Lower Carbon Aviation Fuels: contributing to the energy transition

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Introduction

Lower Carbon Aviation Fuel (LCAF) can serve as a complementary measure alongside Sustainable Aviation Fuel (SAF) in helping to reduce aviation greenhouse gas (GHG) lifecycle emissions. An LCAF may be certified as a CORSIA eligible fuel if it meets the CORSIA Sustainability Criteria, including a 10% reduction in lifecycle emissions compared to the conventional aviation fuel baseline of 89 g CO_2/MJ. During the energy transition and pursuit of pathways to a net zero future in aviation, all measures will be needed.

While the principal focus in CORSIA development has been on SAF as the longer-term fuel of choice, ICAO recognizes that LCAF can play a role. This is proven in the recent agreement for sustainability criteria and life cycle assessment methodologies for LCAF at the CAEP/12 Meeting, in February 2022.

SAF, LCAF and offsets are all included in the basket of measures supporting CORSIA. However, both SAF and LCAF have the benefit of enabling reductions associated with the physical fuel. SAF enables emissions reduction in the combustion phase of the fuel lifecycle. LCAF enables emissions reduction in the production phase of the fuel lifecycle. LCAF also offers near-term and scalable reductions in the GHG intensity of aviation fuels while SAF production expands over the coming years. For example, five billion liters of LCAF at 80 gCO_2/MJ could provide the equivalent GHG emissions reduction of about one billion liters of SAF at 45 gCO_2/MJ.

There are several means by which LCAF can reduce GHG emissions in the fuel production phase. These include measures such as application of best practices, implementation of technology, and use of newly developed crude oil with improved characteristics.

We outline some of these approaches below. Some of them relate to crude oil production (upstream) and others to crude refining to produce aviation kerosene and other products (downstream). Not all of the approaches will necessarily be implemented in LCAF production, and the degree to which they contribute to the overall lifecycle GHG emissions will vary. However, taken together, they can offer a significant reduction to the lifecycle carbon footprint of conventional aviation fuels.

Technology measures to reduce lifecycle carbon intensity of aviation kerosene

Energy Conservation

Among the most economical methods of reducing GHG emissions is to reduce energy consumed. Oil and gas companies can invest in new technologies and research including energy efficient design of plants, advanced computer controls, advanced modelling of reservoirs to increase production efficiencies, new extraction and processing methods, and improved technologies for monitoring the efficiency of equipment in the field.

Methane Emissions Reduction through Flare Management and Gas Recovery

Particular focus is called for with methane emissions. This is because methane is both the principal component of natural gas and a powerful GHG. Oil and gas companies can employ a range of actions to reduce methane emissions including replacing and upgrading field equipment, improving leak detection and employing new techniques for production.

There are also measures to reduce methane from flaring. Flaring can occur in the oil and gas industry for many reasons ranging from initial start-up and testing of a facility to unplanned equipment malfunctions, and in cases where the gas cannot be sold or re-injected into a well. A flare gas recovery system can be utilized to collect the gas, remove any liquids, and recycle the gas back to the process or into the refinery fuel gas system. The cost-effectiveness of flare gas recovery may vary widely between sites depending upon the nature and distribution of the sources of material going to flare.

Venting Control

Atmospheric process vents are generally pipes connected to vessels that emit process gases directly into the environment. The vents may be open to the atmosphere or controlled by a pressure relief valve that allows only occasional release of the process gases. The best control for these process vent emissions is to eliminate the need for discharge by altering the process operation or recycling the material. If this cannot be done, vapour controls such as recovery or destruction can be considered for application to the vent stream.

Storage, loading and unloading of oil in ships, shuttle tankers, storage tanks and terminals can also be sources of gas emissions to the atmosphere. These too can be mitigated with technologies like Vapor Recovery Units and practices like 'closed hatch' measurement and sampling.

Fugitive Emissions Detection

Refineries typically contain hundreds of thousands of piping components such as valves, connectors, flanges, pumps and compressors. Each of these has the potential for the process fluid to escape around the seal. While the quantity of emissions from each individual component is usually very small, the large number of components in a refinery may make fugitive emissions the largest aggregate source of hydrocarbon emissions.

Emissions leaks are not usually visible. They have typically been found through the use of sensitive gas sampling devices to 'sniff' for parts-per-million (ppm) concentrations on the piping component. As the 'sniffer' has to be very close to the leak site this is a labour-intensive process. New optical gas imaging equipment and satellite imagery can visualize leaks and make detection simpler and much more cost-effective.

Carbon Capture and Storage

Carbon Capture and Storage (CCS) can use existing processes and technologies to collect and compress CO_2 generated by fossil fuel production, conversion and combustion. Compressed CO_2 is then permanently stored at depths beyond one kilometre below the earth's surface, within geological formations suitable for permanent storage. There are opportunities within refineries to capture CO_2 from processes such as catalytic cracking and hydrogen generation although further technology development will be key to bringing down costs.

Renewable Electricity

Electricity powers much of the equipment used in crude production and refining, such as the pumps used for extraction and flow throughout process units. Some oil and gas facilities are able to leverage renewable power, either through their own production or via purchase from providers. Facilities may be able to supply their own renewable power through technology like solar panel arrays. Or they may be able purchase it from a utility through renewable power purchase agreements. For offshore oil production platforms there may be an opportunity to connect by cable to shore-side electricity to replace energy produced on the platform by natural gas compressors or to make use of offshore wind energy.

Blue and Green Hydrogen

Hydrogen is used in refining processes to remove undesirable elements like sulphur from products. It is most commonly produced by the steam reforming of natural gas (methane) into hydrogen and carbon dioxide. A lower carbon intensity hydrogen can be produced by capturing and storing the carbon emissions, often referred to as 'blue hydrogen'. Hydrogen can also be produced by using renewable electricity to split water into hydrogen and oxygen, often referred to as 'green hydrogen'. These alternative hydrogen sources can be applied in fossil fuel production to further lower GHG emissions.

New Development and crude oil selection

GHG emissions during fuel production can also be reduced through facility and operational changes enabled by newly developed crude. Lifecycle GHG emissions associated with the processing of a particular crude into fuel can vary according to factors such as the characteristics of the crude. For example, crude with a lower gas to oil ratio generally requires less gas compression, which can be an energy-intensive process. Crude with lower sulphur generally requires less hydro-processing to remove the sulphur, which in turn requires less energy and can result in lower emissions. A newly developed crude may have such characteristics to a greater extent than crude currently being produced and processed.

As new crude is called for to replace what is consumed, it presents an opportunity for crude oil producers to locate, develop and supply crude with improved characteristics. It also provides fuel producers (refiners) an opportunity to use such crudes to the extent that their refinery configuration and product demand allow.

SAF produced by co-processing of biological molecules in refineries

One additional approach that supplements SAF and LCAF is "co-processing", which is the simultaneous processing of bio-based material, such as fats, oils and other feedstocks, with fossil-based feeds using refinery infrastructure and economies of scale efficiencies. SAF produced through co-processing and that meets CORSIA criteria is recognized under CORSIA as an eligible fuel.

Using an existing refinery can offer benefits in terms of cost savings and carbon intensity reduction as it removes the need to build dedicated processing units. The potential volume of SAF that a refinery can produce through co-processing is currently limited by ASTM D1655. The standard currently only permits co-processing of 5% vegetable oils or waste oils and fats, and Fischer-Tropsch synthetic liquids for SAF production. Although 5% may seem like a small amount, it could still be considerable if the scale of refinery operations is considered. For example, if a refinery unit is processing 10,000 barrels per day (bpd) of aviation kerosene, then 5% amounts to about 500 bpd (nearly 30 million liters per year) of SAF.

Co-processing can increase the supply of sustainably certified SAF in the short-term at current co-processing limits and could become more significant if these limits are increased and other feedstocks are certified. Using existing refinery infrastructure allows for more rapid production of SAF as construction of new facilities proceeds.

Looking ahead

Two-thirds of the Ipieca member companies have now communicated net zero aims by 2050 at time of publication. To achieve these targets, they will need to: firstly, substantially reduce operational emissions which is key to enabling production of lower carbon intensity fuel such as LCAF and secondly, bring new lower carbon intensity transport fuels to the market such as SAF from biofuels, waste, and synthetic or e-fuels. All of these options are among those being actively pursued today by the oil industry through manufacturing in modified facilities, new build joint venture plants, and pilot and demonstration facilities.