OIL AND GAS CLIMATE INITIATIVE

THE ROLE OF LOW CARBON FUELS IN DECARBONIZING TRANSPORT

A REPORT FROM THE
OIL AND GAS CLIMATE INITIATIVE

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Contents

Decarbonizing transport – OGCI's perspective

OGCI and transport

OGCI is helping to develop a portfolio of decarbonization solutions in the transport sector.

The Oil and Gas Climate Initiative (OGCI) aims to accelerate the industry response to climate change and scale up practical solutions in accordance with the goals of the Paris Agreement. We work from the principle that decarbonizing energy systems is a complex task that demands the collective efforts of the oil and gas industry, our customers and other stakeholders. In that spirit, we leverage the combined strength of our member companies and collaborate broadly with others to lower the carbon impact of our own operations, reduce the carbon intensity of products used by our customers and implement complementary solutions that cross industry boundaries.

In 2020, OGCI has focused on transport, exploring how we can best contribute towards material CO_2 emissions reductions throughout the sector. To address this challenge, we have drilled down to four priority core themes: efficiency, low carbon liquid fuels, hydrogen and closing the carbon cycle through mobile CO_2 capture.

Our objective is to develop a portfolio of solutions for the short, medium *and* long term, that can decarbonize the various modes of transport. OGCI's initial focus is on challenging areas such as long-haul commercial vehicles, deep-sea marine vessels and international aviation, where short-term gains may be realized by blending renewable fuel components into established distribution networks. Our joint efforts are designed to harness the capability of industry partners, complement actions carried out by our members both individually and collectively and leverage the Climate Investments fund to spur innovative solutions.

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Reducing emissions in transport

Individual OGCI member companies are playing active roles in developing a broad range of energy carriers and propulsion technologies to address the individual demands for all modes of transport. As a collective group, OGCI is initially focusing on those sub-sectors that are challenging to decarbonize.

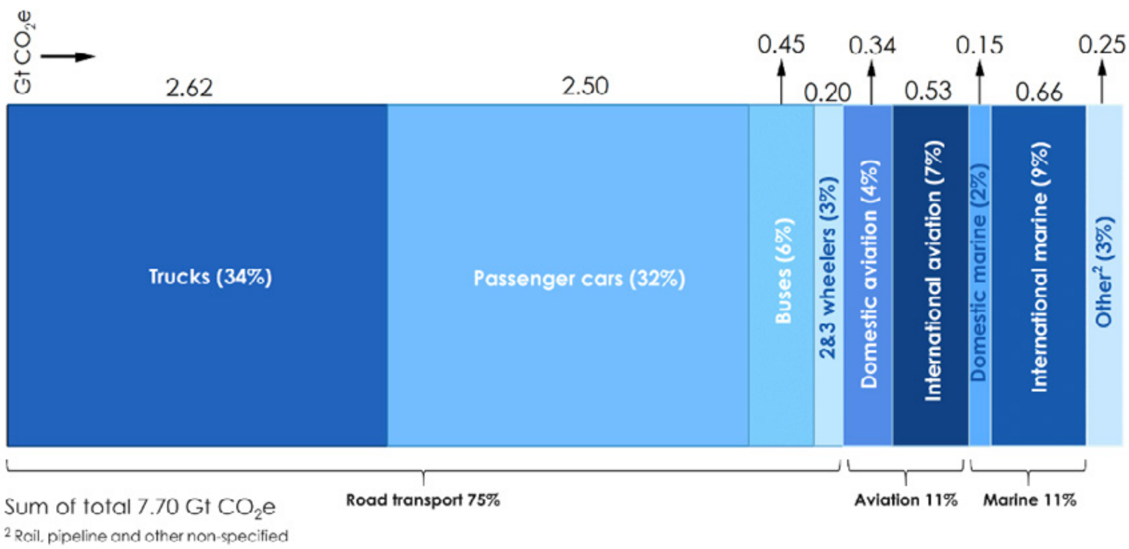
In some of the road transport sub-sectors, such as two-wheel vehicles, passenger vehicles and light commercial vans, electrification is already playing a role in reducing emissions, especially when powered by renewable energy. This trend will continue in parallel with the development of more efficient engines and transport fuels that have a far lower carbon footprint than those in the market today. These decarbonization pathways are expected to collectively lead to a considerable reduction in the CO_2 emissions generated in road transport, even within the next decade. Policies intending to reduce emissions in this sector will need to consider local and regional culture and economics and the pace of adoption of technological innovation.

The options available to decarbonize international shipping and aviation, as well as long-haul trucking, are presently limited. In these sub-sectors, there are few viable alternatives to liquid fuels that meet both the necessary energy density and the fuel handling/storage requirements. OGCI is working jointly and in close cooperation with other leaders on additional decarbonization initiatives in these areas, focusing on hydrogen in long-haul trucking and mobile carbon capture in shipping. In this paper, we are focusing on the role low carbon fuels can play in decarbonization.

Where the emissions come from

The transport sector produced nearly 8 Gt CO_2-equivalent (CO_2e) of direct greenhouse gas emissions in 2017 and hence accounted for 24% of total energy-related emissions (IEA, 2019). Around 75% of these emissions originated from **road transport**, including passenger cars, trucks and buses.

Figure 1. Greenhouse gas emissions from the transport sector



Source: IEA, McKinsey
Note: Breakdown of annual CO_2-equivalent (CO_2e) emissions from transport by sub-sector (IEA, 2018). Difficult-to-abate sectors are presented in darker shades of blue.

The **aviation** and **marine** sectors appear to be relatively small emitters in comparison, with each accounting for 11% of all direct transport emissions. These sectors are, however, projected to grow fast over the long-term and their emissions are much harder to abate with high associated costs (IEA, 2018).

Emissions from the aviation sector increased by 32% from 2014 to 2018, reaching an estimated 918 Mt CO_2 per year in 2018 (ICCT, 2018). Forecasts by the International Civil Aviation Organization (ICAO) showed CO_2 emissions from international aviation tripling by 2050 (ICAO, 2019). Under a scenario where other sectors of the economy decarbonize in line with the Paris Agreement's climate ambitions, aviation could account for up to 25% of the global greenhouse gas emissions budget by 2050 (Carbon Brief, 2016). While the repercussions of Covid-19 may slow the pace of growth, finding long term decarbonization pathways for long-haul aviation remains crucial.

Similarly, it is estimated that shipping emitted an average of 1,016 Mt CO_2 per year from 2007 to 2012, equivalent to 2.6% of global CO_2 emissions (IMO, 2014). The shipping sector could account for as much as 10% of all global greenhouse gas emissions by 2050 according to a business as usual scenario that includes increasing decarbonization of power generation, industry and road transport (CE Delft, 2017).

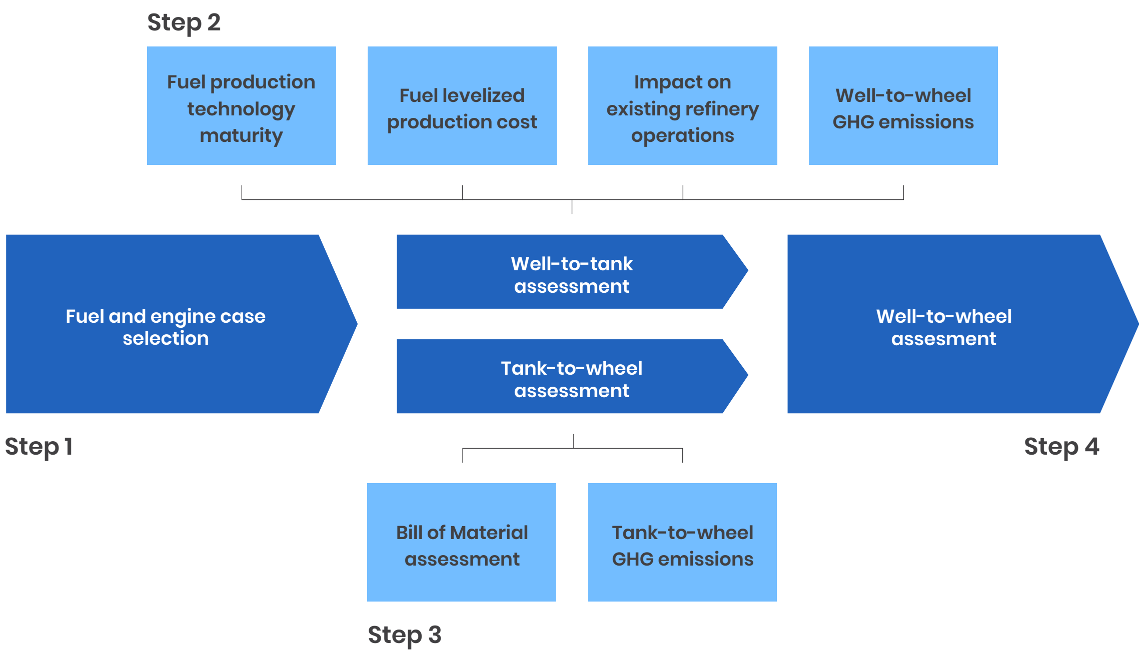
Low carbon fuels – the potential impact

Exploring the value of low carbon fuels

OGCI recently completed a study to identify the well-to-wheel (WtW) CO_2e emissions reduction potential of a variety of reformulated, blended and alternative transport fuels for all modes of transport, including passenger and commercial road transport, maritime and aviation.

We examined fuels that can be used with existing engines and infrastructure (drop-in fuels) and those that require modifications to the engine and/or fuel storage system (Figure 2). The second category of fuels may also require development of new supporting infrastructure, as well as changes to fuel specifications and the operation of existing oil refineries. The aim was to identify promising opportunities as well as potential actions that OGCI could take to address market barriers and implementation challenges.

Figure 2. Technical, economic and environmental areas assessed in the study



Source: E4tech, AVL, OGCI
Note: Methodology applied to assess the techno-economic aspects of the study. Bill of Material assessment used to quantify additional cost of modifying the engine/fuel storage system for alternative fuels with respect to baseline hardware. WtT = well-to-tank emissions from production of the fuel; TtW = tank-to-wheel emissions from combustion of the fuel in the vehicle, vessel or aircraft; WtW = well-to-wheel (total) emissions.

Implementation pathways for low carbon fuels

This study identified three implementation pathways for adopting low carbon fuels in the transport sector, along with the corresponding CO_2 emissions reduction potential and barriers to market adoption. The three pathways are:

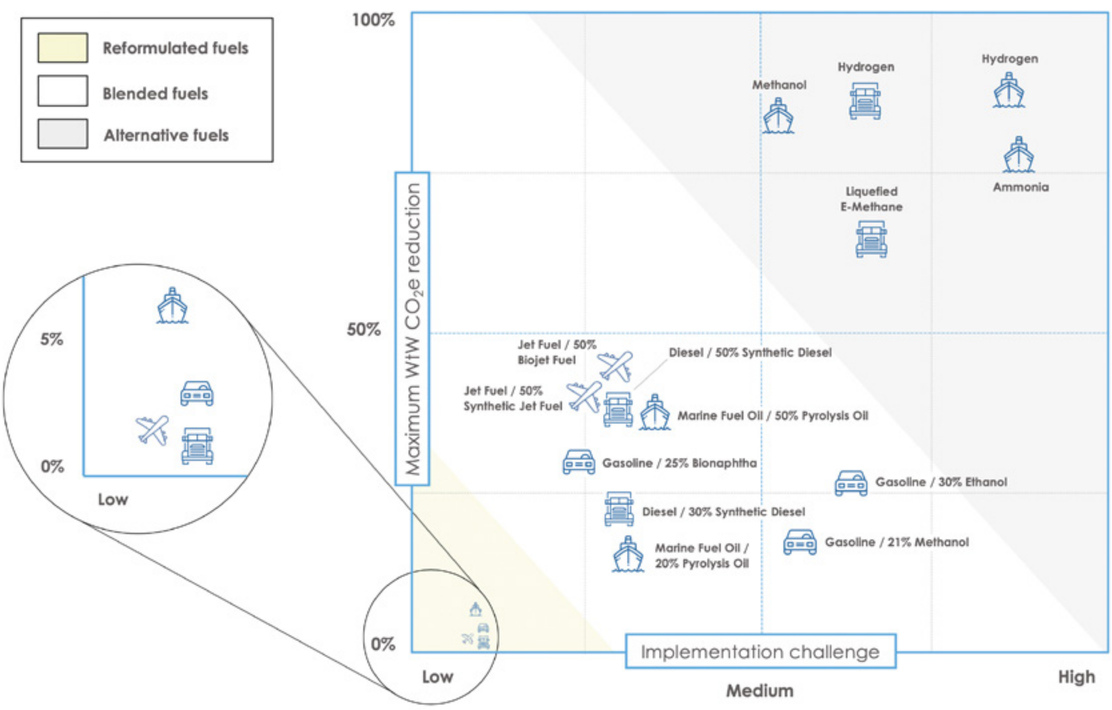
1. **Reformulated fuels in existing engines:** adjusting the operation of refinery processing units to produce gasoline, diesel, marine and jet fuels that create fewer CO_2 emissions when deployed in existing vehicles, marine vessels and aircraft. These reformulations are 'drop-in' fuels, which means they satisfy all fuel specifications and can be used in an existing engine without modification.

2. **Blended fuels in existing engines:** blending conventional refinery fuels with compatible fuels synthesized from sustainably sourced biomass or low carbon electricity, and deployed in existing vehicles, marine vessels and aircraft as 'drop-in' fuels.

3. **Alternative fuels in modified engines:** fuels that differ considerably from existing transport fuels in the way they are produced, stored, handled and/or used. Common examples include hydrogen, ammonia and methanol. Alternative fuels generally require modifications to existing engines and fuel storage systems, development of supporting infrastructure, and rely on fuel production pathways that have not been widely proven at commercial scale.

Depending on the target sub-sector, the full WtW CO_2e emissions reduction potential of the three pathways varies considerably, ranging from around 1% for a reformulated diesel fuel to well over 80% for a number of alternative fuels on a per vehicle, vessel or aircraft basis (Figure 3). The absolute impact on emissions, however, depends on the scale of implementation. As an example, if the 2.8% WtW CO_2e emissions reduction obtained from reformulating gasoline could be realized across the global passenger vehicle fleet, the absolute emissions reduction would be around 70 Mt CO_2e each year. This is equivalent to eliminating half of the direct CO_2e emissions produced annually by short-sea shipping.

Figure 3. Scale of impact and difficulty of implementation for different fuels



Source: OGCI

Note: Maximum WtW CO_2e emissions reduction potential vs. implementation challenge for selected reformulated, blended and alternative fuels by transport sub-sector. Implementation challenge is ranked based on three equally weighted criteria: (1) fuel production pathway (technical maturity and deployment status, levelized production cost, availability / scalability of feedstock, and drop-in potential of the fuel); (2) engine technology (technical maturity of the engine / fuel storage hardware, engine / fuel storage hardware cost, expected market penetration of modified hardware); and (3) infrastructure (direct impact on existing refining operations, maturity of required fuel dispensing infrastructure).

Realizing these benefits, however, requires addressing very different challenges relating to fuel production, engine technology and infrastructure. Figure 3 plots the specific fuel/engine combinations we explored for each sub-sector on two axes representing the carbon reduction potential and the feasibility of implementation and widespread deployment needed to realize this potential. The top left quadrant of high CO_2 reduction potential and low implementation difficulty is noticeably empty.

"Effective and urgent decarbonization pathways are likely to involve an overlapping portfolio of short, medium and long term solutions."

This reflects the reality that challenges related to fuel production, engine technology and infrastructure often limit the short-term impact of promising low carbon fuel pathways, despite offering major potential to decarbonize the sector over the long term. As a result, effective and urgent decarbonization pathways are likely to involve an overlapping portfolio of short, medium and long term solutions.

The rate of market adoption of some low carbon mobility solutions, especially in road transport, is also likely to vary from region to region depending on local regulations, the level of policy support and the status of existing infrastructure. In international marine and aviation, however, major changes are likely to happen across the entire industry and not be regionally fragmented, reflecting the global nature of these sectors.

Key takeaways - short and longer term solutions

Key takeaways

Our work indicates that there is no single technology, energy carrier or pathway that can successfully decarbonize the transport sector. Instead, an overlapping portfolio of short, medium and long term solutions – including reformulated, blended and alternative fuels, as well as electrification – will be required to address the specific needs and challenges of individual sub-sectors.

While reformulated fuels can have an immediate impact on CO_2 emissions across all sub-sectors, blended fuels will first require alternative fuel supply chains to be established or scaled up in a sustainable manner. Similarly, the impact of alternative fuels on CO_2 emissions will be constrained not only by the fuel supply chain, but also by how quickly new vehicles and vessels are adopted by the market, as well as the time and cost required to develop the necessary distribution and refueling infrastructure, mostly from the ground up.

As a result, the deployment timeframe for reformulated, blended and alternative fuels will vary by sub-sector, often overlapping to ensure a smooth transition with limited impact on the market. We believe a phased approach – where reformulated and blended fuels are deployed in existing engines in some sub-sectors, while alternative fuels and electrification are deployed in others – presents a promising opportunity to accelerate the decarbonization of the global transport sector.

Reformulated fuels in existing engines – short term impact (2025-30)

Reformulating existing transport fuels to reduce their carbon intensity[1] can represent a key short term decarbonization pathway for some sectors, providing WtW CO_2e emissions reductions of up to 6.1% (E4tech, AVL, 2019).

Reformulation involves adjusting the operation of the refinery processing units to produce gasoline, diesel, marine and jet fuels that satisfy all aspects of existing fuel quality specifications, but which create fewer CO_2 emissions when used in existing vehicles, marine vessels and aircraft.

While reformulated drop-in fuels have a relatively small impact on WtW CO_2e emissions on a per vehicle basis, they can be deployed quickly and at scale within the large existing global fleet by leveraging established infrastructure. Given that the average age of the fleet is rising[2], fleet replacement is slow and requirements to adopt new vehicle or engine technologies are largely not yet in place, even older vehicles can benefit from this approach. This would help to reduce absolute CO_2 emissions considerably in the short term and continue to have an impact into the 2030s.

[1] Fuel carbon intensity is defined as the amount of CO_2 produced from the combustion of a fixed amount of energy of a given fuel, e.g., grams CO_2 per megajoule of fuel (gCO_2/MJ).

[2] The average age of the US passenger car fleet is now 12 years, according to the Bureau of Transportation Statistics, 2019.

Blended fuels in existing engines – short to medium term impact (2025-40)

Conventional refinery fuels blended with components that are produced from sustainably sourced biomass or synthesized using low carbon electricity, provide additional scope to reduce WtW CO_2e emissions, even when deployed in existing vehicles, vessels, and aircraft as drop-in fuels.

In the short term, widespread deployment of blended fuels will be limited by the industry's ability to establish *and* scale up the alternative fuel supply chains, initially constraining the maximum blending levels that can be achieved. In the medium term, accommodating the alternative fuels at blending levels of up to 50% will require major changes to the operation of the refinery processing units that produce existing gasoline, diesel, marine and jet fuels.

Blended fuels represent a particularly attractive decarbonization pathway for difficult-to-abate sectors, including both marine and aviation. When blended fuels are deployed in existing marine vessels and aircraft using established distribution and refueling infrastructure, the WtW CO_2e emissions can be reduced by up to 37% and 44%, respectively, over the medium term (E4tech, AVL, 2019). Similar WtW CO_2e emissions reductions can also be realized in commercial vehicles.

Alternative fuels in modified engines – long term impact (2040+)

Alternative fuels deployed in modified engines offer the largest potential to reduce WtW CO_2e emissions, particularly in long-haul trucks (up to 86%) and marine vessels (up to 87%) (E4tech, AVL, 2019).

Unlike drop-in fuels, alternative fuels such as hydrogen, ammonia, methanol and liquefied methane require modifications to the engine and fuel storage system, as well as the development of supporting infrastructure to facilitate widespread deployment. These factors will limit the short term impact of these low carbon fuel pathways, but offer major decarbonization potential over the medium to long term, particularly in difficult-to-abate sectors.

Scalability of fuel supply remains another key challenge, with many promising alternative fuels relying on production methods that have not yet been widely proven at commercial scale, including sustainable biomass-based routes and green[3] hydrogen produced from electrolysis with renewable electricity. The latter could be accelerated through hybrid pathways involving a mix of low carbon hydrogen produced from a range of sources, including blue[4] hydrogen enabled by carbon capture and storage (CCS).

Although not considered in this study, sustainable aviation fuels based on biomass or green/blue hydrogen show similar potential to reduce WtW CO_2e emissions as other alternative fuels (Figure 3), with reductions of up to 80% possible over the long term (Biofuels Digest, 2020).

Next steps

OGCI is exploring collaboration with transport industry organizations, companies developing new fuel supply opportunities, shipping companies and truck manufacturers to augment ongoing initiatives in the sector and complement the activities of our member companies and OGCI Climate Investments. Our ongoing efforts are aimed at addressing the key barriers to market adoption for a portfolio of short, medium and long term solutions that can have a material impact on transport CO_2 emissions, particularly in sub-sectors that are challenging to decarbonize.

[3] **Hydrogen produced by the electrolysis of water, where renewable electricity is used to break the water into its component elements of hydrogen and oxygen.**

[4] **Hydrogen produced by reforming natural gas, with the resulting CO_2 captured and stored in a stable environment using carbon capture and storage (CCS).**

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Cautionary statement

This document contains certain forward-looking statements. Forward-looking statements are statements of future, not past, events or circumstances, including projections, ambitions, aims, targets, expectations, estimates, plans and objectives. Forward-looking statements involve risk and uncertainty because they relate to events and depend on circumstances that will or may occur in the future and are outside of the control of OGCI and/or its member companies. Actual results or outcomes (including demand growth and relative energy mix; new technologies; efficiency gains and cost savings; and emission reductions) could differ from those expressed in such statements, depending on a variety of factors. Third party scenarios discussed in this report reflect the modeling assumptions and outputs of their respective authors, not OGCI and/or its member companies, and their use or inclusion herein is not endorsement by OGCI or its member companies of their likelihood or probability.

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What is OGCI?

The Oil and Gas Climate Initiative is a CEO-led consortium that aims to accelerate the industry response to climate change. OGCI member companies explicitly support the Paris Agreement and its goals. As leaders in the industry, accounting for over 30% of global operated oil and gas production, we aim to leverage our collective strength and expand the pace and scope of our transitions to a low-carbon future, so helping to achieve net zero emissions as early as possible.

Our members collectively invest around $7B each year in low carbon solutions. OGCI Climate Investments, our $1B+ fund, invests in solutions to decarbonize sectors like oil and gas, industrials and commercial transport. OGCI members include BP, Chevron, CNPC, Eni, Equinor, ExxonMobil, Occidental, Petrobras, Repsol, Saudi Aramco, Shell and Total.

OUR MEMBER COMPANIES