ADVANCEFUEL

The potential of advanced renewable fuels

Advanced biofuels can contribute to decarbonising sectors – especially those that are difficult to be electrified, such as aviation, marine or heavy-duty road transportation. Small amounts of biofuels are used currently, but the amounts of advanced biofuels in road transportation will increase significantly due to stricter carbon emission regulations within the next decade in EU member states and beyond.

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Where can advanced biofuels contribute most to decarbonise different sectors?

Advanced biofuels can bring cost-effective reductions with positive environmental impacts for transport, and the heat and power sectors. For transport, advanced biofuels need to be well refined to meet the fuel standards and to be used in the current fleet of engines. Nevertheless, in the heat and power sector, the use of advanced biofuels is much easier. In transport, advanced biofuels are more complicated due to policy and regulations; commercially available solutions are not compared fairly when it comes to the environmental impact. To bring real change in carbon emissions, we need to switch from the tailpipe-only to the full life-cycle analysis (LCA) for environmental impact assessment, meaning from the cradle-to-the-grave or at least from the well-to-wheels (WTW) approach.

The environmental impact of electric vehicles is assumed to be zero emission, while neglecting factors such as electricity and battery production related emissions. In 2019, around 150-200 kg of CO_2-eq/kWh[1] of the greenhouse gases emissions are associated with battery production, which corresponds to emissions generated while driving over 110,000 km with an average new European car (assuming a 75 kWh battery and 118,5 grams of CO_2 per km). In addition, current European average electricity production is associated with 295,8 g of CO_2 per kWh (with the highest rates in Poland at 679g CO_2/kWh and the lowest

1 Romare, Mia, and Lisbeth Dahllöf, "The life cycle energy consumption and greenhouse gas emissions from lithium-ion batteries." Stockholm: Zugriff am 23, 2017.

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in Norway around 30g CO_2/kWh)[2]. These factors are not considered by current regulations, while they exist and contribute to climate change heavily. Subsequently, life-cycle greenhouse gas emissions of advanced biofuels are much lower compared to the European average environmental impact of the EVs.

In the case of Hydrotreated Vegetable Oil (HVO) over 50% lower, whereas in the case of E85 about 30% lower[3]. HVO has a lower environmental impact than EV driven in Norway (around 95% hydropower in the total national electricity production). Therefore, if the carbon emissions of all transport options are treated honestly by taking into calculation life-cycle GHG emissions related to the full technology, then advanced biofuels will have an equal chance for competition in the market. This change will drive the investments, increase the production capacities and what is the most important bring a real reduction in carbon dioxide emissions. With electrification being strongly favoured, **advanced biofuels can contribute most to decarbonizing sectors that are difficult to be electrified, such as aviation, marine or heavy-duty road transportation.** However, the price of advanced biofuels and feedstock availability is still a big challenge.

What is the impact of advanced biofuels on road transport today and within the next decade in EU Member States?

Advanced biofuels are deployed in very small amounts on a global scale. However, production capacity and consumption is increasing gradually. **Aviation and shipping currently use small amounts of biofuels, but their demand is growing fast due to stricter carbon emission regulations.** According to the Annual Energy Outlook 2019 of the U.S. Energy Information Administration (EIA), energy consumption by light-duty vehicles will decrease in 2050 while medium and heavy-duty transportation, aviation, and shipping will increase by 2050. This will lead to a decline in motor gasoline consumption and drive the growth of distillate fuel oil and jet fuel consumption. Growing number of electric vehicles (EVs) on the roads, will drive the electricity consumption up, but the total share of EVs is expected to be still minor in 2050, compared to the Internal Combustion Engine Vehicles (ICEV).[4]

The biggest share of biofuel consumption is in road transportation especially light passenger vehicles and road freight. Advanced biofuels are becoming gradually more viable as their production costs continue to decrease. A good example is the price of ethanol that is expected to drop by 18% and 4% over the next decade.[5] The same trends are predicted for biodiesel. In contrast, crude oil prices are expected to increase by 40% over the period 2018-2027. These trends will enable the deployment of advanced biofuels that are becoming progressively more attractive in economic terms. **Within the next decade in EU Member States and beyond, the amounts of advanced biofuels in road transportation will increase significantly.**

What developments for advanced biofuels do you foresee by 2030 in the aviation sector?

In 2008, the aviation industry established sector-specific climate targets:

1. 1.5% fuel efficiency improvement from 2009 until 2020.

2. Carbon neutral growth from 2020 onwards.

2 https://www.electricitymap.org/?page=map&solar=false&remote=true&wind=false

3 Hall, Dale and Nic Lutsey, "Effects of battery manufacturing on electric vehicle life-cycle greenhouse gas emissions." 2018.

4 EIA, US, "Annual energy outlook 2017: with projections to 2040." 2017.

5 Organisation for Economic Co-operation and Development. OECD-FAO agricultural outlook 2018-2027. OECD Publishing, 2018.

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3. A 50% reduction in carbon emissions by 2050 relative to a 2005 baseline.

Since 2008, there have been done over 150,000 commercial flights using sustainable aviation fuels (SAF). In 2009, a technical specification was developed for aviation alternative fuels – to ensure these fuels are fit-for-purpose in existing aircraft. The main standard is ASTM d7566. In 2019, there are five conversion processes approved as annexes to ASTM d7566. Four airports are regularly distributing SAF: Oslo (Lufthansa, KLM, SAS, KLC), LAX (United and KLM), Stockholm (SAS, KLM, BRA), and Bergen (all departures). Batches sustainable aviation fuels have also been delivered to: Stockholm Bromma, Are Ostersund, Goteborg, Karlstad, Halmstad, Brisbane, and Chicago.

In 2017, the approximate amount of produced SAF was 42 million liters. However nowadays there are agreements from commercial airlines to purchase over 1.5 billion liters SAF in the future. **Currently, 28 airlines are members of the SAF group that represents 1/3 of total global aviation fuel demand and has pledged to only use SAF meeting the highest standard of sustainability certification.**

The potential for battery energy and the electrification of aviation are in the distant future – according to the International Air Transport Association, electric commercial aircraft are unlikely before 2040. **Aviation will be dependent on liquid fuels for a long time, thus the only way to mitigate the emissions of the sector is using SAF that have the potential to reduce carbon emissions by up to 80%.** There are five types of renewable fuels applied commercially:

1. Fischer Tropsch (FT) fuels such as Biomass-to-Liquid (BtL). BtL can be blended up to 50% with fossil-based jet fuel.

2. Hydrotreated Esters and Fatty Acids (HEFA), also could be blended up to 50% with fossil kerosene.

3. Renewable Synthesized Iso-Paraffinic (SIP) fuel and could be blended with fossil kerosene up to 10%.

4. Synthetic paraffinic kerosene with aromatics via Fisher Tropsch with 50% of blending with fossil kerosene.

5. Alcohol-to-jet (ATJ) from isobuanol (certified in 2016) and ethanol (certified in 2018). ATJ could be blended with the fossil kerosene up to 50%.

The mitigation of environmental impacts in the aviation industry will be buttressed by the Carbon Offset and Reduction Scheme for International Aviation (CORSIA) which is a global market-based measure that is designed to offset international aviation carbon emissions to stabilize the levels of such emissions from 2020 onwards (CNG2020). Offsetting carbon emissions will be achieved through the acquisition and cancelation of emissions units from the global carbon market by airline operators.

Aviation is the fastest-growing transport sector and the most difficult to electrify. Advanced biofuels are the only solution that can be applied to meet the ambitious 2015 Paris Agreement climate targets. In 2030, advanced biofuel volumes of SAF will be significantly larger than today. Important fuel producers such as NESTE and UPM are already installing new fuel production capacities, that will be dedicated to the refining of advanced biofuels for aviation.

What future do you see for the end use performance of advanced renewable liquid fuels?

In road transport and shipping, advanced biofuels can be used in the current fleets of unmodified engines

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(regular spark ignition and compression ignition engines). Some of them can be used directly without any retrofitting of engines or refueling systems within the full concentration ratios of fossil fuels. They are "drop-in" fuels, such as Hydrotreated Vegetable Oil (HVO), and ethanol is a commercially attractive advanced biofuel when produced from non-food/feed-based feedstocks. However, ethanol requires some modifications in current engines to be used in the full range of concentration with gasoline. Ethanol has a higher Research Octane Number (RON) than gasoline. Therefore, when using it in a special dedicated engine, that has a higher compression ratio. E85 comprising 85% of ethanol and 15% of gasoline can bring a significantly higher thermal efficiency of the energy conversion process compared to the case when used in the regular unmodified Spark Ignition (SI) engine. Heavier alcohols, such as butanol, are significantly more compatible with the present-day internal combustion engine technology and could be used in higher concertation ratios with gasoline compared to ethanol. A very important fact is that alcohols strongly reduce the local emissions such as hydrocarbons (HC) and particulate matters (PM) even in the small portions of blends. Which is beneficial especially for the direct injection SI engines. However, due to the high heat of vaporization of alcohols, in the cold engine conditions, this effect can be disadvantageous, and increase the local emissions. Therefore, engine optimization is essential.

Current trends drive an optimization of fuels and engines together to reveal the truly best options from the performance, emissions, and costs perspective. The next generation of IC engines will be able to explore the full potential of advanced biofuels. A state-of-the-art engine was launched by Mazda that is operating in advanced combustion regimes being able to provide high efficiencies and very low emissions. Mazda Skyactive-X is a first in the world commercial homogeneous charge compression ignition (HCCI) engine, reaping the benefits of both spark-ignition and compression-ignition engines by operating with Spark Controlled Compression Ignition (SPCCI). The thermal efficiency of ICE is directly related to the compression ratio of the engine. Mazda Skyactive-X has significantly higher compression ratio compared to regular SI-ICEs. This enables the new HCCI engine to deliver outstanding fuel savings. Additionally, it can explore the advantages of advanced biofuels, such as high RON of ethanol to increase further fuel economy.

In comparison to the present road transport, there are already commercial technologies on the market that can deploy advanced biofuels and reduce the environmental impact of the transportation. Internal Combustion Engine technology is developing dynamically and running on advanced biofuels will provide the largest cuts in carbon dioxide emissions compared to other modes of transport (EVs, plug-in hybrids, FCVs, etc). We will see more advanced biofuels each year.

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