LIQUID BIOFUELS

A SUSTAINABLE SOLUTION FOR TRANSPORT SECTOR

SUMMARY

The transportation sector accounts for nearly a quarter of global energy-related carbon dioxide emissions, so finding a solution is critical and discovering a path to decarbonizing transportation will be central to meeting the climate targets agreed upon by the international community. Fossil-based liquid fuels are commonly being replaced by biomass-based alternatives, also known as biofuels. Biofuels offer a low-carbon transport fuel alternative while also reducing global oil dependence, improving national energy security, and promoting economic development. Biofuels can be produced from a range of different feedstocks, from crops like maize and sugarcane to agricultural residues and even the bio-fraction of municipal waste. This production is done via many different technological processes, resulting in different fuels suited to different parts of the transport sector. Ethanol and biodiesel account for the majority of biofuels being produced today, although there are several other biofuels produced on a commercial scale. The production of biofuels is heavily dependent on national policy, so different countries have adopted a range of different strategies for promoting biofuels. These range from fiscal incentives to blending and volumetric mandates to greenhouse gas reduction targets. These policies will be especially important for shaping the role of biofuels in their respective markets in the coming years. These markets are predominantly transport sectors that will be difficult to electrify, including heavy-duty vehicles, marine transport, and aviation. Biofuels will continue to be important for conventional road transport as well. This factsheet also addresses some of the major questions and challenges surrounding biofuels, including the impact of biofuel production on food prices, land usage, emissions, and the impact of electrification on biofuels.

INTRODUCTION

Global oil consumption has been a heated topic of international discussion in the last several decades. With over 14 million tonnes consumed every day [1], and global consumption continuing to increase, questions of energy security and international conflict, the limited availability of this resource, the high costs associated with import for many countries, and the environmental and social repercussions of such extreme oil dependence become more and more important to address. As nearly 65% of global oil consumption is by the transportation sector, primarily for road transport [2], this sector is the central stage for addressing the challenges of global oil dependence.

Figure: Typical Biomass Feedstock for producing liquid biofuels. Source: Pixabay

In addition, the issues of greenhouse gas (GHG) emissions and climate change have become increasingly important in relation to fossil fuel use by the transport sector. The consequences of global climate change are severe and far reaching. So, in the face of these changes, the world has come together to mitigate anthropogenic GHG emissions. Under the 2015 Paris Agreement, nations set nationally determined contributions (NDC's) outlining their climate action plans, with the ultimate goal of restraining global temperature rise to well below 2°C above pre-industrial levels [3]. As the transport sector accounts for nearly a quarter of global energy-related CO2 emissions [4], decarbonizing transportation is crucial to achieve this.

Liquid biofuels offer a technically and economically feasible alternative to oil-derived fuels, while avoiding many of their principal drawbacks. They can be locally produced, can greatly improve national energy security, provide jobs and income for farmers, promote economic development, and curb anthropogenic GHG emissions. They play a key role in many decarbonization scenarios for reaching the targets in the Paris Agreement. The IEA Technology Roadmap, for example, finds that to have a 50% chance of limiting warming to 2°C the contribution of bioenergy in the transport sector will have to increase tenfold from 2015 levels by 2060 [4].

Biofuels can be produced from a huge range of organic materials through a variety of technological production pathways, resulting in a number of different fuels, each with different properties. The aim of this fact sheet is to provide key information on different biofuel feedstocks and types, the policies governing their production today, their potential in years to come, and the major challenges and criticisms they face. This fact sheet focuses on biofuels for transportation, and does not address other applications such as electric power, heating and cooling.

DEFINITIONS

Biofuels are often classified into different categories (e.g. conventional, advanced, first-generation, second-generation, etc.). Different countries, organizations, and policies draw the lines between these categories in different ways, differentiating by criteria including feedstocks, technological maturity, conversion technology, energy efficiency, and emissions reduction potential.

The United States' Renewable Fuel Standard (RFS), for example, defines four categories of biofuels: biomass-based diesel (diesel fuels which meet a 50% lifecycle GHG reduction), cellulosic biofuel (biofuels that meet a 60% lifecycle GHG reduction and are produced from cellulose, hemicellulose or lignin), advanced biofuel (biofuels that meet a 50% GHG reduction and are produced from any qualifying renewable biomass besides corn starch), and renewable or conventional fuel (ethanol derived from corn starch which meets a 20% lifecycle GHG reduction) [5]. IEA Bioenergy, on the other hand, defines '1st generation biofuels' as liquid biofuels produced from "food-or-food-related feedstocks like cereals, other starch-rich crops, sugars and oil crops," and '2nd generation biofuels' as liquid biofuels produced from the "structural components of plants and trees like lignocellulose" [6]. The European Union Renewable Energy Directive II defines advanced biofuels based on a list of qualifying feedstocks used for their production [7].

This fact sheet will not differentiate biofuels using any such definitions. Instead it will examine feedstocks, conversion methods, and individual performance for a range of liquid biofuels.

Figure: Poet-DSM Advanced Biofuels opened a commercial-scale cellulosic ethanol plant in the U.S. in 2014 in Iowa, with the capacity to produce 95 million litres of ethanol from corn residue. Source: POET - DSM

FEEDSTOCK

Liquid biofuels can be produced from a huge range of feedstocks, from cereal, sugar, and oil crops to residues or waste. An overview of the most common feedstock categories is included below.

Crops with High Sugar or Starch Content

Crops with high sugar content such as sugar cane, sugar beet, and sweet sorghum, as well as crops with high starch content like maize/corn, wheat, cassava, and millet can be used to produce liquid biofuels. These crops have been the predominant feedstocks for global biofuel production in the last several decades. The most widely used crops are sugar cane [8], which requires a tropical or warm temperate climate and is grown primarily in Brazil, and maize, of which the world's largest producer and exporter is the United States [9].

Oil Crops and Waste Oils

High oil content seed from crops such as soybean, oil palm, and rapeseed/canola can be used to produce biofuels as well, as can used cooking oils and other waste vegetable oil products and animal fats. Soybean, oil palm, and rapeseed/canola are the most common crops producing this type of feedstock for biofuels, although there are many other potential feedstocks.

Cellulosic Biomass

Cellulosic material includes cellulose, hemicellulose and lignin from plants or trees. This can come from wood, short rotation crops high in cellulose (fiber sorghum, switchgrass, etc.), agricultural residues (straw, corn stover, bagasse etc.), industrial residues and forestry residues. The high availability of cellulosic material makes this a strong potential feedstock choice, although there are logistical collection challenges that will need to be addressed.

Waste

A wide variety of waste products can also be used as feedstocks for the production of liquid biofuels, including the biodegradable fraction of municipal solid waste (MSW) and industrial waste. While more research and development is needed for waste to biofuel conversion, it is increasingly being used for a range of biofuels and holds much potential.

Figure: Hungary's Pannonia Ethanol is the largest ethanol production facility in Europe. It processes nearly 1.1 million tons of corn each year into 4,00,000 tonnes (500 million liters) of ethanol, 3,25,000 tonnes of various high protein/high fat animal feeds and 12,000 tonnes of corn oil. Source: Pannonia Ethanol

Other Biomass Feedstock

There are many other organic materials that can be used to produce biofuels, and ongoing research continues to add to the list of possible feedstocks. Promising feedstocks not mentioned above include tall oil, which is a by-product of the pulp and paper industry, as well as micro-organisms like algae, yeasts, and cyanobacteria. Algae is a photosynthetic organism that contains lipids, protein and carbohydrates, and can be used to produce a variety of biofuels. However, algae-based biofuel technologies are not yet commercial, and more advances need to be made in order for algae to become a feasible feedstock choice [10 - 12].

TYPES OF LIQUID BIOFUELS

Different production methods, utilizing a variety of suitable feedstocks, can produce a wide range of different fuels, each with different fuel properties. The majority of biofuels being produced today are ethanol and biodiesel, but several other types of biofuels are also produced in commercial quantities [13 - 14].

Ethanol

Ethanol is a gasoline alternative produced, for example, via the fermentation of sugar by yeast. It is currently a biofuel with the greatest volume produced annually, with 109 billion liters produced globally in 2019 [15 - 16]. The most common feedstocks are crops with high sugar content or high starch content, predominately maize and sugar cane. Ethanol can also be produced from lignocellulosic materials, which require additional pretreatment to convert the cellulose and hemicellulose found in the feedstock into useable sugars. Gasoline-ethanol blends up to around 10-15% ethanol can be used with existing fuel infrastructure and engines (this number varies between countries), and blends with higher ethanol content (85% and up) are compatible with more recent and efficient vehicle engines that have higher compression ratios. Since ethanol has a higher octane number than gasoline, it can be used as an octane booster and increase engine efficiency, and there are some engines that actually require higher octane fuel.

Biodiesel

Biodiesel is a diesel fuel alternative, produced from biomass with high oil content, such as soybeans, rapeseed/canola, and palm oil as well as waste oils such as used cooking oil. In a process known as esterification, the oil in these feedstocks is

Figure: Lantmannen Agroetanol, in Norrkoping, Sweden, produces nearly 2,30,000,000 liters of ethanol. Part of that is used as biofuel and another fraction is used for other chemical operations like windscreen washing. Residues from the production unit is used as a supplement to protein feed and is climate friendly. The carbon di-oxide released during the process is used to make green carbonic acid. Source: Lantmannen Agroetanol

Figure: Till 2019, Agrana's bioethanol plant in Pischelsdorf, Austria cpnverts nearly 6,20,000 tonnes of feedstock to 1,90,000 tonnes of ethanol. Also, another 1,90,000 tonnes of protein-rich animal feed can be produced in the form of DDGS (Distillers Dried Grains with Solubles) and is mareted worldwide through the name of Actiprot.

Source: Agrana

TABLE : PROPERTIES OF COMMON CROP BASED BIOFUEL FEEDSTOCK

Feedstock	Dry mass fraction (%)	Crop yiel (tonnes/ha)	Fuel yield (L/ha)
Soybean	92%	1.1-3.1	226-715
Rapeseed/Canola	74%	1.2-3.0	1350
Oil palm	85%	3.3 - 3.9	759-894
Cassava	38%	9.2-13.4	1260-1836
Maize	85%	1.9-8.2	760-3280
Wheat	85%	2.0-5.3	680-1802
Sorghum	85%	1.0-5.6	380-2128
Sugar cane	27%	58.6-82.6	4102-5782
Sugar beet	21%	20.1-74.1	2211-8800

*yield range represents variation in yield with location, Fuel yields are calculated from crop yields and conversion efficiencies from UN FAO (2008) reacted with methanol in the presence of a catalyst to form a methyl ester with similar properties to conventional diesel fuel. It is often referred to as fatty acid methyl ester (FAME) biodiesel, to distinguish it from other renewable diesel alternatives.

Pure Plant Oil (PPO)/Straight Vegetable Oil (SVO)

Some biodiesel feedstocks, particularly vegetable oils and waste oils, can also be used as biofuels without any modification or intermediate processing, and are referred to as pure plant oil (PPO) or straight vegetable oil (SVO) [17]. These fuels can only be used in modified or retrofit engines due to the differences in viscosity and combustion properties when compared to conventional diesel. Because of this, they are most commonly used in small-scale applications such as for tractors and other diesel farm engines, private vehicles, or municipal vehicle fleets [18]. In this sense, they are quite promising for small-holder farmers in developing countries; an example is the use of oil from neem seeds and other oil seeds in South Asia.

Renewable Diesel (RD)/Hydrotreated Vegetable Oil (HVO)

Renewable diesel, also referred to as hydrotreated vegetable oil (HVO) or hydroprocessed esters and fatty acids (HEFA), is another diesel fuel alternative [19] . HVO fuels can be produced through hydrogenation from many of the same feedstocks as biodiesel. Hydrogenation is an alternative conversion process to esterification, where instead of reacting with methanol, the feedstock is reacted under pressure with hydrogen in the presence of a catalyst, to form straight, long chain paraffinic hydrocarbons. HVO diesel has several advantages, including a high cetane number, high energy density, stability in storage, clean burning, and safe operation at lower temperatures. In addition, HVO diesel is a drop-in fuel, meaning it can be used with existing infrastructure without modification. Drop-in HVO diesel can also be upgraded to drop-in renewable kerosene for jet fuel.

Biomass to Liquid (BtL) Fuels

While the fuels discussed above account for a large majority of the biofuels being produced, there are a wide range of further biomass-derived liquid fuels currently being researched and developed. Biobutanol, which is produced through the fermentation by specific microorganisms, has an ASTM fuel quality standard for blends of up to 12.5% with gasoline, and has a relatively high energy density when compared to other gasoline alternatives. Biobutanol also has the potential to be converted into a jet fuel [20]. Another example is biocrudes, which are produced through hydrothermal liquefaction (HTL) [21]. These bio-crudes are produced using heat and pressure, and the production results in an intermediate crude oil that, like petroleum crudes, can be refined into a range of fuels and chemicals. They can either be co-processed with fossil fuels at traditional refineries, or fractionated and used in direct applications that include fuel oil applications such as marine and heating oils [22].

Biomass to liquid (BtL) fuels are produced from solid biomass feedstocks such as wood residues from forests, crop residues from farms, and municipal solid waste. The production is a two-step process that includes gasification followed by synthesis or by fast pyrolysis. The feedstock is first gasified through combustion with a limited supply of oxygen to produce a synthetic gas that contains a mixture of carbon monoxide, carbon dioxide, hydro-

Figure: BioDiesel Plant ASB Biodiesel Ltd. (Hong Kong, HK) is "The world's largest Multi-Feedstock BioDiesel plant" Customer: ASB Biodiesel Ltd. / Technology: Multi-Feedstock MF100+ (incl. high-FFA esterification) / Commissioning: 2015 / Capacity: 100,000 tons per year / Raw material: Animal fat, used cooking oil, trap grease, palm sludge oil. Source: BDI Bioenergy International GmbH

Figure: The Sunbird Bioenergy plant in Sierra Leone has a designed production capacity of 85 million litres of ethanol per year from sugarcane and cassava. The ethanol produced is either sold to the Sierra Leone biofuel blending program or exported to Europe. Source: Sunbird Bioenergy gen, methane, water, and nitrogen, along with some contaminants. This syngas is then cleaned and conditioned, before being catalytically converted to a liquid or a gaseous fuel, typically through the Fischer Tropsch process. Several different fuels can be produced via this pathway. One example is synthetic diesel, which is produced from the carbon monoxide and hydrogen in the gas. Other examples include synthetic kerosene, which can be used as a jet fuel, and biomethanol, which is produced from the conditioned syngas via a catalytic process [23]. Biomethanol is also produced by the hydrogenation of carbon monoxide along with other mixed alcohols. Pyrolysis oil or bio-oil is another BtL fuel, which is made by rapidly heating biomass particles in the absence of oxygen, and quenching the vapors into a dark-brown liquid biofuel.

POLICY & TARGETS

Biofuel production is highly dependent on the existing policies and regulatory climate in a region. Policies from the mid 2000's are largely responsible for biofuel production today, and recent policy introductions and revisions in major biofuel producing countries are likely to play a significant role in shaping the industry in the coming years [24].

Policy Instruments for Promoting Biofuels

There are three main types of policies typically used for promoting biofuel production and use: mandates, financial incentives, and a carbon value in the marketplace.

Mandates can be set either in one of two ways. The first is in terms of volume standards for the production of biofuels, as is done in the United States [5]. The second is in terms of targets or requirements for the amount of biofuel fuel producers must blend with fossil-based fuels, as is done in Brazil [25]. These mandates can also include sustainability criteria, in the form of minimum lifecycle GHG emission reduction (with reference to fossil fuels) or explicit regulation on feedstock sustainability.

Financial incentives can take a variety of forms, affecting different parts of the biofuel supply chain. They include direct payments, tax credits and grants. Direct payments are granted to farmers and providing a safety net of support. Tax credits can be used to promote investments in biofuels, and are often paired with production mandates (i.e. only biofuels that contribute to the mandate and meet the sustainability criteria qualify for tax credits, or penalties are applied to fuel suppliers not delivering the required quantities of biofuels). Grants are especially useful in promoting research and development of new technologies.

Valuation of carbon emissions can help to create market conditions in which sustainable, emissions-reducing biofuels can thrive. Policies that promote such valuation include carbon taxes (successfully used in Sweden, among other countries) and emission reduction targets, as for example have been implemented in Germany [26 - 28].

TABLE 3: BIOFUEL POLICY AND TARGETS FOR BIOFUEL PRODUCING COUNTRIES

Country	Policy	Targets
United States	Renewable Fuel Standard	136 billion L of renewable fuel (57 billion L of "conventional" biofuels, 79 billion L of "advanced" biofuels) by 2022
Brazil	RenovaBio	Biofuels contributing 18% of country's energy matrix by 2030
India	National Policy on Biofuels, Ethanol Blending Program (EBP)	20% blending of bioethanol and 10% blending of biodiesel by 2030
China	Expansion of Ethanol Production and Promotion Policy	Nationwide use of 10% ethanol, 2.272 billion L of biodiesel by 2020
EU	Renewable Energy Directive	RED II: 14% renewables in transport with 3.5% from advanced biofuels by 2030
Indonesia	Ministry of Energy and Mineral Resource Regulations	20% ethanol blending, 20% biodiesel blending (from 2020)
Malaysia	National Biofuel Policy	10% biofuel blending for on-road sector from 2020
Argentina	Biofuels Law	12% ethanol blending, 10% biodiesel blending (current mandates)

Mandates in Northern America

On December 19, 2019, USEPA decided the volume requirements as part of the Renewable Fuel Standard (RFS) program for the year 2020. This mandate includes expected production volumes for cellulosic biofuel, biodiesel and other advanced biofuels for 2021 as well.

As far as the Canadian provinces are concerned, British Columbia has a mandate for 10% ethanol and 10% biodiesel blending by 2020 while Ontario mandate includes condition that biodiesel should have a GHG reduction by 30% in 2016 gradually rising to 70% by 2017-2018 [29].

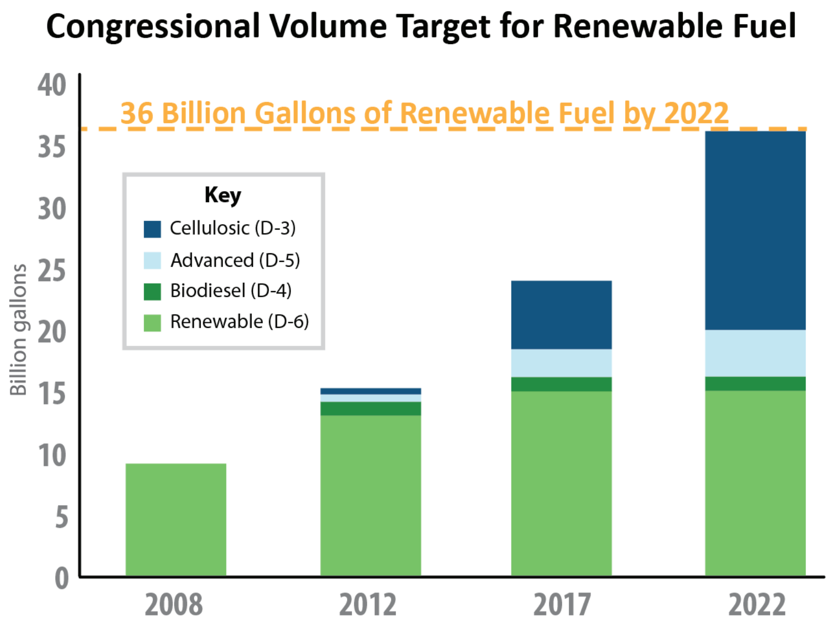

Figure: Congressional volume target for renewable fuel set by Renewable Fuel Standard, USA.
Source: US Environmental Protection Agency

In Mexico, by October 2018, the ethanol blending mandate was increased to 10%. Previously in 2017, the blending mandate of renewable ethanol was 5.8%.

In Panama, the government introduced a 2% ethanol mandate back in 2013 that eventually rose to 5% in 2014, to 7% in 2015 and 10% in 2016.

Mandates in South America

The Brazil Government introduced a National Biofuel Policy, RenovaBio, in December 2017. It was a new regulation (No. 791) which highlighted the importance of production and the use of biofuels for the transition towards a sustainable economy. This mandate focused explicitly on bioethanol but enabled the promotion of other biofuels as well. One of the major objectives of RenovaBio was to increase the production of ethanol over 50 billion liters by 2030. In accordance with California's Low Carbon Intensity Program, the mandate introduced carbon saving credits (CBios). These credits were assigned to producers and consumers of biofuels. The total number of credits earned signified the life cycle GHG emissions during the entire supply chain of a specific fuel. However, the information on how these credits are calculated by the Policy is still unclear. In addition to these credits, RenovaBio insists on introducing subsequent sustainability criteria measures and certification processes. Other factors such as land or water usage and cleaner production technologies that reduce the biofuel plant's emission are to be looked at as well. For fuels except for ethanol, that reduce the carbon emissions through combination with fossils, Brazil's current biodiesel blending ratio of 10%, is expected to reach 15% by 2022 and 30% by 2030. As far as biomethane is concerned, the blending ratio with existing natural gas is said to reach 5% by 2022. Biokerosene that could be mixed with conventional aviation fuel, is anticipated to reach a 10% blending rate by 2030.

The blending ratio for biodiesel in Brazil has been increased to 11% from 10%, as of September 1 2019. Almost 50% of the total soy oil used was directed towards biodiesel production. Moreover, Brazil's Ethanol blending ratio in the transportation sector is to be increased to 27-27.5% as of March 16 2019, from 20% in 2018. The Ethanol demand in the country will increase by 60 million litres towards the end of 2020 considering the reduction in price of sugar feedstock [29].

Argentina has 19-20 bioethanol plants that show a production capacity of nearly 1.5 billion litres. The feedstock used by these facilities include both sugarcane (predominantly) as well as corn. As of 2019, the government had incorporated a 11.6% ethanol blending mandate (Close to E12). About 5 billion litres of biodiesel is produced in Argentina as of 2019. The blending mandate for renewable diesel is 9.6% [30].

As of March 1st, 2018, Colombia planned to increase its blending mandate of ethanol to 10% due to a large production volume of over 5,00,000 litres per day in Central Meta. Most of the provinces do not have a mandate due to cross-border smuggling. For biodiesel, a 10% blending mandate was issued in Bogota and other Central and Eastern plains of the country [31].

In Paraguay, the country's representatives were looking to increase biodiesel blending to 15% by 2021 from the present 2% levels. Although, the local biodiesel manufacturers want to witness a gradual but indeed, a steady increase of blending rather than a fast ramping up process, to keep up with the production capacities [29].

The European Union

In January 2019, the final version of the REDII was published in the Official EU Journal. The new target demands transport fuel suppliers who sell at least 4, 50,000 litres or more to keep up the production volumes to meet the required volume percentage of 12.4-14% biofuels in the transportation sector from 2020-2030. Advanced biofuels should meet a blending mandate of 0.2% in the transportation fleet from 2020-2022, cellulosic and other biomass-based biofuels should account for 14% of the transport fuels from 2020-2030 [32].

Asia-Pacific

In Queensland, Australia, there is a 10 % ethanol mandate and a 4% biodiesel mandate in the transportation sector as of 2018 [33].

From 2020, China seeks to implement a 10% biofuel use overall until further notice. This implementation was brought forward by the National Energy Administration (NEA), National Development and Reform Commission (NDRC) and other ministries under the "Implementation Plan Regarding the Expansion of Ethanol Production and Promotion for Transportation Fuel" [34].

In Indonesia, due to lack of domestic supplies to produce ethanol locally, the mandate initially concentrated on introducing E2 first and has now gradually improved the policy to E10 by 2020. A 5% blending mandate for biodiesel was implemented in 2015 after which the government has now planned to introduce a

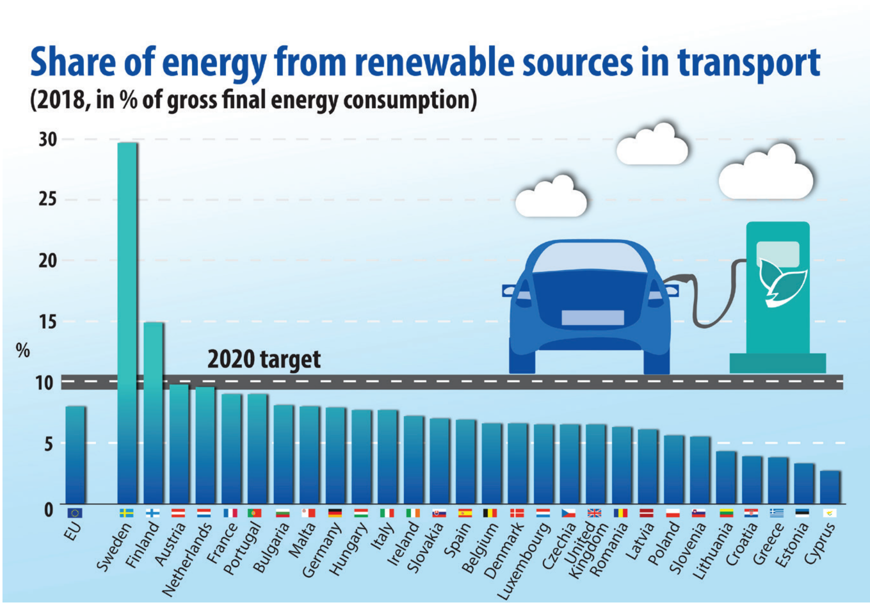

Figure: Share of energy from renewable sources in transport (2018, in % of gross final energy consumption). Source: Eurostat

20% blending (B20) mandate for biodiesel from 2020 [35].

The Malaysian government has set a national biofuels policy. By 2019, the country's 10% blending mandate for biofuels in the transport sector was a success. The same blending mandate is expected to continue in 2020 until further notice [36].

Under a BAU situation, India will meet E5, E10 and E20 blending mandates for ethanol by 2020, 2025 and 2030 respectively. Likewise under the BAU scenario, India will meet 1%, 5% and 10% mandates in biodiesel by 2020, 2025 and 2030 respectively [37 - 38].

FUTURE MARKETS

Biofuels are going to be indispensable for decarbonizing the transport sector as a whole, and while road transport is likely to remain the largest market for biofuels, they are especially crucial for applications where electrification does not look to be a viable option in the next several of decades. In these markets, including heavy-duty vehicles and aviation and maritime transportation, biofuels will play an increasingly pivotal role.

Road Transport

As mentioned above, road transport promises to remain the largest market for biofuels. There are many biofuels that are commercially available today, and many vehicles are already running on biofuel-blended fuels. However, with over one billion vehicles on the road, most running on internal combustion engines and having an average vehicle lifespan of over 10 years, liquid fuel dependent vehicles will not disappear from roads soon. This makes finding a solution to cut emissions from existing vehicles critical [39]. Biofuels have the potential to fuel this global vehicle fleet while dramatically cutting CO_2 emissions, and thus are likely to become of increasing importance in this sector.

Heavy-duty vehicles (HDV) include vehicles such as long haul trucks, cement mixers, mobile cranes, dump trucks, and garbage trucks. These vehicles typically run on diesel fuels, and are responsible for an increasing fraction of transport-related emissions and pollution as light-duty vehicles become more efficient. Biodiesel and HVO fuels, which can be used as drop-in fuels in these vehicles, therefore have strong potential to reduce emissions from this sector (ICCT) [40].

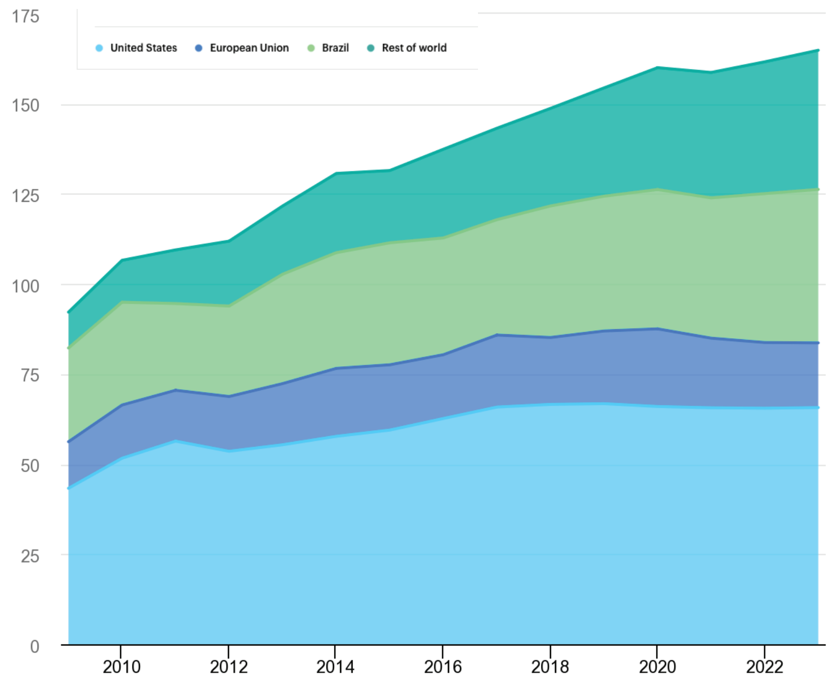

Figure: Global biofuel production, 2011-2023. Source: International Energy Agency

TABLE 4: SELECT FEW OPERATIONAL BIOFUEL PRODUCTION FACILITIES						
OPERATOR	LOCATION	FUEL	FEEDSTOCK	CAPACITY	OPENED	STATUS
GRANBIO	ALAGOAS, BRAZIL	CELLULOSIC ETHANOL	SUGARCANE STRAW AND BAGASSE	82 MILLION L/Y	2014	OPERATIONAL
ADDAX BIOENERGY SIERRA LEONE, AOG, & SUNBIRD BIOEN-ERGY	MABILAFU, SIERRA LEONE	ETHANOL	SUGAR CANE AND CASSAVA	85 MILLION L/Y	2014	LOW-SCALE
RAIZEN	COSTA PINTO, BRAZIL	ETHANOL	SUGARCANE	2 BILLION L/Y	2010	OPERATIONAL
VERBIO AG	GERMANY	BIODIESEL	RAPESEED OIL	821 MILLION L/Y	2014	OPERATIONAL
WORLD ENERGY BIOX BIOFUELS LLC	HOUSTON, TEXAS, USA	BIODIESEL	CRUDE DEGUMMED VEGETABLE OIL	340 MILLION L/Y	2017	LOW-SCALE
UPM	LAPPEENRATA, FINLAND	HVO	TALL OIL	120 MILLION L/Y	2015	OPERATIONAL
NESTE	ROTTERDAM, THE NETHERLANDS	HVO	ANIMAL WASTE FATS	1.7 BILLION L/Y	2011	OPERATIONAL

Maritime

The merchant shipping sector is responsible for transporting more than 80% of the world's traded goods, as well as for 2-3% of global CO2 emissions [41]. In March 2018, the International Maritime Organization (IMO) agreed on an initial emission reduction strategy, aiming to reduce total GHG emissions from international shipping by 50% by 2050, compared to 2008 levels [42]. In addition, regulations on sulphur emissions in addition to large areas (the Baltic Sea, the Caribbean, the west coast of the US, and most ports and approaches) where low sulphur and low particulate marine fuels must be used mean that 70% of the fuels currently used by this sector will need to be modified or changed, or ships will have to install expensive exhaust-scrubbing equipment [43]. Biofuels are a technically viable solution that could both meet the sulphur emission limits and significantly reduce CO2 emissions, however there are several major challenges that must be overcome. One of the main challenges is that the merchant shipping sector requires huge volumes of fuel, on scales much larger than current biofuel production, and it has no experience with sourcing and handling the required amounts of biomass. Additionally, as with aviation biofuels, in order for a meaningful transition to be made, biofuels need to be cost competitive with existing fuels, and ensuring fuel quality and integrating biofuel supply and storage into existing infrastructure must be considered. Research into multifuel engines that could run on range of fuels including a variety of different biofuels would allow for diversification in maritime biofuels and make meeting fuel demands of large ships with biofuels much more feasible. However, just like the sustainable aviation biofuels, more effective policy support will be crucial in making a transition to alternative fuels in the maritime sector as well.

Aviation

Aviation is a significant source of GHG emissions, accounting for 2% of total anthropogenic emissions [44]. While there is research being done in electric and solar-powered aircraft, it is very unlikely that these technologies will succeed before 2050 considering large travel distances. Even after 2050, this idea could barely remain as a niche thereby diverting most of the attention on aviation biofuels that are economically feasible to produce and utilize. This makes bio-based jet fuels crucial for meeting short and medium term emission reduction goals [45]. The International Civil Aviation Organization (ICAO) agreed on a 2050 Vision for Sustainable Aviation Fuels, which calls for "a significant portion" of conventional aviation fuels to be replaced with sustainable alternatives by 2050.
To ensure aircraft performance and safety, any aviation biofuel must be a drop-in fuel, i.e. it must be compatible with plane fuels systems, engines, and existing fueling infrastructure. As of now, five conversion processes had been approved by the ASTM for production of aviation biofuels [46]:

1. Fischer-Tropsch hydroprocessed synthesized paraffinic kerosene
2. Synthesized paraffinic kerosene produced from hydroprocessed esters and fatty acids
3. Synthesized iso-paraffins produced from hydroprocessed fermented sugars
4. Synthesized kerosene with aromatics derived by alkylation of light aromatics from non-petroleum sources
5. Alcohol-to-jet synthetic paraffinic kerosene

These methods have been commercialized or are in the process of being commercialized. Quite a few producers have reached agreements with airlines and airports to provide certain amounts of aviation biofuels annually to take steps towards realizing the ICAO 2050 Vision. However, it is important to note that these agreements are non-binding, and that in order to make substantial progress in displacing conventional aviation fuels, aviation biofuels will need to be much more cost competitive, and supportive government policies will be crucial.

Figure 12: Variation in Food Prices with Global Crude Oil Price and Biofuel Production from 2000-2016

BIOFUEL DEBATES

Food versus Fuel

A frequent criticism of biofuels has been that they compete with food supply, raising food prices and causing food shortages. Although a large fraction of liquid biofuels is derived from crop-based feedstocks, there is little historical correlation between global biofuel production and food prices, as measured by the FAO Food Price Index. While growing biofuel production is sometimes associated with rising food prices (as in the early 2000's), it is also sometimes associated with falling food prices (as in 2009 and 2012-2016).

A 2013 World Bank report on the matter concludes that the effect of biofuels on food prices "is not as strong as has been reported in previous studies." Rather, there is a strong and clear correlation between crude oil prices and food prices, due to the highly fossil-fuel dependenet nature of agriculture globally.

Land Requirements

Linked with the perceived conflict between use of land for food and fuel is a concern that available land is limited, so that growing more feedstocks for biofuel will mean less food available unless the production of food and fuel is extended to additional lands. The resulting land use change – whether direct or indirect – could lead to changes in the amount of carbon stored in the soil and taken up by forests, contributing to global carbon emissions.. There is always complexity in land use issues. Biofuels may enrich crop rotation which is the case with rapeseed in the EU. They may have negative implications as in the case of expanding agriculture into forested area or creating monoculture landscapes which is often the case with sugarcane. This is where sustainability criteria and Policy come into play and globally agreed trade and product standards.

In any case, recent analyses have established that large potential exists for sustainable cultivation of biomass feedstocks on existing land, without competing with food production or requiring additional land. Part of the potential arises from more thorough collection and use of the non-edible residues associated with food crops. Part of the potential also arises from measures to raise food crop yields and reduce food waste, reducing the amount of land required to supply food needs and releasing land to grow energy crops. Yet further potential lies in restoring degraded lands, at present poorly suite to agriculture, to more productive use.

By-product handling

When discussing the sustainability and land use of biofuels, an important consideration is the potential of valuable co-products from biofuel production. The processing of some crops (maize, cereals, rapeseed/canola, soybean, etc.) for biofuel production produces nutrient-rich residues. For example, during the biodiesel production process from oil crops, the pressing of seeds release oil along with a protein-rich meal cake. Soybean meal is gaining vast popularity due to a significant amount of nutrients imbibed in it, and are used as valuable feed for less-ruminant livestock such as chickens and moderately-sized pigs. Over 70% of meal cake with just 17-20% oil is obtained during the biodiesel production steps from soybean. For every 1 tonne of rapeseed feedstock, 0.3-0.4 tonnes of oil and over 0.6 tonnes of seed cake are produced. This by-product is rich in fiber, and when mixed kernel cakes obtained from oil palm seed processing steps, it serves as one of the best ruminant feed mixtures for cows, horses, and goats [47].

Biodiesel and HVO production from animal fleshing wastes such as tallow leaves behind meat and bones that upon grinding and milling, releases over 50% of protein and calcium-rich bone meal. In the European Union, by the year 2000, the use of this bone meal as feed for livestock was banned due to the threat of mad cow disease. In addition to the aforementioned agricultural by-products, useful industrial by-products such as glycerine and oleochemicals are produced during biofuel supply chains. For each tonne of biodiesel produced, 100 kg of glycerine is released that is used as a supplement in food and dairy industries, manufacturing pharmaceutical products and plastics PFAD, also known as palm fatty acid distillates, are utilized as important oleochemicals in pesticide and fertilizer manufacturing industries.

Electrification versus Biofuels

A range of projections predict that by 2040, anywhere from 24% to 44% of the global car fleet will be electric [48]. This is very promising for decarbonization, but it also means that a majority of the global fleet will still rely on liquid transportation fuels, and that finding decarbonization solutions for the interim decades and for the non-full electric vehicle options that will dominate the sales of new cars for the foreseeable future remains crucial. This is where biofuels are key, as their commercial availability and compatibility with existing infrastructure make them an incredibly valuable tool for taking immediate steps towards decarbonizing transportation.

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For a complete list of references, click here: References

POSITION OF WBA

Climate change is a serious threat facing humanity worldwide. The unsustainable utilization of fossil fuels for our energy needs is the main cause and it is imperative that we reduce our dependency on coal, oil and gas by rapid deployment of renewable energy and energy efficiency measures around the world. We have made considerable progress in the electricity and heating end use sectors where renewables contribute to more than 25% of the final energy consumption. Transport sector is a laggard. The addiction to crude oil and products along with lack of clear and stable policies means that the renewable share in transport is less than 5%. Major part of the share is due to the utilization of sustainable and renewable liquid biofuels produced from biomass around the world.

Liquid biofuels offer multiple benfits including reducing carbon emissions, cleaner air, generating employment, local economic development etc. Bioethanol, biodiesel and other biofuels (e.g. HVO, renewable diesel, cellulosic ethanol) offer much needed renewable fuels for decarbonizing the transport sector. A diverse range of feedstock can be used to produce these biofuels. Some of the technologies are at commercial scale while others are in various stages of development. In some situations, liquid biofuels also offer the cheaper alternative to fossil oil. Moreover, they are the only reliable option in hard to decarbonize sectors such as aviation, maritime and heavy duty vehicles.

Countries around the world are recognizing the multiple social, economic and environmental benefits of promoting liquid biofuels. Currently US, EU and Brazil lead the biofuel production globally while countries in Asia, Africa etc. are setting ambitious policy targets for promoting biofuels domestically. However, policy uncertainty remains in many regions driven, in part, by misinformation and myths perpetuated about bioenergy and biofuels.

In our opinion, liquid biofuels offer numerous benefits and urge policy makers to incentivize liquid biofuels produced sustainably by implementing long term, stable and ambitious policies in line with international energy and climate targets.