G20 Energy Transitions Working Group (ETWG)

The role of sustainable fuels in hard-to-abate decarbonization

CONCEPT NOTE

September 2024 - Authors: Clarissa Lins, Bruna Mascotte and Tamara Fain

The authors would like to thank the participants of the roundtable, as well as IEA and Shell plc, which kindly provided up-to-date presentations on sustainable fuel market perspectives.

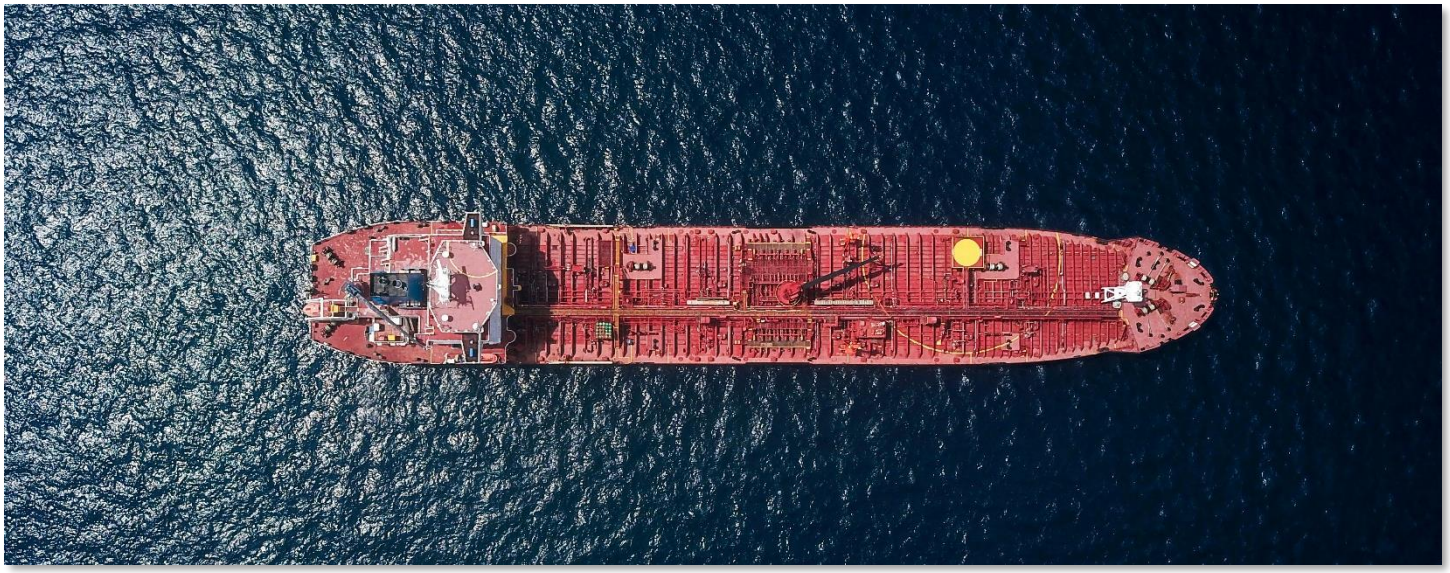


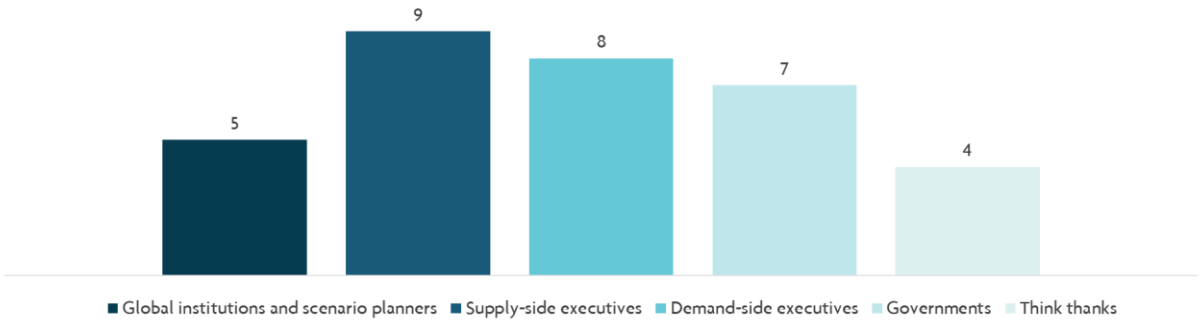
Photo: Shaah Shahidh via Unsplash

Context

Under **Brazil's G20 Presidency** in 2024, the **Energy Transitions Working Group (ETWG)** aims at addressing global energy challenges, being co-chaired by **Mariana Espécie**, Special Advisor to the Minister of Mines and Energy (MME), and **Ambassador André Correa do Lago**, Secretary for Climate, Energy, and Environment of the Ministry of External Affairs (MRE). The ETWG focuses on (i) accelerating financing for energy transitions, particularly in emerging markets and developing economies, (ii) addressing the social dimensions of this transition, and (iii) exploring innovative perspectives on sustainable fuels.

To enrich discussions on the latter, **CEBRI** – part of the Organizing Committee at **T20** - and **Catavento** have structured the roundtable **"The role of sustainable fuels in hard-to-abate decarbonization"**. More than 30 high-level stakeholders [Fig. 1] from different geographies participated in the event, including C-level executives from both the supply side (biofuel and e-fuel producers) and demand representatives (aviation, shipping, refinery, iron and steel), as well as experts on sustainable fuels and government officials.

Fig. 1. Roundtable attendees by profile (# of attendees)



Insights gathered during the session are consolidated into this concept note, which were shared with the Working Group's Chairs and presented at the G20's ETWG High-Level Dialogue in Foz do Iguaçu in October/2024. This event was part of a series of collaborative initiatives between CEBRI and Catavento throughout the ETWG's agenda under the G20 framework.

EXECUTIVE SUMMARY

1. The challenge of hard-to-abate sectors

For some sectors, such as electricity supply, the path to net-zero emissions is clear. **However, the pace of transformation in other industries is expected to be much slower.** Some industrial and transport sub-sectors are significant GHG emitters and are more challenging to decarbonize due to their specific physical, technological, or market characteristics. This includes – but is not limited to - **shipping, aviation, road freight transport, and heavy industry sectors, such as iron and steel** production. These sectors account for almost **one-fifth of the world's energy consumption** (84 EJ in 2022) and are responsible for around **16% of global CO_2 emissions** from energy and industrial processes (6 $GtCO_2$ in 2022)[1].

Most emission reduction strategies in these high-emitting sectors should focus on **improved energy efficiency and the direct use of clean electricity** where possible. Where this is not feasible, the use of **renewable heat and biomass (including biofuels)** and the **indirect use of clean electricity through hydrogen and e-fuels** will play a crucial role. In the International Energy Agency (IEA)'s net zero by 2050 scenario (NZE), **demand for low-emission** fuels such as biofuels, hydrogen and hydrogen-based fuels **double from today to 2030** and then again to 2050. They account **for ¼ of global energy supply in a net zero energy system by 2050**, split nearly equally between the transport and industry sectors[2].

As can be seen in the table below based on IEA's net zero scenario [Fig. 2], biofuels can respond to 8-12% of energy consumption in hard-to-abate sectors in 2030, with their share in 2050 depending on the decarbonization route of each sector – up to 33% in aviation's energy consumption, while only 6% in heavy-duty trucks. As for hydrogen and hydrogen-based e-fuels, their share in 2030 shall be limited to competitiveness and technical barriers, although a robust ramp up in

[1] IRENA. Decarbonising hard-to-abate sectors with renewables: Perspectives for the G7. 2024
[2] IEA. Towards common definitions of sustainable fuels. 2024

supply is needed to reach net zero targets by 2050, accounting for up to 63% of shipping's energy consumption by this year, for example.

Fig. 2. Relevance of selected hard-to-abate sectors and the role of biofuels, H_2 and e-fuels in IEA's net zero scenario

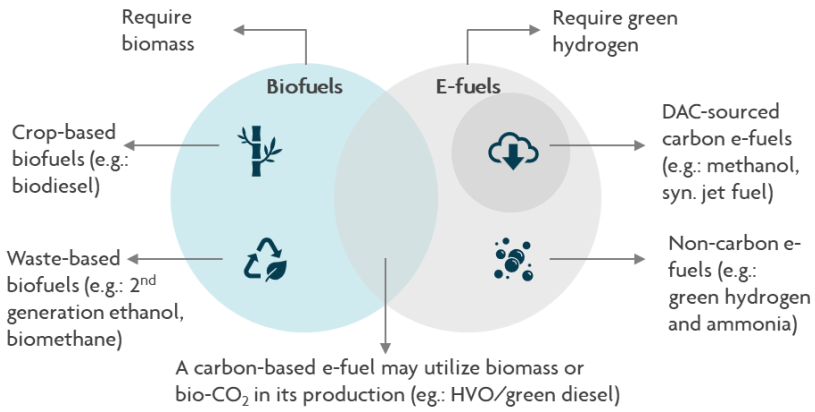
	% of global energy consumption, 2022	% of global energy-related CO_2 emissions, 2022	Biofuel in energy consumption		H_2 and e-fuels in energy consumption	
			2030	2050	2030	2050
Shipping	2.5% - 11.2 EJ	2% - 0.855 $GtCO_2$	8%	19%	10%	63%
Aviation	2.5% - 11 EJ	2% - 0.792 $GtCO_2$	10%	33%	1%	45%
Heavy-duty trucks	6% - 26.8 EJ	5% - 1.8 $GtCO_2$	12%	6%	1%	27%
Iron and steel	8% - 35 EJ	7% - 2.6 $GtCO_2$	-		5%*	44%*

** Share of green hydrogen-based near zero emission production.*
Source: Catavento analysis based on IEA. Net Zero Roadmap: A renewed pathway to net zero emissions. 2023.

2. Perspectives for upscaling sustainable fuel market

Also called low-emission fuels[3], sustainable fuels can be either **bio-based or e-fuels,** depending on their input components [Fig. 3].

Fig. 3. Simplified framework over the types of sustainable and low-emission fuels



Source: Catavento. Low-carbon fuels for heavy transport decarbonization. 2024

Biofuels are produced from renewable biological sources, which absorb CO_2 from the atmosphere as plants grow.

[3] IEA. Low-emission fuels.

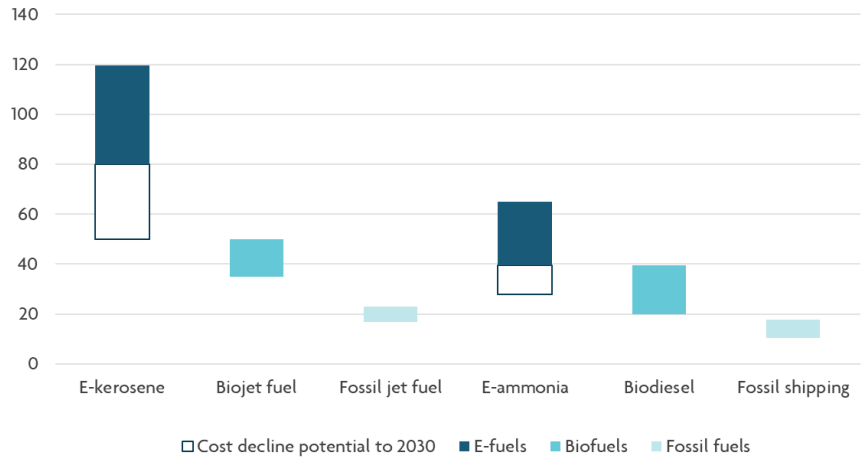
E-fuels - also known as electrofuels, synthetic fuels, Power-to-X (PtX), Power-to-Liquids (PtL) or renewable fuels of non-biological origin (RFNBOs) — are a synthetic alternative to fossil fuels. They are obtained from electrolytic hydrogen and are considered low-emission alternatives when their hydrogen is produced using low-emission electricity and any carbon inputs are obtained in a way that leads to low life cycle GHG emissions[4]. The combination of green hydrogen with nitrogen produces e-ammonia, a gaseous chemical that is used today mainly as a precursor to fertilizers, but that also has application as a fuel. The combination with carbon opens the possibility to produce a wide range of products, including e-methanol and e-jet fuel.

According to the IEA, low-emission fuels covered only around 1% of global final energy consumption in 2022, largely from liquid biofuels, compared with almost **5% needed by 2030 in its net zero scenario**.

One of the greatest barriers to the use of low-emission fuels is **value chain traceability and sustainability**, including aspects related to impacts of renewable energy generation and crop growth in **land use, deforestation, biodiversity and local socioeconomic factors**. More precisely, **carbon accounting standards** are needed to consider the actual climate benefit of different sustainable fuel options. The assessment of GHG emissions, based on lifecycle assessment principles, should cover the whole supply chain and final use, and requires the development and use of transparent and internationally agreed GHG accounting. This is especially needed for upscaling bio-based sustainable fuels, since the impacts of land use change emission estimates can be considerable and are a major source of disagreement across different policy frameworks[5].

There is also a growing consensus on the challenge of **cost competitiveness**, since low-emission fuels imply a considerable cost premium compared to fossil fuel substitutes, even considering potential cost reductions throughout 2030 [Fig. 4][6]. Each sector will have to address this challenge considering its particularities, through carbon pricing mechanisms, mandates, and demand-side initiatives that showcase willingness to pay for a green premium.

Fig. 4. Low-emission fuels levelized cost ranges (US$/GJ, 2030)



Source: IEA. Renewables 2023. 2023

[4] IEA. The Role of E-fuels in Decarbonising Transport. 2023
[5] IEA. Carbon Accounting for Sustainable Biofuels. 2024
[6] IEA. Renewables 2023. 2023

Finally, **investments in biofuels** are expected to **grow by 8% in 2024,** reaching **US$ 14 bn.** In parallel, investments in **hydrogen electrolyzers** are set to reach **US$ 5 bn in 2024**, more than doubling 2023 values.[7]. Although growing, the total invested in low-emission fuels represents only around **1% of total clean energy investments expected in 2024** (US$ 2 tn), showcasing the opportunity to increase capital allocation into innovative solutions that will be crucial for the decarbonization of high-emitting sectors.

3. Key takeaways from the roundtable

Several key messages regarding the challenges and opportunities for scaling up sustainable fuels were highlighted during the discussions and are summarized below. As there was no universal consensus on all aspects, we have divided the key takeaways into areas of general consensus and areas of differing opinions.

Sustainable fuels will play a significant role in decarbonizing heavy transport and industry

Consensus among participants

- **Sustainable fuels** are an important component of a **broader mix of decarbonization initiatives** for hard-to-abate sectors, specially being **drop-in solutions** and minimizing infrastructure adaptation;
- There is still a **common perception** among potential customers of scalability challenges due to **feedstock limitations aligned with required sustainability criteria**. This implies that increased production does not necessarily result in economies of scale and cost reduction, given the constraints in raw materials for biofuels (e.g., availability of used cooking oil) and e-fuels (e.g., green H_2, biogenic, or DAC carbon molecules);
- Heavy transport and industry also face the challenge of managing assets with **long lifespans**, such as airplanes and ships built today that will still be operating in the next 20 to 30 years. Fast-tracking existing assets adaptation and renewal, as well as infrastructure development—including safety and permitting aspects—is urgent;
- **Hardware producers** (e.g., airplane and ship manufacturers) have a crucial role in demonstrating the technological maturity and applicability of sustainable fuels in safe and efficient operations.

No consensus

- Sustainable fuels could potentially serve as a **final decarbonization solution** to some sectors and companies, while others consider them as a **transitional** energy source until direct hydrogen and electrification become commercially viable.

[7] IEA. World Energy Investment 2024. 2024

Cost remains the primary challenge, as most, but not all, technological hurdles have been addressed

Consensus among participants

- Heavy industry and transport should no longer be referred to as "hard-to-abate" but rather as "**expensive-to-abate**." While some technological challenges considering sustainable fuels remain, particularly in moving from pilot stages to commercial availability, many have already been solved;
- Although consumer companies have set voluntary commitments, there is a **lack of customer willingness to pay for premiums**, highlighting the **critical role of regulation and public policies** in driving decarbonization in these sectors at the necessary pace. Measures such as **carbon pricing** and reducing the **cost of capital** for relevant low-carbon infrastructure projects could enhance their competitiveness compared to fossil fuel options;
- These sectors typically purchase fuels based on short-term contracts; however, scaling the supply of emerging technologies requires **long-term offtake agreements** to secure financing, even if it means committing to a higher price. Customers need to provide demand visibility to the supply side to enable the scaling up of production;
- It should not be expected for sustainable fuels to achieve **price parity with fossil-based alternatives**, as the latter can have different properties (e.g., density) and may require additional CAPEX for adaptation (if not a drop-in solution), along with increased OPEX;
- The impacts of decarbonization costs on a **just transition** need to be carefully considered and the adoption of sustainable fuels should not lead to increase in final prices to consumers, which could reduce societal support for decarbonization. Conversely, in specific sectors, the increase in fuel costs could have a minimal effect on the final price of goods for consumers, which calls into attention the challenge of addressing the green premium throughout the value chain.

No consensus

- **Subsidies and other incentives** are essential for kick-starting and scaling up the adoption of sustainable fuels in heavy industry, while players should also develop **innovative long-term business models to make sustainable fuels affordable;**
- **Existing fossil fuel subsidies** should be gradually reallocated to support sustainable low-carbon fuels, taking into account and mitigating potential negative impacts on society.

Demand and supply commitments require greater regulatory certainty, both through international agreements (e.g., CORSIA, IMO) and national decarbonization policies and standards

Consensus among participants

- There is a need for a **universally agreed taxonomy of what constitutes 'sustainable fuels,'** with a particular focus on life cycle emissions for **carbon accounting**, **certification**, **land use considerations, traceability, and sustainability** throughout the value chain. Sustainability must be ensured in a pragmatic way, without overburdening the nascent market or increasing complexity;
- A global **book-and-claim system** for sustainable fuels could significantly drive market development by bypassing physical infrastructure and availability barriers. It could also help direct clean energy investments towards emerging and developing economies with renewable energy potential, available land, and feedstock;
- Producers and consumers of sustainable fuels still face **barriers related to financing mechanisms** that hinder adoption, particularly due to land use criteria for biofuels and higher capital costs for new projects, especially in emerging and developing markets.

No consensus

- Public policies, taxonomies, and regulations should be **technology-neutral,** ensuring a level playing field and allowing technologies to compete freely with one another;
- A **portfolio approach** to decarbonization should be adopted, considering not only costs but also other robust criteria, and using **targeted interventions** (e.g., auctions) to promote specific solutions that are considered preferable, avoiding picking winners and losers.

Recommendations for the G20

1. **Acknowledge the importance of sustainable fuels as a key component of a decarbonized energy system**
   a. Recognize that **G20 countries** have **diverse energy, climate, and socioeconomic contexts**, and that emerging and developing nations may require different low-carbon solutions compared to advanced economies;
   b. Highlight the **significant role of both biofuels and e-fuels in transitioning heavy industry and transport** to a low-carbon economy, especially as **drop-in solutions** that reduce **infrastructure adaptation** requirements;
   c. Understand that sustainable fuels may not follow the same **cost reduction trajectories** as other low-carbon technologies (e.g., solar and wind power) and may not achieve cost parity with fossil-based alternatives, therefore requiring a different set of policy tools to **attract investments and demand**.

2. **Foster consensus to overcome the challenges hindering the scale-up of the sustainable fuel markets**

    a. Promote a common **global definition of sustainable fuels** based on **carbon accounting** for lifecycle emissions, applicable to certification and standards;

    b. Accept **all types of feedstocks** that demonstrate proven lifecycle emission reductions, while avoiding green protectionism;

    c. Ensure **traceability measures and transparency** regarding the **sustainability** credentials of sustainable fuels, including considerations of **land use** impacts.

3. **Support regulatory and market-based mechanisms to efficiently promote sustainable fuels**

    a. Incentivize **demand-side commitments** for sustainable fuels based on a **stable and predictable regulatory environment**, including robust **public policies**, such as mandates, contracts for difference, book-and-claim systems and incentives, to kick-start the industry;

    b. Adopt a **technology-agnostic approach** to different feedstocks and production pathways for sustainable fuels, while recognizing the **co-benefits** of the various low-carbon options;

    c. Mitigate the exposure of low-income communities to **inflationary pressures** associated with the adoption of sustainable fuels.