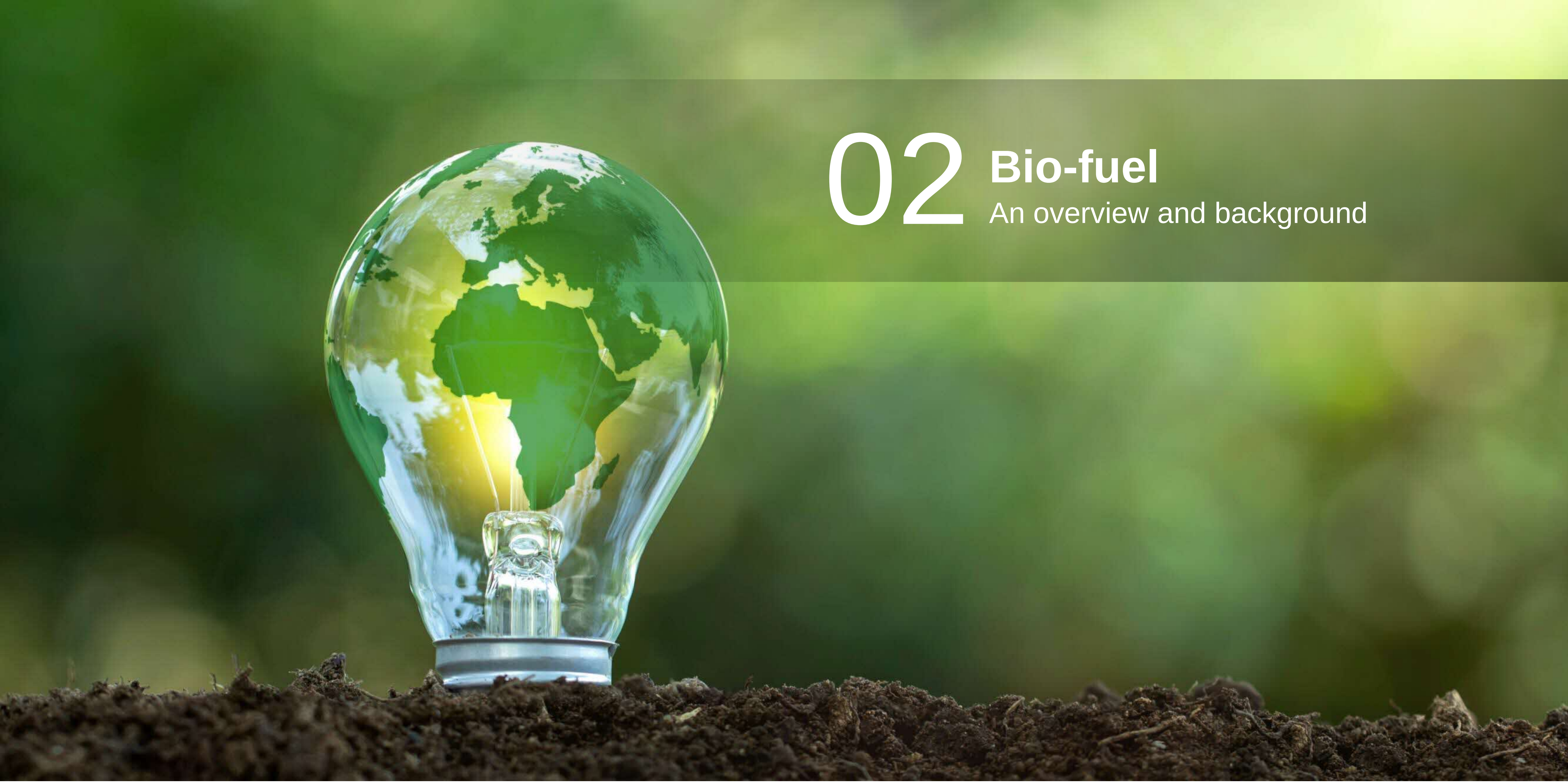
Source: IEA, DBS Bank

**IEA NZE: International Energy Agency, Net Zero Emissions by 2050 scenario*



02 Bio-fuel

An overview and background

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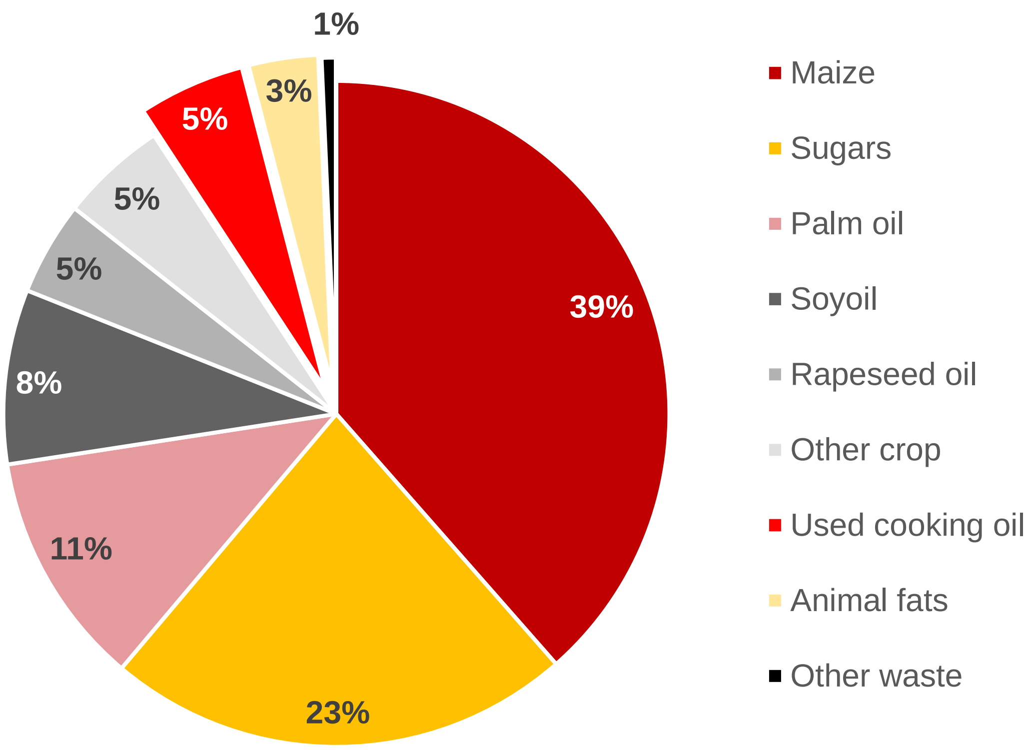
1 – Understanding Biofuel

> 90% of feedstock for biofuels are from edible crops and oils with used cooking oil (UCO) being a key non-edible feedstock



Source: IEA (2021), DBS Bank

- Biofuel is **any kind of fuel directly derived from plant or animal matter**, also known as biomass
- **>90% of biofuel today is made using edible crops** with maize, sugar cane/sugar beet and vegetable oils being the most used feedstock
- Biofuel can be categorized based on the feedstock used: **Type I, Type II and Type III**
- Biofuel can also be categorized based on its usage with more prominent types being **biodiesel, ethanol**, **biogas and aviation biofuel**

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1 – Biofuel type based on feedstock used

Type II biofuel is coming into focus given that it promotes the circular economy with use of waste materials as feedstock

Type I Biofuel

Feedstock: Corn, sugar cane, vegetable oils

Benefits: Renewable resource, lower greenhouse gas emissions, reduce dependence on foreign oil, stimulate agriculture sector

Considerations: Deprive crops for food use, potentially higher greenhouse gas emissions depending on production process

Type II Biofuel

Feedstock: Corn cob, bagasse, palm oil mill effluent (POME), used cooking oil (UCO)

Benefits: Do not compete with food production, promote circular economy, lower greenhouse gas emissions

Considerations: Expensive and energy-intensive processing required for certain feedstock

Type III Biofuel

Feedstock: Algae

Benefits: Do not compete with food production, high yield per acre compared to traditional crops, can be grown in non-arable land

Considerations: Very expensive and energy intensive processing required as technology is relatively new

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1 – Common biofuel type based on usage

Biodiesel and ethanol are the most common biofuel, which is use in land transport; aviation biofuel is increasingly gaining more attention given sustainability goals of airlines

Biodiesel*

Feedstock: Vegetable oils and used cooking oil (UCO)

Characteristic: Depending on processing methods, can be either blended with petroleum diesel or used without blending

Use case: Heavy vehicles like trucks and industrial machinery

Ethanol

Feedstock: High sugar crops like maize or sugar cane

Characteristic: Use as blend with gasoline with higher blend mix requiring specially designed vehicles

Use case: Light vehicles like passenger cars

Biogas

Feedstock: Crop residues like maize stover, food waste

Characteristic: Use to power biogas plants to generate electricity and heat, cost remains higher than wind and solar

Use case: Generate electricity and heat

Aviation Biofuel

Feedstock: Used cooking oil (UCO), agriculture waste

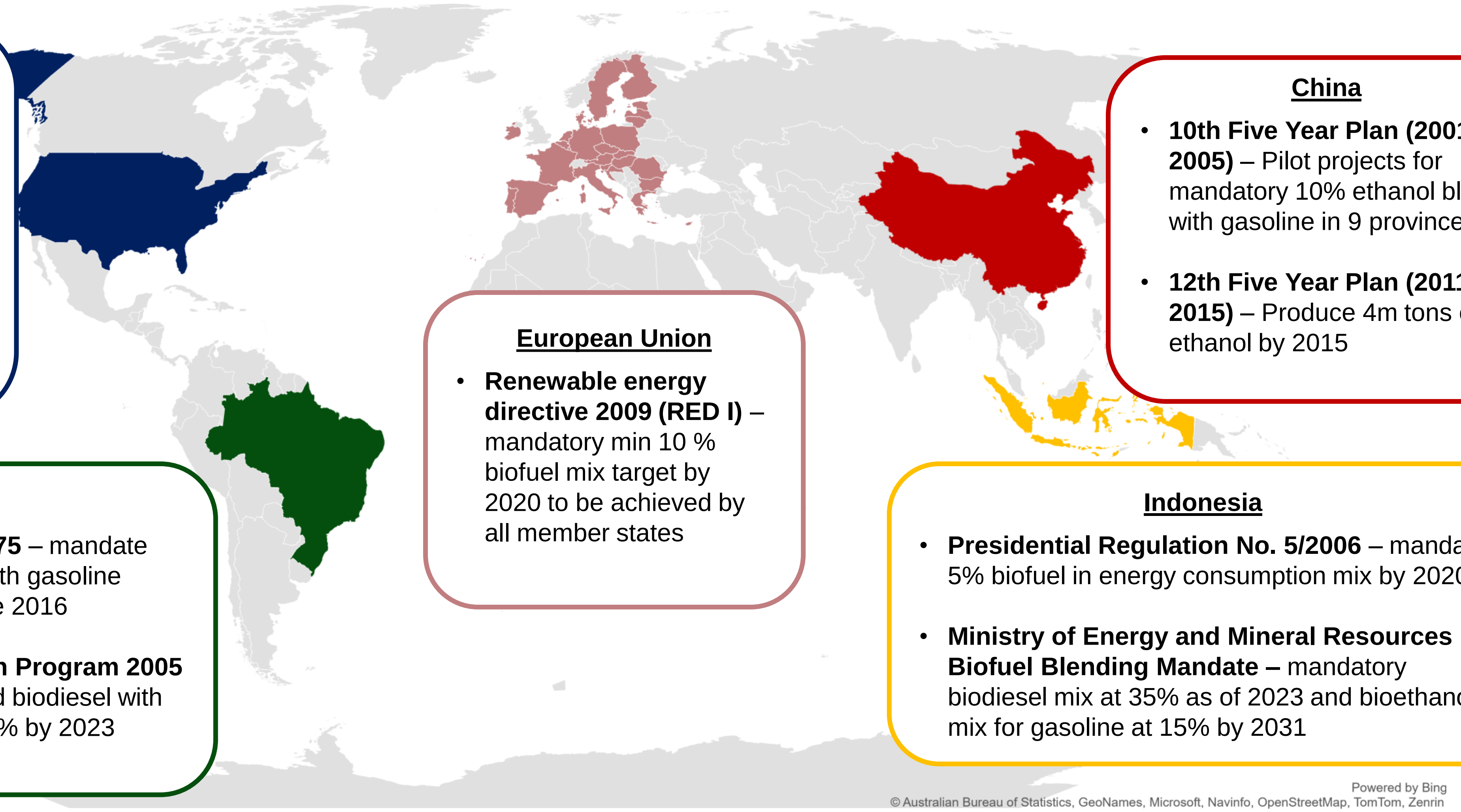
Characteristic: Typically blended in small percentage with conventional jet fuel given high cost (can be used without blending)

Use case: Aircraft

**Note: We classified renewable diesel, a term predominantly used in the U.S. to differentiate from traditional biodiesel as it can be used without blending with diesel, under biodiesel*

2 – How biofuel became prevalent?

Regulatory requirements which mandate certain biofuel production target and % blend mix with traditional fuel led to significant surge in biofuel usage as part of energy mix



USA

- **Energy Policy Act of 2005** – mandate blending of 7.5 billion gallons of biofuel annually by 2012
- **Energy Independence and Security Act of 2007**- mandate increase of biofuel production to 36 billion gallons by 2022

China

- **10th Five Year Plan (2001-2005)** – Pilot projects for mandatory 10% ethanol blend with gasoline in 9 provinces
- **12th Five Year Plan (2011-2015)** – Produce 4m tons of ethanol by 2015

European Union

- **Renewable energy directive 2009 (RED I)** – mandatory min 10 % biofuel mix target by 2020 to be achieved by all member states

Brazil

- **National Alcohol Program 1975** – mandate requirement to blend ethanol with gasoline starting from 4.5% to 27% since 2016
- **National Biodiesel Production Program 2005** – mandate requirement to blend biodiesel with gasoline starting from 2% to 15% by 2023

Indonesia

- **Presidential Regulation No. 5/2006** – mandate 5% biofuel in energy consumption mix by 2020
- **Ministry of Energy and Mineral Resources Biofuel Blending Mandate –** mandatory biodiesel mix at 35% as of 2023 and bioethanol mix for gasoline at 15% by 2031

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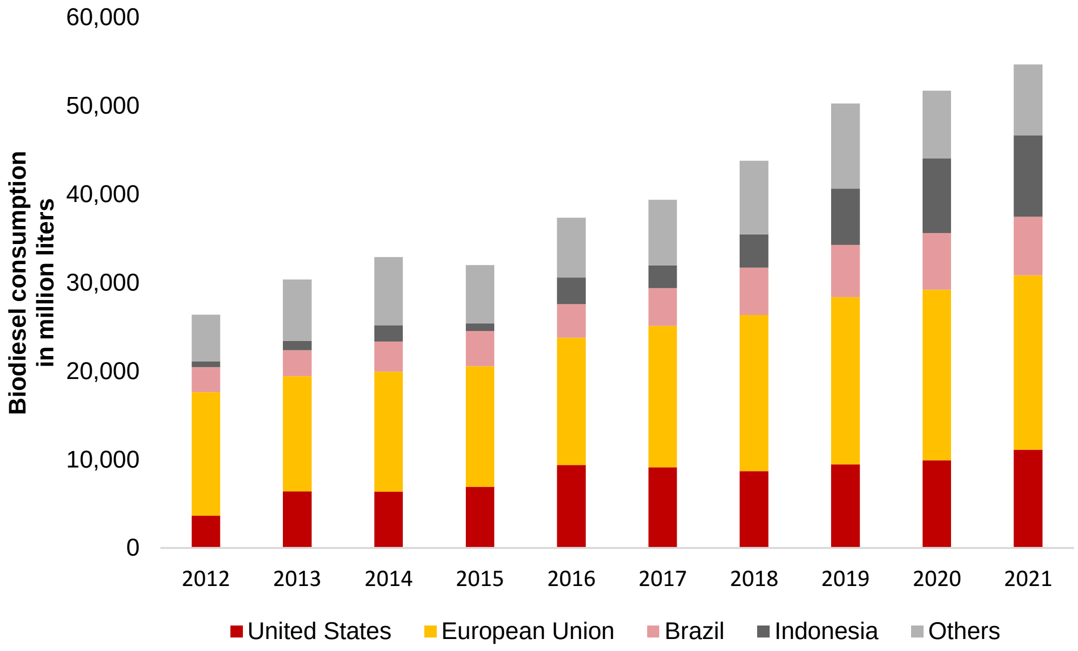
Source: United States Environmental Protectional Agency, International Energy Agency Bioenergy, EUR-Lex, Ministry of Finance of Republic of Indonesia, Reuters, DBS Bank

3 – Where is biofuel being used?

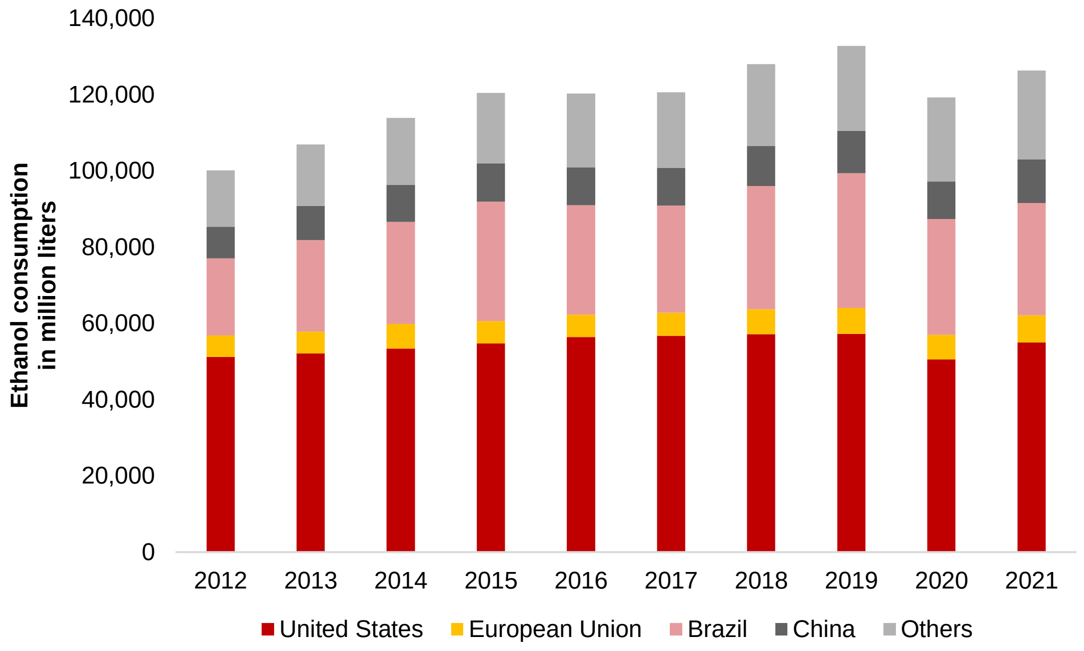
Biofuel demand is concentrated in countries with regulatory mandates to include biofuels in their energy mix like US, EU Brazil and Indonesia

Biodiesel demand from USA, EU, Brazil and Indonesia contributed to 85% of global demand with 36% of demand coming from EU



Source: OECD, DBS Bank

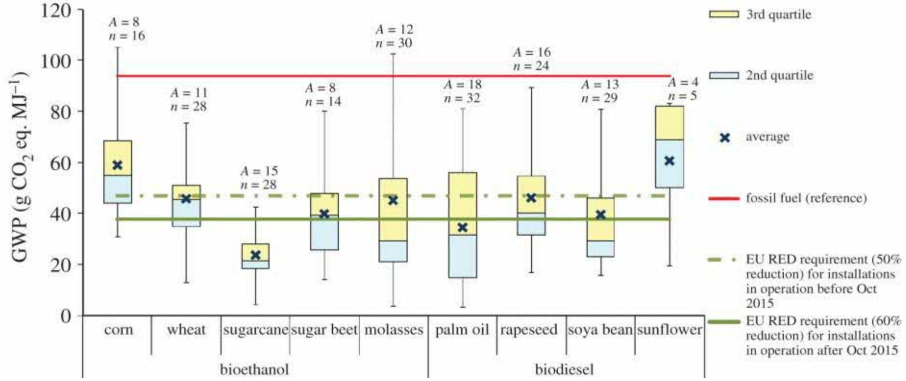
Ethanol demand from USA, EU, Brazil and China contributed to 81% of global demand with 44% of demand coming from USA



Source: OECD, DBS Bank

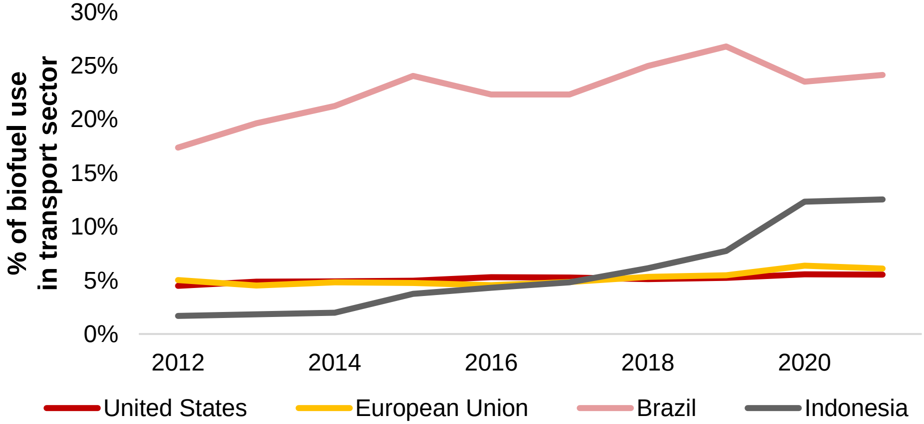
4 – Why is biofuel being used?

Majority of biofuel has lower global warming potential (GWP) measured in terms of carbon intensity versus conventional petrol/diesel



*Source: The Royal Society (Jeswani, Chilvers, Azapagic)**

Regulatory policies especially aggressive biofuel blend mandate has been effective in diversifying energy mix for transportation sector



Source: U.S. Energy Information Administration, Eurostat, Brazil Ministry of Mining and Energy, Indonesia Ministry of Energy and Mineral Resources

- Top three reasons for promoting use of biofuel include: **(i) protect the environment, (ii) promote the agriculture industry and (iii) provide energy security**
- **Environment:** Biofuel burns more cleanly than fossil fuel, as such emits less carbon dioxide. Impact of lowering of carbon intensity varies depending on feedstock used. On average, the **carbon emission can be reduced by 36%-74%**.
- **Agriculture sector:** According to International Renewable Energy Agency (IRENA), the **biofuel industry created 2.4 million jobs in 2021**. These jobs are mostly in the agriculture sector and concentrated in emerging countries. Brazil has the largest biofuel workforce at 863k, followed by Indonesia at 556k.
- **Energy security:** Having experienced major energy crises especially for net oil importers, there is a **need to diversify energy base.** It has been somewhat successful with 5% of biofuel transportation energy mix in developed US and EU countries. Countries with more aggressive blending policies like Indonesia and Brazil saw more material impact to energy diversification effort at 13% and 24% of biofuel transportation energy mix respectively.

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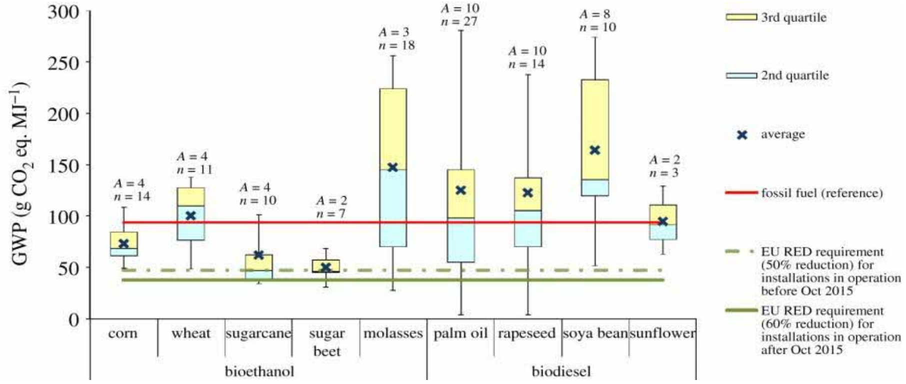
Link: https://royalsocietypublishing.org/doi/10.1098/rspa.2020.0351#d1e3689

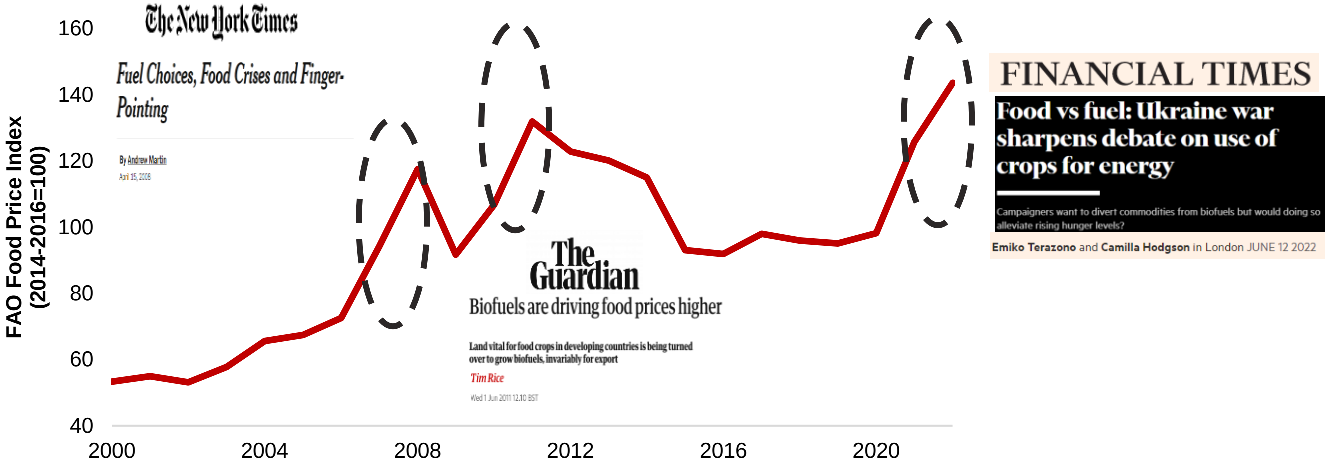
5 – What are the key considerations for biofuel?

Considering land-use change, biofuel produced using most conventional feedstock does not reduce carbon intensity vs fossil fuel



*Source: The Royal Society (Jeswani, Chilvers, Azapagic)**

Regular headlines on food vs fuel debate whenever food prices soar



Source: Food and Agriculture Organization (FAO) of the United Nations, The New York Times, The Guardian, The Financial Times, DBS Bank

- **Land-use GHG impact:** Should carbon emission from land-use change be considered, on average, study shows **most conventional feedstock is more carbon intense than fossil fuel**. In addition, for those less carbon intense feedstock, the carbon emission saving is lowered to 21%-48% range (versus 36%-74% without land-use change consideration).
- **Food vs fuel debate:** With 90% of biofuel being produced using crops for food use, there arises food vs fuel debate especially when food prices are high. The debate revolves around whether it is **socially justified to process food crops into fuel** and contribute to pushing food prices higher, which will lead to more hunger.
- **Increase energy price:** Biofuel has historically cost more than fossil fuel, as such mandated blend will push up fuel prices. According to a study in the Applied Journal, researchers estimated that a biofuel mandate of 20% in Europe will lead to **2%-18% higher fuel cost**.
- **Need for government support:** As of Mar-22 prices, biodiesel costs 70-100% more than diesel while ethanol costs 7-56% more than gasoline (adjusted for similar energy production) in the US and EU. Studies from Energy Economics and Spanish Journal of Agricultural research found that consumers are **willing to pay a slight premium** of between 5-11% on average for biodiesel and ethanol. At their average willingness to pay price point, we believe there will be **no business case for biofuel without government intervention**.

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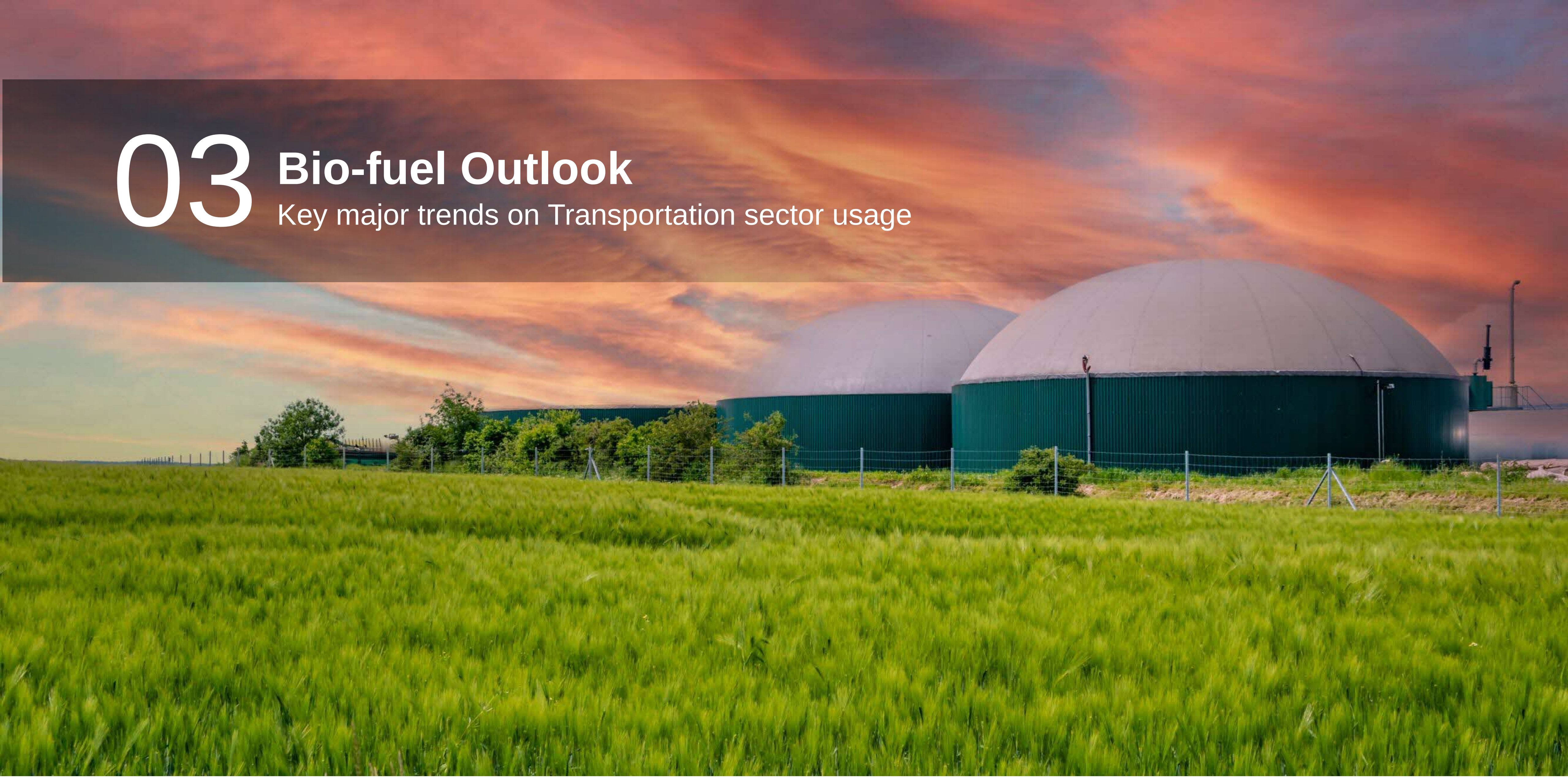
Link: https://royalsocietypublishing.org/doi/10.1098/rspa.2020.0351#d1e3689

03 Bio-fuel Outlook

Key major trends on Transportation sector usage



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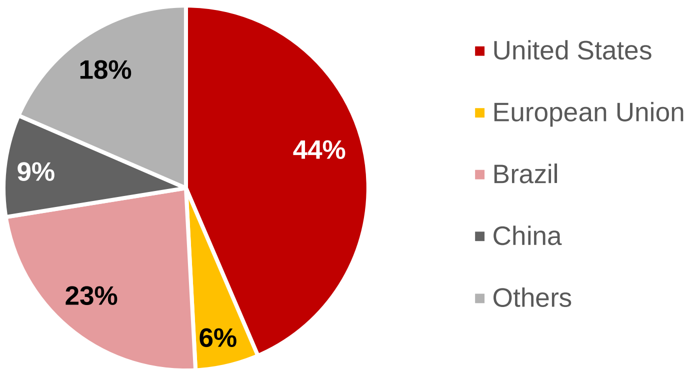
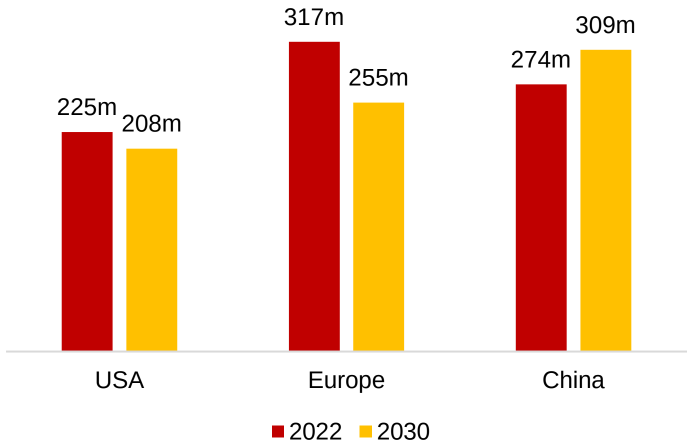
Land transport – Electrification headwind for ethanol

Ethanol demand breakdown by country (2021)



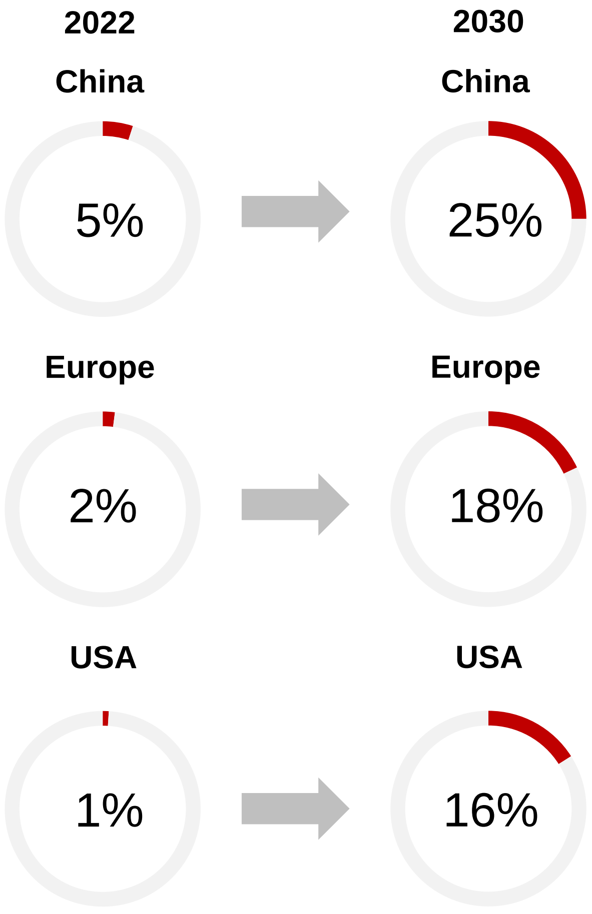
Source: OECD, DBS Bank

ICE car on the road forecast in selected countries with high ethanol usage



Source: IEA, DBS Bank

EV as % of total passenger cars on the road



Source: IEA, DBS Bank (2030 forecast is based on Stated Policies Scenario; EV refers to battery electric and plug-in hybrid electric vehicles

- Ethanol is predominantly used to **fuel light vehicles** i.e., passenger cars
- With wide network of charging infrastructure and affordable pricing, **rapid adoption of electric passenger vehicles** is expected in the USA, Europe and China
- We expect **demand for ethanol to decline in USA and Europe** alongside expected decline in internal combustion engine (ICE) cars as consumers transition to EV
- In China, ICE car on the road is expected to rise along with rising income, but at a slower pace **tempered by EV adoption**
- Given limited biofuel incentive, we expect China **demand to remain tempered** (9% of demand in 2021)
- Whereas, in Brazil, given lack of charging infrastructure, high EV prices and resistance from local sugarcane producers, we expect **locals to continue opting for ICE car**
- With increased ICE car population, we expect ethanol **demand in Brazil to remain on a growth trajectory**

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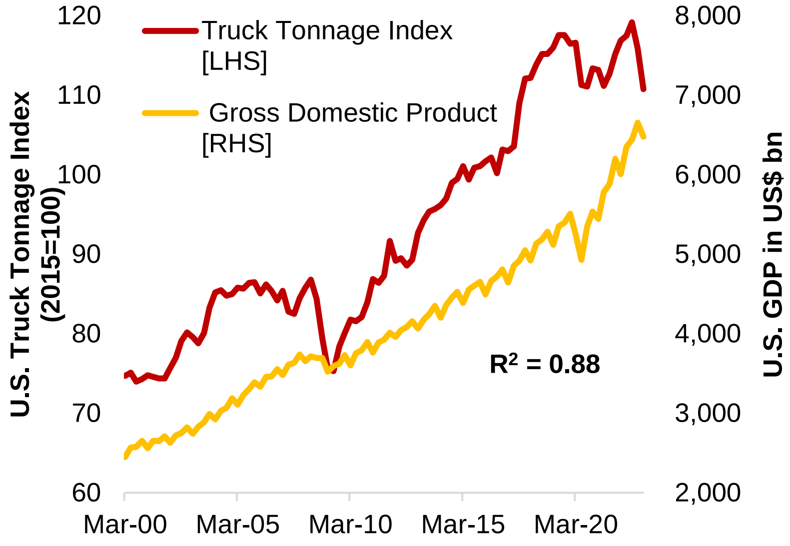
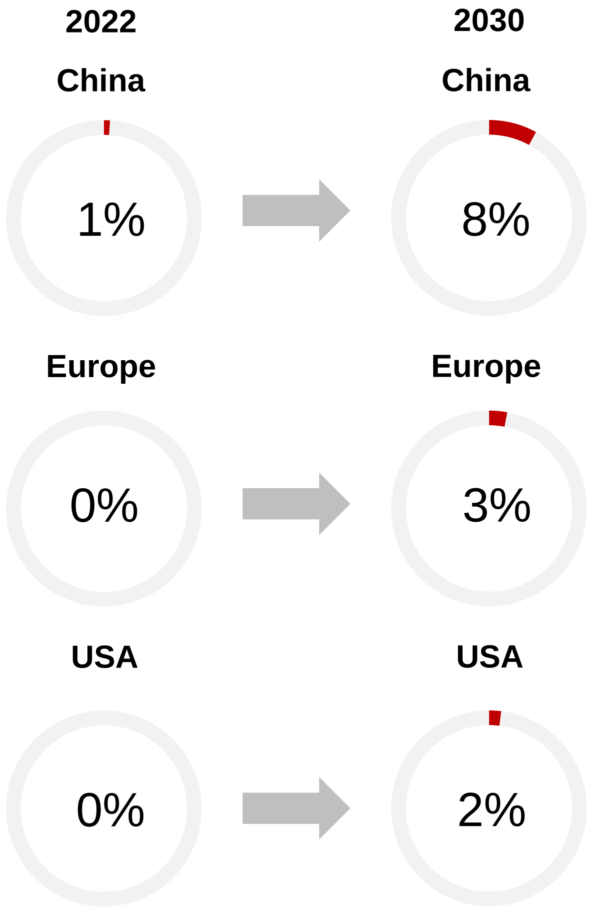
Land transport – Biodiesel to remain relevant

Strong correlation between economic growth and trucking freight activities



Source: Bureau of Transportation Statistics, Bureau of Economic Analysis, CEIC, DBS Bank

EV as % of total trucks on the road



Source: IEA, DBS Bank (2030 forecast is based on Stated Policies Scenario; EV refers to battery electric and plug-in hybrid electric vehicles

- Biodiesel is predominantly used to fuel heavy vehicles **i.e., trucks**
- Trucks weigh significantly more than passenger cars, especially with goods onboard, necessitating **a larger and significantly more costly battery pack** for EV model
- Given the higher cost, **adoption of EV truck is expected to be slow** with total cost of ownership (TCO) expected to match ICE truck around 2026 in Europe and 2029 in USA (International Council on Clean Transportation (ICCT))
- We expect **steady growth in demand for biodiesel worldwide** as consumers demand more goods with rising global income, which in turn drive freight trucking activities
- However, we expect to see a **shift in feedstock used for biodiesel production** due to regulatory changes in the EU (contribute to 36% global biodiesel demand in 2021)

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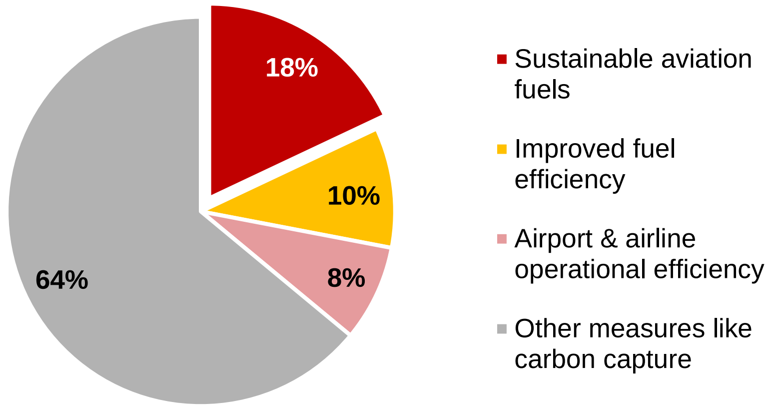
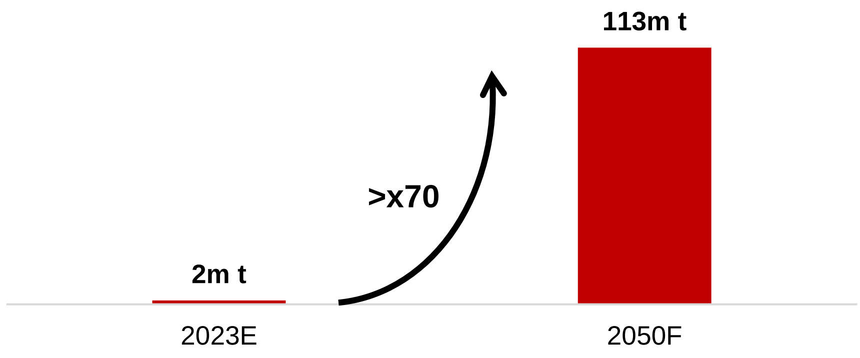
Air transport – Sustainable aviation fuel (SAF) critical to hit net zero by 2050

Use of sustainable aviation fuel (SAF) stands out as a critical factor to achieve net zero CO_2 target by 2050



Source: Air Transport Action Group (ATAG), DBS Bank

Exponential growth in SAF capacity required to achieve net zero CO_2 target by 2050 in base case scenario



Source: Various sources, Air Transport Action Group (ATAG), DBS Bank

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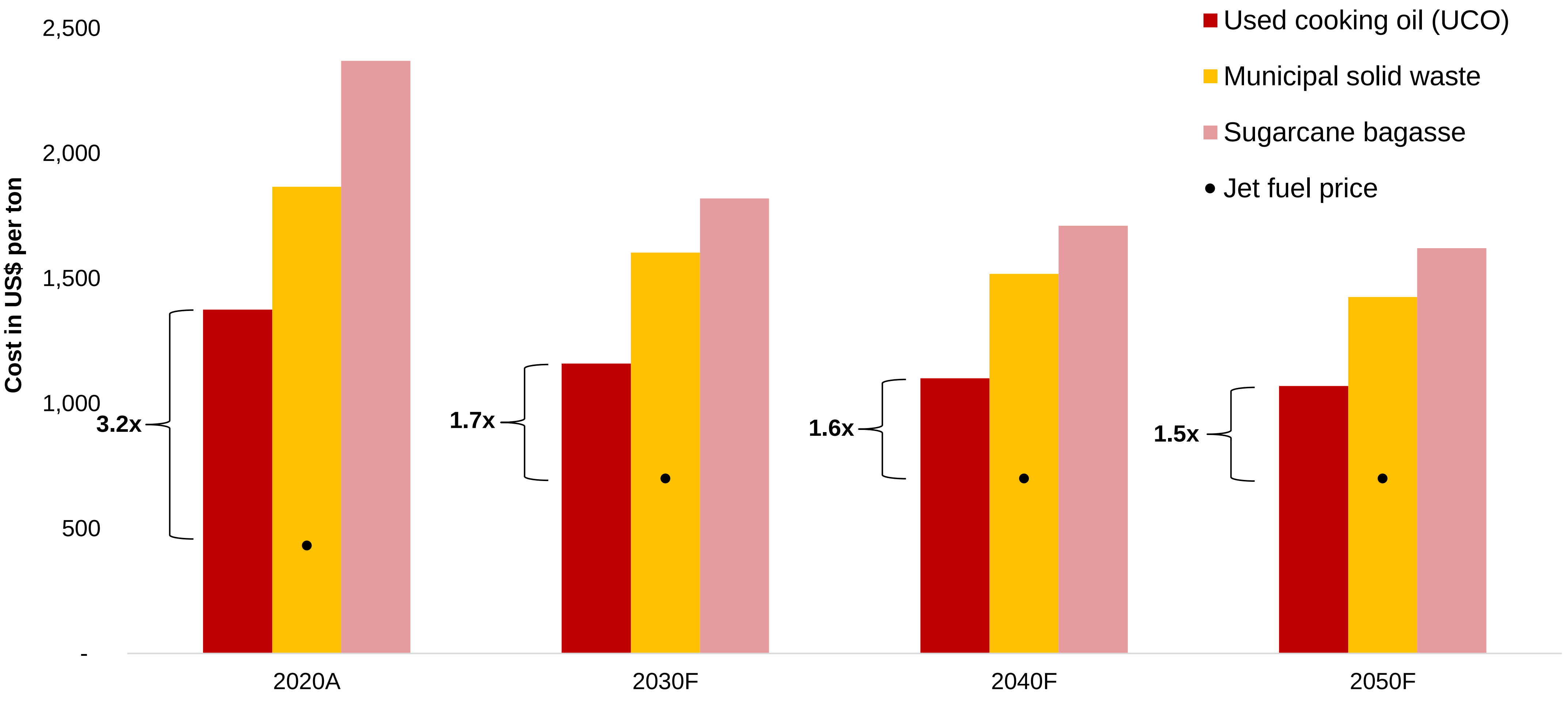
- Air transport remains challenging to electrify, as such most experts believe the **optimal path to net zero is through use of sustainable aviation fuel (SAF)**
- To qualify as SAF, the fuel is **produced using sustainable resources** which can be sustainable crops (generally crops with low land use change risk) and/or sustainable waste/residues
- No specific certification requirement for SAF in US, while **EU requires SAF to meet Renewable Energy Directive (RED) standards**, which in turn requires certification from organizations like ISCC (International Sustainability and Carbon Certification) and RSB (Roundtable on Sustainable Biomaterials)
- Under a base case scenario in the Waypoint 2050 report by ATAG, **113m ton of SAF by 2050** is required for SAF to achieve 18% contribution towards net zero in base case scenario, which represents **>70-fold increase in existing production capacity**
- Costs remain a key hurdle for SAF adoption at **~2x of traditional jet fuel** (May-23), while consumers are **willing to pay up to 13% more** for jet biofuel usage according to a study published in International Journal of Sustainable Aviation in 2017, as such government support is critical to increase SAF adoption
- EU set out binding targets of **6% SAF fuel mix for fuel made available in EU airports in 2030, rising to 70% by 2050** under its ReFuelEU Aviation policy, which is supported by state aid for production capacity buildout and tax incentives
- US targets **9m ton SAF production by 2030** and **106m ton by 2050** under its SAF Grand Challenge Roadmap, which is supported by grants and tax incentives, with a goal of SAF contributing **at least 50% reduction in aircraft GHG emissions** (versus 18% in base case scenario from ATAG)

Air transport – UCO is one of the most cost-efficient feedstock for SAF

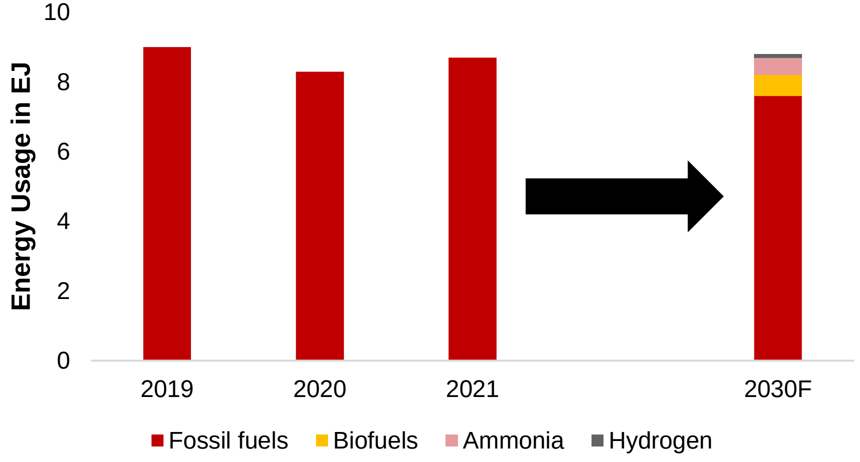
UCO is expected to remain among the most cost-efficient feedstock in foreseeable future and premium to jet fuel is expected to narrow with improved technology/larger scale



Source: World Economic Forum, DBS Bank (Assume jet fuel price will remain constant around US$700 per ton, about trading price in May-23)

Marine transport use outlook – Technological advancement key to lower emissions

Alternative fuel adoption expected to remain slow in the near term



Source: IEA, DBS Bank

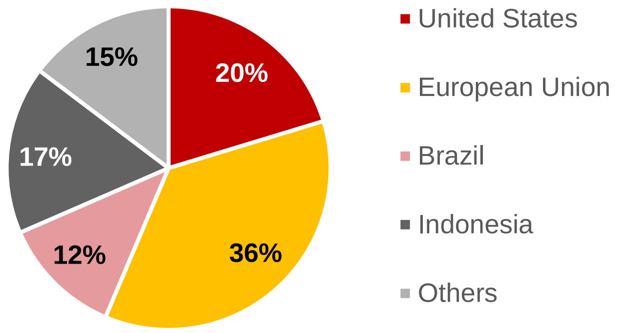
- Shipping accounts for **2% of GHG emission** with over 99% of marine fuel currently used being fossil fuel
- Key drivers behind low alternative fuel uptake include **high cost versus fossil fuel**, **alternative fuels in early trial stages** and **lack of government regulations** to promote alternative fuel usage
- EU set out GHG intensity of energy used on-board by a ship reduction targets cut of **2% by 2025, 6% by 2030, 14.5% by 2035, 31% by 2040, 62% by 2045 and 80% by 2050** under its FuelEU Maritime 2021 policy, but there is **no specific target for biofuel usage**
- US introduced Clean Shipping Act of 2022 which **mandates aggressive cut in carbon intensity** of fuel to be at least 20% by 2029, 45% by 2034, 80% by 2039 and 100% by 2040 (yet to pass)
- Based on IEA, it is estimated that **15.2m ton of biodiesel** will be required to achieve biofuel energy contribution of 0.6EJ by 2030 to remain on track to achieve net zero by 2050
- However, given lack of specific biofuel usage mandate and regulatory push towards zero emission, we believe that IEA's 2030 biofuel target is likely overambitious and that **biofuel (low, but not zero emission fuel) adoption will remain muted** in marine sector
- In addition, we see **limitation in biofuel production capacity** and **competing use from land and air transport** hindering marine biofuel adoption
- We see more opportunities in **zero emission fuels like ammonia and hydrogen** to decarbonize marine transport, which will require significant advancement in both vessel and fuel production technology

04 Opportunities

Potential Investment

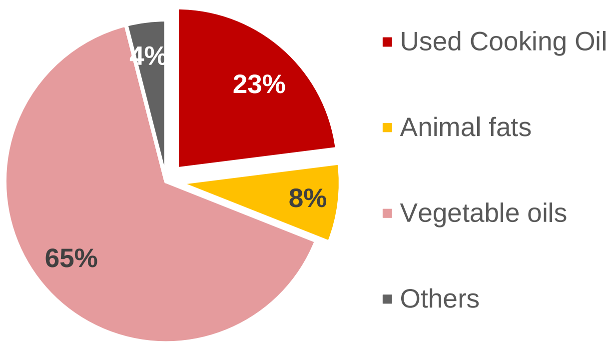
Biofuel opportunity – Future lies in sustainable feedstock

Biodiesel geographical demand breakdown



Source: OECD (2021), DBS Bank

EU biodiesel feedstock variant breakdown



Source: Joint Research Centre (JRC) (2021), DBS Bank

Rule of thumb for allowed feedstocks are those that are not usable for food

Conventional feedstock (to be phased out by 2030)	Allowed feedstock
Palm oil/palm kernel oil	**Palm oil mill effluent (POME)** and empty palm fruit bunches
Wheat	Husks
Sugar cane/ Sugar beet	**Bagasse**
Maize	Cobs ex kernel
Vegetable oils	**Used cooking oil**
	Straw/Other non-food cellulosic material/Biowaste
	Algae if cultivated on land in ponds or photobioreactors

Source: EUR-Lex, DBS Bank

- EU constituents a **significant 36% of global biodiesel demand** in 2021
- Under the Revised Energy Directive 2018 (RED II), EU countries' Type I biofuel % energy contribution to road and rail transportation energy is **capped at 7%**, and the cap will be **lowered to 0% by end-2030**
- While contribution from Type II biofuel is expected to increase to **at least 0.2% in 2022, at least 1% in 2025 and at least 3.5% in 2030**
- According to Joint Research Centre (JRC)'s estimate, **~31% of biodiesel in EU is of the Type II variant**, which is produced predominantly using used cooking oil (UCO)
- Given the shift towards 0% conventional feedstock, there is an opportunity to **replace 65% of the existing feedstock i.e., vegetable oil feedstock**

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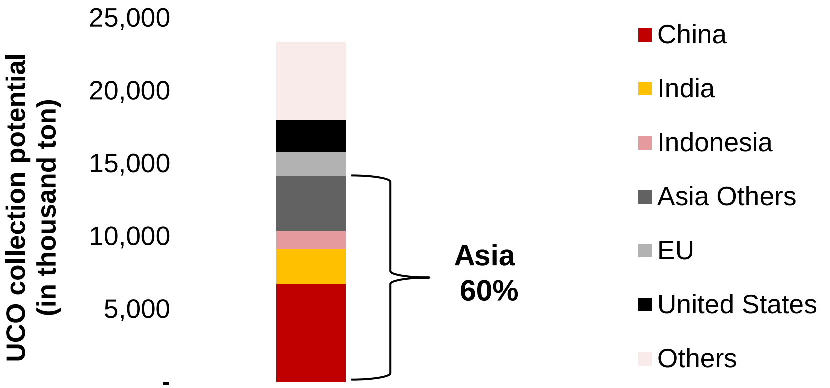
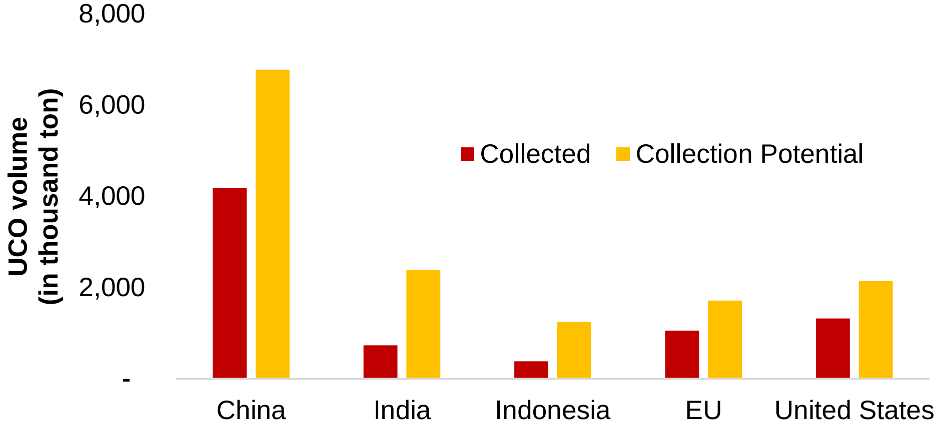
Biofuel opportunity – UCO collection opportunity in Asia

Asia is a heavy consumer of vegetable oils for food purposes and a key source of UCO



Source: OECD (2022), Greenea, DBS Bank

Asian emerging economies have significant UCO collection headroom versus developed economies



Source: OECD (2022), Greenea, DBS Bank

- We expect UCO collection to be a **significant opportunity worth US$8.2bn** (based on est. market price of normalized US$1,040 per ton* and estimated **incremental volume demand of 7.9m ton****, volume required just to replace the 65% share of vegetable oils in EU biodiesel feedstock mix)
- Asia is a key source of UCO, **accounting for 60% of global potential UCO collection**
- Based on our estimates, we believe currently **5.3m ton of UCO is being collected** in China, India and Indonesia with **substantial volume exported to Europe and USA** according to findings from International Council on Clean Transportation (ICCT)
- We estimated that there remain **significant untapped UCO collection potential of 5.1m ton, worth US$5.3bn^,** in heavily populated China, India and Indonesia
- **Low UCO collection volume growth headroom in EU and US** given established infrastructure and operations for UCO collection
- Apart from being a key UCO source, **Asia is also well-positioned as a biodiesel and SAF production hub** with Neste's newly completed refinery in Singapore, which can **process up to est. 4m ton of UCO**

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*Note: UCO collection potential volume is estimated based on vegetable oil usage forecast from OECD with assumption of collection potential percentage based on data provided by Greenea (*average of highest and lowest price in past five years of EUR1,400 per ton in Feb-23 and EUR570 per ton in Apr-18 and EURUSD=1.06, **estimated using 88% UCO biodiesel yield on 15.8bn liters of biodiesel production in EU in 2021, ^estimated based on collection potential multiplied by normalized UCO market price)*

Biofuel opportunity – SAF value chain

Narrowing down to SAF value chain with UCO as feedstock, we see opportunity in disruption/consolidation of fragmented UCO market as major refiners would only work with collector/aggregator of certain size

UCO Collector/Aggregator

Market dynamics: Fragmented market with relatively low barrier to entry, however most operations remain relatively small scale

Refiner

Market dynamics: Capacity concentrated among few players given untested market and need for high capex; some refiners have acquired UCO collectors to ensure stable supply source

Airline

Market dynamics: Cost conscious, but increasingly aware of need to be sustainable; some airlines have invested in refiners and signed offtake agreements to purchase current & future SAF supply

Transition towards Sustainable Feedstock and Circular Economy

Key takeaways:

- Future lies in **transition towards sustainable feedstock** that does not compete with use for food consumption and promotes circular economy i.e., reusing waste products
- Traditional **Type I biofuel will likely continue to play a role in the energy mix** for emerging countries i.e., Brazil and Indonesia to support the agriculture sector
- **Cost remains the biggest hurdle** behind adoption, but is being overcome with government regulations/policy push in the US and EU
- Our view is that **Type II biodiesel and SAF for land and air transport respectively will be high growth segments** within the biofuel industry
- As a consequence, we see **attractive opportunity in collection and sale of sustainable feedstock**, in particular UCO

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