

Task Force 02

SUSTAINABLE CLIMATE ACTION AND INCLUSIVE JUST ENERGY TRANSITIONS

The Role of Liquid Biofuels in Accelerating the Sustainable Energy Transition: Lessons Learned for the Sustainable Expansion of Transport Biofuels in Emerging Markets of Africa, Asia, and Latin America

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Abstract

Sustainable liquid biofuels are fundamental for decarbonizing the transportation sector. Biofuels offer a viable, economical, and environmentally sustainable alternative to fossil fuels, serving as a bridge to future mobility solutions like electromobility and hydrogen, which have longer development timelines. They improve air quality, public health, and contribute to agricultural and economic development, enhancing energy diversification, security, and leveraging each country's comparative advantages. The main challenges for the continued development of biofuels are the absence of an international standard, coordination and certification methodologies, lack of regulations in some countries and the subsidies to fossil fuels. The authors of this policy brief recommend that the G20 and the international community strengthen regulatory frameworks for sustainable biofuel use in land transportation, standardize and harmonize GHG reduction standards and certification mechanisms, and develop common regional and national policies to advance the production and consumption of new biofuels for sectors such as aviation and maritime transportation. An analysis¹ of biofuels implementation in emerging markets of Africa, Asia, and Latin America shows that meeting 25% blending targets requires only 1–7.8% of their total land area, achieving substantial GHG reductions. Favorable climatic conditions for biomass production in these countries and the low greenhouse gas impact of international freight underscore the benefits of global biofuel trade, highlighting the urgent need for widespread adoption to accelerate decarbonization efforts.

Keywords: Biofuels, Ethanol, Biodiesel, Sustainable Aviation Fuel (SAF), Decarbonization, Life Cycle Assessment, Certification.

¹ IEA Bioenergy Technology Collaboration. Program Task 39. Paris. IEA, 2024

Diagnosis of the Issue

The production and sustainable consumption of liquid biofuels play a crucial role in the urgent global effort to decarbonize the transportation sector and transition toward less carbon-intensive economic models. Biofuels are already economically viable and environmentally sustainable². Currently, biofuels substitute more than 5.5% of fossil gasoline and 3% of diesel, with ongoing developments focusing on expanding their applications in sectors like aviation (sustainable aviation fuel — SAF) and maritime transportation³.

The urgency to decarbonize global energy systems is underscored by the limited GHG budget remaining to achieve the targets set forth by the Paris Climate Agreement. The transportation sector is a major contributor to global emissions, prompting initiatives like the Brazilian-led Task Force for Global Mobilization Against Climate Change within the G20 to prioritize actions for sustainable development. Despite the accelerating adoption of battery electric vehicles (BEVs), persistent challenges, particularly in emerging markets, position liquid biofuels as scalable alternatives with proven low carbon footprints.

² Ibid.

³ IICA (Instituto Interamericano de Cooperación para la Agricultura, Costa Rica), *Biocombustibles líquidos: institucionalidad y formulación de políticas públicas*. San José, Costa Rica: IICA 2021.

Biofuels offer practical solutions to mitigate GHG emissions in the transport sector over the next two decades, complementing the gradual adoption of BEVs⁴. Their compatibility with existing vehicles and refueling infrastructure postpones the need for immediate fleet replacements in certain regions and addresses the challenges of hard-to-electrify sectors like aviation and marine transport. Brazil's implementation of flex-fuel engines serves as a successful model, enabling vehicles to operate on any blend of gasoline or ethanol and significantly reducing lifetime GHG emissions compared to regional electricity grid-powered BEVs.

In response to these challenges and opportunities, institutional mechanisms such as the Pan American Liquid Biofuels Coalition have been established to promote the sustainable use of biofuels across the Americas⁵. As global initiatives and regional collaborations advance, leveraging the comparative advantages of different countries and regions through biofuel technologies promises to accelerate the transition toward a more sustainable transportation sector. Furthermore, the pathways for producing biofuels vary significantly depending on regional resources. For instance, countries with abundant agricultural land may focus on ethanol production from sugarcane or corn, while others

⁴ Cantarella, Heitor, Glaucia Mendes Souza, Luiz Horta Nogueira, Rubens Maciel Filho, Gabriel Costa de Paiva, Nicholas Islongo Canabarro, Pablo Silva Ortiz, Tomas Ekbohm, Franziska Müller-Langer, and Jean Felipe Leal Silva. 2023. “Assessment of Successes and Lessons Learned for Biofuels Deployment. ISBN: 979-12-80907-29-5.”

⁵ CPBIO (Pan American Liquid Biofuels Coalition), ACTA 0. Creation of the Pan American Liquid Biofuels Coalition. San José, Costa Rica: IICA, 2023

might prioritize biodiesel from used cooking oil. These regional differences highlight the need for tailored policies and incentives that capitalize on each country's comparative advantages in biofuel production. These policies must also include international standards for fuel properties.

Biofuels present other socio-economic advantages. They improve air quality and public health by reducing harmful emissions such as particulate matter. Also, biofuels enhance agricultural and economic development by creating many direct and indirect jobs, providing new income opportunities for rural communities. This dual benefit supports both energy diversification and security, reducing dependence on imported fossil fuels while promoting local economic growth. In conclusion, while the challenges are significant, the opportunities presented by liquid biofuels for decarbonizing the transportation sector are equally substantial.

Recommendations

Considering the challenges mentioned, the authors of this policy brief deem it necessary to recommend that the G20 and the international community:

a. **Strengthen Regulatory Frameworks Promoting the Sustainable Use of Biofuels for Land Transportation in the Short Term**

Biofuels, including ethanol and biodiesel, are pivotal in mitigating carbon emissions from the global transportation sector. Regulatory frameworks such as biofuel blending mandates, overall mandates, and Low Carbon Fuel Standards (LCFS) have been instrumental in driving their adoption worldwide. As of 2022, 58 countries have implemented bioethanol mandates (Figure 1)⁶, and 48 countries have biodiesel mandates (Figure 2), illustrating widespread adoption but also indicating opportunities for enhancement in regions with lower blends or no mandates.

⁶ Agustín Torroba, *Liquid Biofuels Atlas 2022-2023*. San Jose, Costa Rica, IICA, 2023.

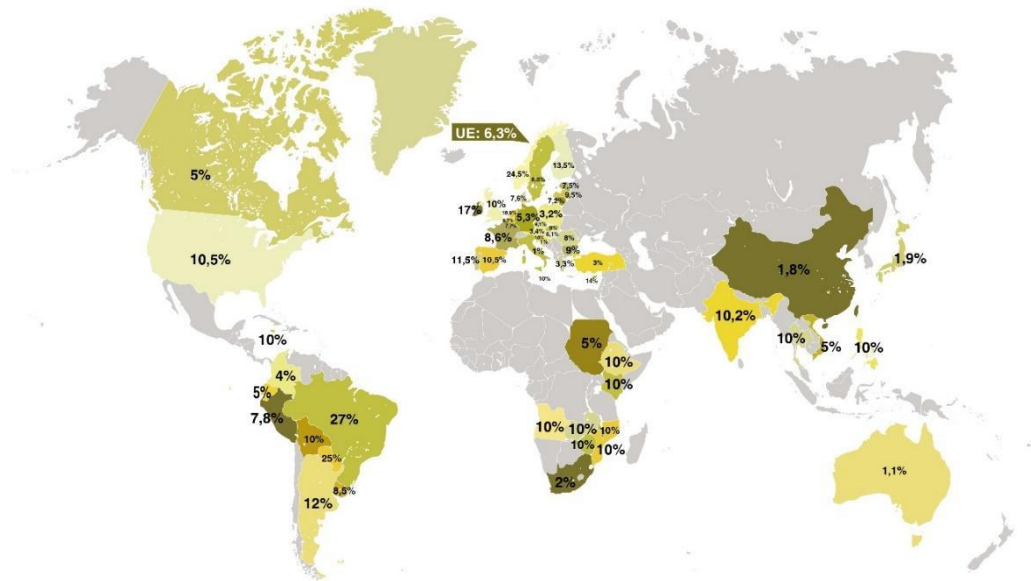


FIGURE 1. Direct and indirect mandates on the use of bioethanol in gasoline in 2022.

Source: A, Torroba, 2023.

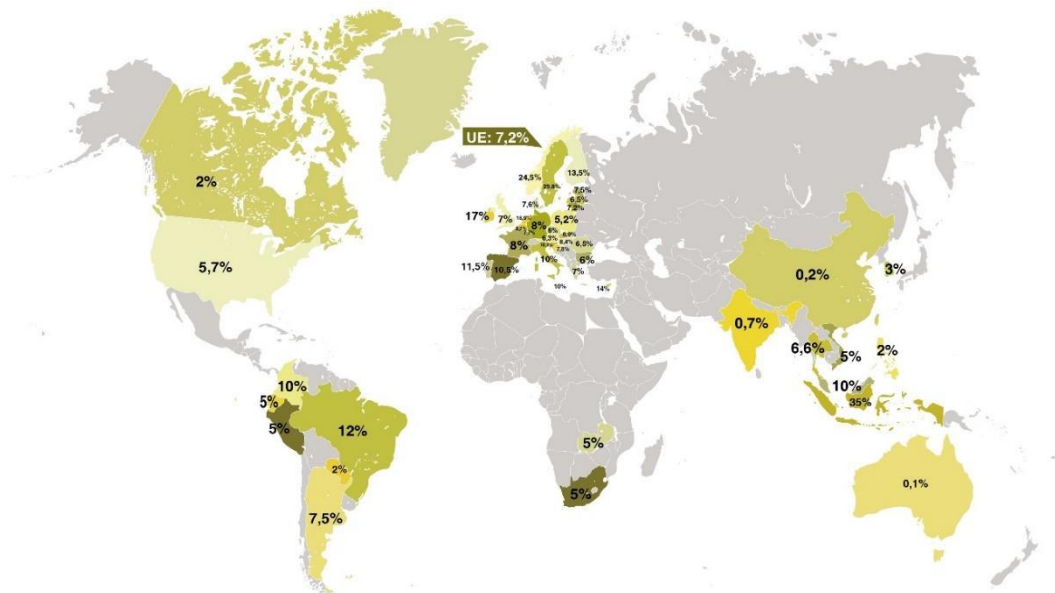


FIGURE 2. Direct and indirect biodiesel in fossil diesel mandates in 2022.

Source: A, Torroba, 2023

Governments should consider increasing biofuel blending targets and introducing new mandates where absent to accelerate the transition to low-carbon transportation. In regions where biofuel adoption is nascent or underutilized, policymakers can incentivize production and consumption through fiscal incentives, subsidies for infrastructure development, and targeted support for research and development (R&D). Financial incentives such as tax credits, grants, or loans can help offset the initial capital investment, making it more accessible to investors and entrepreneurs.

Incentives for technologies to decarbonize mobility should focus on their life cycle greenhouse gas emissions. Figure 3 shows the global warming potential of biofuels in gCO₂e/MJ, which is a measure of GHG emissions during all phases of biofuel production and use for a certain energy quantity that can be obtained from the use of that biofuel. These values are compared to the global warming potential of their equivalent fossil fuel counterparts, indicated by the dashed line. Reductions of GHG emissions of up to 78% for biodiesel and 81% for ethanol in Africa and Asia and 79% for ethanol and 84% for biodiesel in Latin America are possible according to these results. These reductions are possible in countries such as India, Indonesia, and South Africa whose electrical grids are heavily reliant on coal, with an average carbon intensity beyond 600 gCO₂e/kWh⁷. Considering their growing purchase power and the existing vehicle fleet, expanding

⁷ Ritchie, Hannah, Pablo Rosado, and Max Roser. “Data Page: Carbon Intensity of Electricity Generation. Data Adapted from Ember and Energy Institute. 2023.

biofuels in these countries as a first move makes more sense than shifting to electric vehicles.

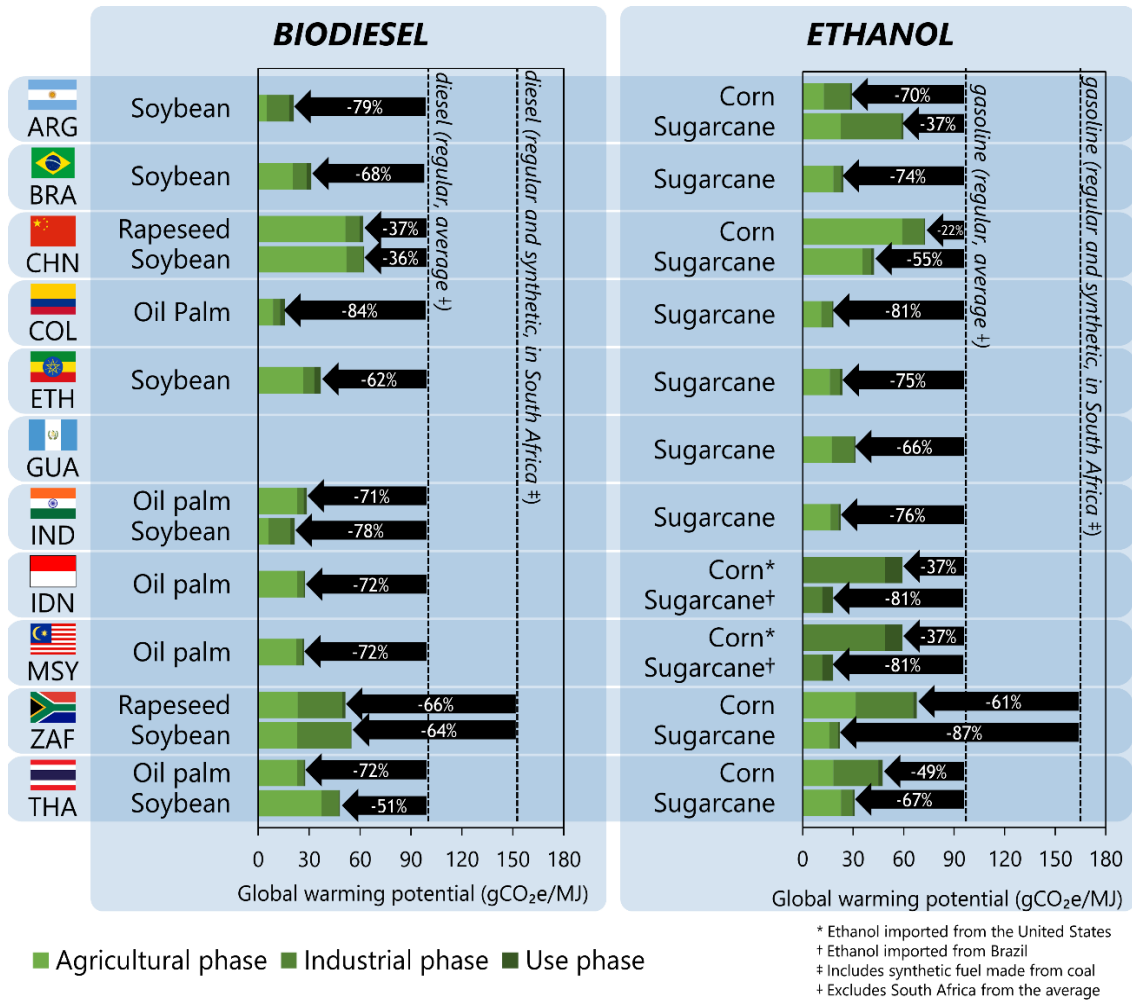


FIGURE 3. Global warming potential of biofuels (biodiesel and ethanol) over their entire production and use, compared to fossil fuels (diesel and gasoline) in several countries, showing the potential for GHG savings

Source: J.F. Leal Silva, L.A.H. Nogueira, H. Cantarella, R. Rossetto, R. Maciel Filho, and G.M. Souza, 2024.

Naturally, the promotion of biofuels expansion should be aligned with sustainability goals and regulatory frameworks that integrate mechanisms for monitoring, reporting, and verifying biofuel sustainability criteria. Countries should create and enforce policies to rule out bioenergy crops expansion into high carbon stock areas as part of the eligibility criteria for fiscal incentives. The expansion should focus on countries with greater availability of pastureland, preferably in subtropical and tropical zones that have better productivity potential with the goal of increasing land productivity without affecting forest areas. Transparent and robust certification should be developed at international level to ensure that biofuels meet environmental standards throughout their life cycle. Aligning these standards with international best practices fosters credibility and facilitates the global trade of sustainable biofuels.

Additionally, to aid food security, these biofuel policies could include mechanisms to incentivize biofuel producers to use feedstock to their full potential by including the adequate production of co-products for the food and feed markets. These co-products include, for example, distillers grains in the case of corn ethanol or soybean meal in the case of biodiesel, both of high nutritional value. This strategy reduces pasture requirements for cattle (replacing land for grazing), thus freeing up arable land for crop production. This is an example that food, feed, and biofuel production can be integrated. Additionally, investments in biofuel production can help the regional modernization of agriculture, which can reflect in increased yields in food production as it was observed in countries with well-established biofuel markets such as Brazil.

b. Work on the Standardization and/or Harmonization of Standards and Certification Mechanisms for Reducing Greenhouse Gas Emissions

It's essential that biofuel production expansion targets degraded areas and pastureland. Certification of sustainability is crucial to demonstrate adherence to sustainability criteria. The current landscape of biofuel standards and certification mechanisms is fragmented, and this lack of harmonization complicates market access of biofuels. Initiatives such as California's LCFS, Brazil's RenovaBio, and the International Civil Aviation Organization's CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation) scheme for aviation biofuels demonstrate progress but face challenges due to incompatible standards and methodologies.

Harmonizing biofuel standards globally is essential to attest their effectiveness in reducing GHG emissions and to promote fair trade practices. Policymakers and industry stakeholders should harmonize methodologies for calculating GHG emissions across different production processes. This includes establishing consistent criteria for land use change, indirect land use change, and other factors that influence biofuel sustainability. It is recommended that countries implement policies to exclude high carbon stock areas from biofuel expansion.

International cooperation on standardization can facilitate economies of scale in biofuel production, making it more cost-effective and attractive for investment. By aligning standards and reducing costs associated with certification, countries can increase confidence in biofuel sustainability and create a level playing field for biofuel producers to effectively compete with fossil fuels.

c. Develop Common Regional and National Public Policies and Standards to Foster New Biofuels for subsectors such as Aviation and Maritime Transportation

Biofuels, particularly SAF, hold significant promise for decarbonizing sectors like aviation and maritime transportation. SAF policies are emerging globally, driven by initiatives like CORSIA for aviation and regional mandates for maritime biofuels. However, the lack of consistent policies and standards across regions impedes the widespread adoption of SAF and other advanced biofuels.

To unlock the full potential of biofuels in hard-to-electrify sectors, policymakers should develop common regional and national public policies tailored to support biofuel production and consumption. Additionally, governments can create a level playing field, such as tax credits, grants for infrastructure development, and guaranteed off-take agreements with airlines and maritime fleets, eliminate subsidies for fossil fuels and internalizing the environmental costs of GHG emissions to enhance the attractiveness of biofuels. These incentives reduce the financial risks associated with biofuel production and stimulate corporate investment in biorefineries and biofuel distribution networks.

Scenario of Outcomes

a. Role for Biofuels in the Decarbonization of the Transport Sector

Biofuels are poised to play a pivotal role in global efforts to decarbonize the transport sector. As highlighted by the International Renewable Energy Agency (IRENA), the use of biofuels in transportation is expected to increase significantly. By 2030, biofuel consumption is projected to multiply more than four times compared to 2019 levels, reaching approximately 17 exajoules (EJ). Looking further ahead to 2050, this figure is expected to rise to more than 25 EJ, marking a more than sixfold increase from 2019⁸.

The International Energy Agency (IEA)⁹ underscores the critical importance of biofuels in achieving the targets outlined in the Paris Agreement. Specifically, biofuel consumption must see substantial growth, particularly in sectors such as aviation and maritime transportation, where viable alternatives to liquid fuels remain limited. These projections underscore biofuels' role not only as transitional fuels but also as long-term contributors to sustainable energy solutions in transportation.

⁸ IRENA (International Renewable Energy Agency), *World Energy Transitions Outlook 2022 1.5°C Pathway*. Abu Dhabi, United Arab Emirates: IRENA, 2022.

⁹ IEA (International Energy Agency, France), *Net Zero Roadmap: A Global Pathway to Keep the 1.5 °C Goal in Reach*. Paris, France: IEA, 2023.

b. Aviation and Maritime Sector Decarbonization

The aviation sector, heavily reliant on liquid fuels, views SAF as instrumental in its decarbonization strategy. SAF is anticipated to contribute significantly to GHG emission savings, with projections indicating that they could achieve up to 65% of emission reductions in international aviation by 2050¹⁰. Meeting this demand will necessitate a substantial increase in SAF production capacity globally, aligning with initiatives like CORSIA to regulate and incentivize the use of SAF. In this matter, second generation (2G) ethanol has an important role because of its reduced carbon footprint compared to regular ethanol.

Similarly, the maritime sector, guided by the International Maritime Organization (IMO), aims to eliminate greenhouse gas emissions from international shipping. Biofuels are expected to play a crucial role here as well, potentially constituting up to 19% of fuel consumption in the maritime sector by leveraging their lower carbon intensity compared to conventional marine fuels. These efforts underscore biofuels' versatility in addressing emissions reduction challenges across different modes of transportation.

¹⁰ Agustín Torroba, *Descarbonizando los cielos: biocombustibles sostenibles de aviación*. San José, Costa Rica: IICA, 2023.

c. Impact on Global Greenhouse Gas Emissions

The International Council for Clean Transportation (ICCT) posts ambitious measures to reduce GHG in the transportation sector¹¹. These include net-zero electrical grids, 100% green hydrogen, phasing out internal combustion engine vehicles (ICEVs) by 2045, and implementing compulsory fleet renewal policies globally. Despite these ambitious measures, they will only mitigate 51% of cumulative GHG emissions from the transportation sector between 2020 and 2050. Moreover, aggressive fleet renewal accelerates the purchase of new vehicles, generating more waste, and the well-to-wheel GHG emissions do not account for the burden of BEV manufacturing and disposal.

Alternatively, a short-term gradual increase in low-carbon biofuels in the fuel pool is suggested, increasing biofuel participation from 4% to 40% between 2026 and 2034, globally. Assuming that low-carbon biofuels are estimated to have GHG emissions 70% lower than fossil fuels and process improvements to reduce biofuel carbon intensity by 2% annually starting in 2026, adapting the scenarios from the ICCT report to not include fleet renewal policies (aggressive fleet renewal policies that might face challenges from consumers in most countries), but instead biofuel expansion leads to a reduction of 154 billion tonnes of CO₂e by 2050, 6% more than the ICCT's "all out" scenario. As the fleet ages and naturally transitions from internal combustion to electric vehicles, biofuel production can shift focus to hard-to-electrify sectors. Given the current demand for diesel and gasoline is about 50 million barrels per day (Mbpd), 40% of this demand equals 20

¹¹ Sen A, Miller J, Hillman Álvarez G, Rodrigues PF. *Visión 2050: Estrategias para alinear el transporte mundial por carretera con temperaturas muy por debajo de los 2 °C*. 2023.

Mbpd, roughly the forecasted jet fuel demand for 2050 (18 Mbpd). Thus, this strategy provides an opportunity to keep the carbon budget in check while developing biofuel production capacity for hard-to-electrify sectors.

d. Challenges and Opportunities

Despite the promising outlook, the widespread adoption of biofuels faces several challenges. These include scaling up production to meet increasing demand, standardizing certification mechanisms to ensure environmental integrity, and harmonizing policies across different regions and sectors. Variations in regulatory frameworks and certification standards pose barriers to biofuel trade and investment, necessitating international cooperation and alignment. However, these challenges also present opportunities for innovation and collaboration. Biofuels not only provide immediate GHG reduction benefits but also serve as a bridge to more advanced renewable energy solutions. By leveraging existing infrastructure and vehicle fleets, biofuels facilitate a smoother transition towards electrification while minimizing the environmental footprint associated with premature vehicle retirements. In conclusion, biofuels emerge as a crucial component in global efforts to decarbonize the transportation sector. Their scalability, compatibility with existing infrastructure, and potential for substantial GHG emissions reductions make them indispensable in the energy transitions. By expanding biofuel production, policymakers can accelerate progress towards international climate goals while promoting energy security and economic development globally.

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