The role of biofuels and the Global Biofuels Alliance in the global energy transition

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Abstract

The world faces an urgent need to transition to renewable energy sources, and bioenergy—energy derived from organic materials—plays a critical role in the clean energy transition. This paper provides an overview of the key data and the scientific advancements driving the global biofuel market, as well as the rationale behind the 2023 launch of the Global Biofuels Alliance (GBA). It explores the regulatory challenges and investment incentives needed to align biofuels markets, industries, and firms, with particular emphasis on the Global South. The paper also summarizes the history and projected demand growth for biofuels, featuring a case study on Brazil's biofuels sector that offers valuable lessons for other Global South producers and consumers. Conclusions highlight the challenges faced by the GBA and potential solutions to accelerate decarbonization through enlightened multilateralism and global cooperation.

Keywords: energy transition, bioenergy, regulation, sustainability, climate change, global cooperation

Subject classification codes: B52, G18, H41, O13, Q42, Q54, Q55

Introduction

Climate change presents an existential challenge for humanity. The Earth's average temperature is rapidly warming as rising levels of carbon dioxide (CO_2) and other greenhouse gasses (GHGs) trap the sun's infrared radiation within the atmosphere. The primary anthropogenic sources of GHGs are the burning of fossil fuels, deforestation, land use changes (such as urbanization and converting grasslands for agriculture), and certain industrial and mining practices. Among these, fossil fuel use contributes up to 85% of emissions from energy use, highlighting the urgent need to phase out fossil fuels and accelerate the transition to renewable energy sources, including biofuels—renewable fuels derived from organic materials such as plants and agricultural wastes[1].

Even though biofuels are not a focus of energy markets at present, increasing global production and consumption has to be an important part of the clean energy transition. For example, biofuels for passenger vehicles reduce GHGs by 75%, compared to the equivalent energy produced from fossil fuels[2]. Biofuels are an affordable pathway to sustainable energy consumption and also providing additional benefits, such as income generation and employment creation. This paper summarizes the history of the use of biofuels as a source of clean energy and the key data and scientific advancements that drive projected demand in the global biofuels market. It highlights the regulatory challenges and investment incentives required to align markets, industries, and firms, with a specific focus on low- and middle-income countries (LMICs) in the Global South. A case study on the bioenergy sector in Brazil, a global bellwether for biofuels, describes lessons for other Global South producers and consumers. Conclusions highlight challenges and potential solutions to accomplish the Global Biofuels Alliance (GBA)'s mission to accelerate decarbonization through increased use of biofuels and the importance of global cooperation, rather than competition and conflict, in accelerating the clean energy transition.

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[1] Source: International Energy Agency, *Greenhouse Gas Emissions from Energy Data Explorer.* Accessed at: https://www.iea.org/data-and-statistics/data-tools/greenhouse-gas-emissions-from-energy-data-explorer?utm_

[2] IEA (2024)

The role of biofuels in the energy transition

Biofuels are a form of bioenergy, which is a broader category that also includes solid biomass, used widely for cooking and heating in developing countries. Emerging "modern solid bioenergy" technologies are now being developed to generate electricity and heat, as well as to power hard-to-abate industrial production, such as steel and cement. This discussion here focuses on "modern liquid bioenergy" and "modern gaseous bioenergy," which are primarily used in transportation systems.

The growing use of biofuels in the transportation sector can be viewed alongside the global push toward electrification (e.g., electric vehicles), both of which play an important role in the global energy transition. The type of broad electrification of transport systems currently favored in higher-income countries is not a practical approach for most LMICs due to the expensive infrastructure requirements (e.g., networks of charging stations, enhanced electrical grids, needed adaptations to public transit), challenges in securing electric vehicle batteries, and the complex supply chain of the critical minerals needed to produce these batteries.

By contrast, biofuels can provide realistic, affordable, and carbon-efficient pathways to decarbonization within the transport system, and in other sectors, such as heat and power. When measured on a lifecycle GHG basis, the most common biofuels, including ethanol derived from sugarcane or corn and biodiesel, produce less harmful emissions than the equivalent use of fossil fuels. In South American countries, switching heavy vehicles to biodiesel could reduce GHG emissions by up to 78%, while using ethanol in passenger vehicles instead of gasoline could cut emissions by 80% to 85%[3]. Projections indicate that comparable reductions in GHG emissions are possible in India, Indonesia, South Africa, and other countries where transport is heavily

[3] Irena (2023).

reliant on fossil fuels and electrical grids on coal. Biofuels offer additional advantages as a substitute for fossil fuels. Liquid biofuels can be used as "drop-in" alternatives for fossil fuels, as their use is compatible with much of the existing infrastructure used for petroleum and natural gas. Moreover, biofuels are produced from raw materials, which are broadly available in countries around the world.

As shown in Table 1, biofuels can be produced from a variety of sources, including biomass, plant and animal waste, and agricultural and forest residues. While some biofuels, such as ethanol produced from corn or sugarcane, are well known, biofuel technology is evolving quickly beyond these "first generation" biofuels into a broad range of "advanced" biofuels.

Table 1. Types of biofuels and their production

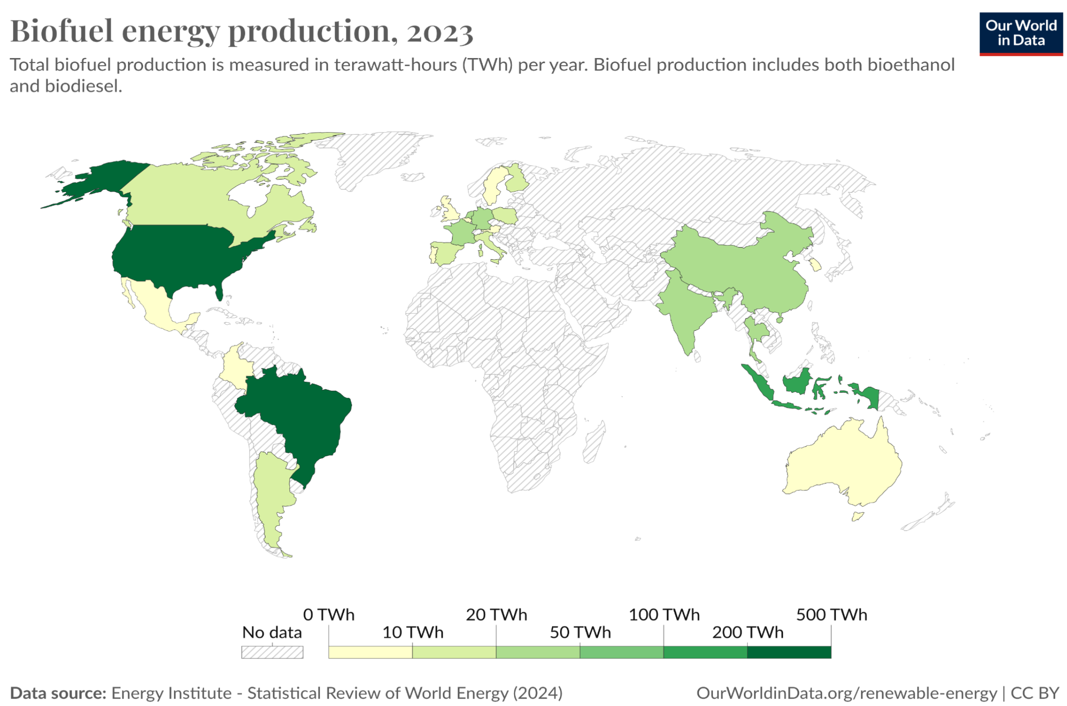
Biofuels	**Production Pathways**	**1st Generation Feedstocks** (from food crops)	**2nd Generation Feedstocks** (from non-food crops)
Traditional Biofuels			
Ethanol	Distillation of sugars, starches, and cellulosic biomass	Sugarcane, corn, wheat, beets	Agricultural residue, switchgrass
Biodiesel	Processing of vegetable oils and other lipids	Soybean, rapeseed, or palm oils	Animal fats, used cooking oils (UCOs), non-edible oils
Advanced Biofuels			
Renewable Diesel (HVO)	Hydrotreatment of vegetable oils and other lipids	Soybean, palm, and rapeseed oils	Animal fats, non-edible oils, agricultural and forest residues, municipal solid waste (MSW)
Sustainable Airline Fuel (SAF)	Hydrotreatment of vegetable oils and other lipids or alcohol-to-jet conversion	Soybean, palm, and rapeseed oils or ethanol (1G)	Animal fats, non-edible oils, agricultural and forest residues or ethanol (2G)
Renewable Natural Gas (biomethane)	Upgraded from biogas, byproduct of anaerobic digestion of waste/residues	Maize and grass silage	Agricultural residues, Animal fats, UCOs, MSW

Source: Adapted from Boston Consulting Group (2024), page 66.

While raw materials for biofuels production are widely available, only a small number of countries/regions currently account for 88% of biofuel production (Figure 1), including the

United States, Brazil, Europe, India, and Indonesia. A large proportion of this biofuel production is consumed domestically, rather than being exported. Currently, African countries are virtually absent from the biofuels market, accounting for less than 1% of global production and consumption. While the current producers are generally expanding their production, for biofuels to play a more significant role in the clean energy transition, both demand and supply need to accelerate. This highlights the role of the Global Biofuels Alliance.

Figure 1. Map of global biofuels production, 2023



The Global Biofuels Alliance: Leading the global charge?

The presidency of the G20 has recently been held by its Global South members on a rotating basis, including Brazil, India, and South Africa, bringing more focus to issues affecting LMICs. In 2023, during India's G20 Presidency, Prime Minister Narendra Modi launched the GBA, an initiative aimed at developing biofuels as a green pathway for the global energy transition, creating jobs, and spurring economic growth[4]. Since its inception, the GBA has expanded to include 22 member countries and 12 international organizations that come together on a voluntary basis as a multilateral, multi-stakeholder alliance.

The GBA's mandate is to increase both the demand for and supply of biofuels, aligning with the most widely accepted pathway toward achieving Net Zero Emissions (NZE) by 2050. The most authoritative NZE by 2050 pathway is provided and regularly updated by the International Energy Agency (IEA) in Paris. This pathway uses advanced modeling to estimate the emission reductions required to limit global temperature rise to no more than 1.5 degrees Celsius[5] and sets intermediate targets for 2030. Targets for the expansion of all types of bioenergy, including both solid and liquid biofuels, as a part of total energy supply are ambitious, with the goal to increase from 6% in 2024 to 13% in 2030, and to 18% in 2050[6].

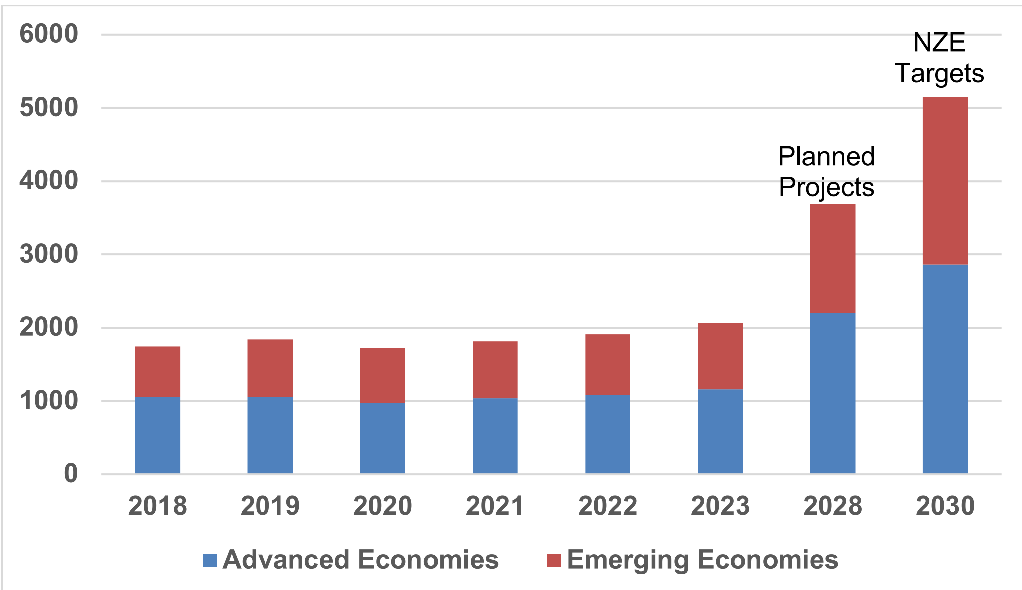
An expanded market for liquid biofuels is a critically important building block to achieve these goals. Hence, the IEA's most recent warning in 2024 is cause for concern: "Global liquid biofuel production is not currently on track to deliver what is required by 2030 in the NZE Scenario, based on current market trends and policies"[7]. In fact, production is far off track. Over the last five years, global output has only increased by approximately 4% per year (Figure 1), when it needs to increase by 13% per year to meet the 2030 targets in the NZE Scenario, this would require a doubling of current output over the next five years.

Figure 2 outlines the challenge and highlights the pivotal role that emerging market and developing economies must play to meet it. The conclusion is that liquid biofuel production in both advanced and emerging economies will more than double by 2030, compared to current

[4] G20 New Delhi Leaders Declaration. (2023)
[5] See: International Energy Agency: *World Energy Outlook 2024*
[6] *International Energy Agency*. 2024. Making the NZE Scenario a Reality.
[7] *Ibid.*, p. 144.

levels. Existing and planned projects, if implemented, would account for about 50% of the projected increase. The IEA estimates that new biofuel production facilities take two to three years to build, making the projected increase plausible[8]. This increase would have an important impact, raising the share of biofuels used in global road transport from 5% at present to 11% by 2030, and in shipping and aviation, from 0% to 8% by 2030

Figure 2. Liquid biofuel production by economic grouping in the NZE scenario, 2018-2030 (in thousands of barrels of oil equivalent)



The main challenge for the GBA is to create a global market for biofuels with more producers and consumers, moving away from the disconnected regional and national markets that are the current reality. This will necessitate the promotion of policies on both the demand side, through legislation and policy mandates, and the supply side, through assuring that increased supply is sustainable. As outlined in the 2023 New Delhi Declaration, the GBA exists to foster global collaboration in four main areas: (1) facilitating technological advancements, (2) strengthening national bioenergy laws and regulations, (3) promoting sustainable biofuel

[8] *Ibid.*

production through globally accepted certification standards, and (4) spurring international collaboration and knowledge exchange to adapt production to local conditions. Together, the GBA's efforts aim to support and guide the implementation of strategies that drive both the demand for and supply of sustainable biofuels.

Stimulating growth in the biofuels industry: Demand and supply side measures

Is a larger and more global biofuels market within the realm of the possible? There are several growth-supportive factors on the demand side that would support an expanded market. For example, 58 countries already have legislated ethanol mandates, that is blending of ethanol with gasoline, and an additional 48 have biodiesel mandates, that is adding ethanol to diesel fuel. However, these measures need to be strengthened.

As the leading biofuels producers are also the leading consumers, policies in each of these high-producer countries and regions should be replicated in countries with emerging biofuels industries. These have generally included strengthened fuel mandates, including blending requirements, stricter GHG emissions requirements economywide, and augmented direct investment subsidies.

Some biofuels market leaders are implementing new policies. In 2023, the European Union (EU), for example, implemented an energy directive that required member countries to achieve a 29% share of renewable fuels in transportation and/or a 14% reduction in GHG emissions by 2030[9]. India raised the blending mandate for ethanol in gasoline from 4% in 2019 to 11% in 2022. In 2024, Brazil signed a new biofuels law, known as *Fuel of the Future*, discussed below, which also raised blending rates for gasoline and diesel and sets targets for

[9] European Commission (2023). Accessed at: https://energy.ec.europa.eu/topics/renewable-energy/bioenergy/biofuels_en?utm. .

shipping and aviation. Meanwhile, the U.S. has enacted a series of recent measures, including via the Inflation Reduction Act of 2022, to increase domestic production of biofuels.

When considering the supply side, the major obstacle has been limited availability of sustainable feedstocks. This challenge may be addressed by advances in second generation feedstocks, which are produced from forest residues and agricultural wastes and therefore do not compete for land used to grow food. Other means to address this supply-side restriction include deploying new technologies to enhance land productivity and improving the efficiency of waste and residue collection.

Case study on Brazil: A bellwether for bioenergy in global south

Endowed with a highly productive agricultural sector, Brazil is the world's second largest biofuels producer and the largest in the Global South. Biofuels, mainly derived from first generation ethanol and biodiesel, supply more than 22% of annual transportation energy demand. Nearly 90% of passenger vehicles in Brazil are "flex-fuel," meaning their engines can run on ethanol, gasoline, or a mixture of both, depending on market pricing. Brazil's bioenergy experience provides an example of how the GBA could fulfill its mission of promoting biofuels as a critical component of the energy transition in the Global South.

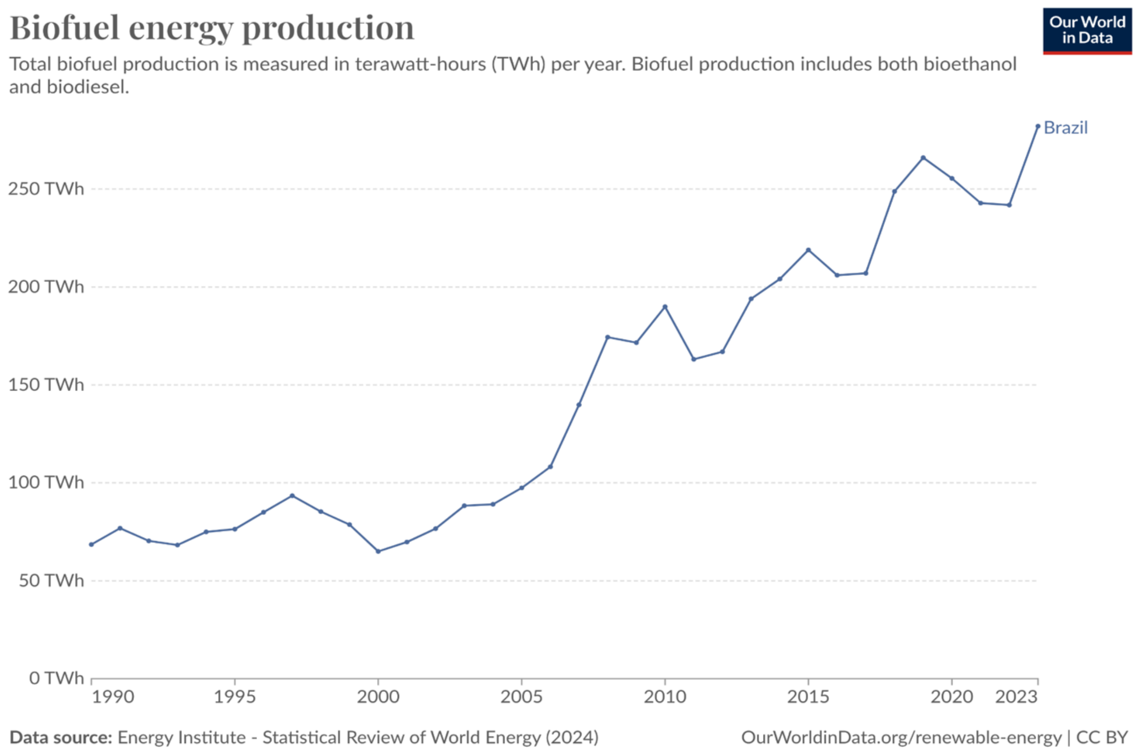
History and Evolution of Biofuels in Brazil

Rooted in a 500-year tradition of sugarcane cultivation, Brazil's bioenergy leadership traces back to the global oil shocks of the 1970s that threatened its imported oil-dependent economy. Since this time, various Brazilian political administrations came to embrace biofuels as a key component of the country's long-term energy security strategy. Public policy to expand biofuel production and demand has included government research and extension funding, fuel mandates, financial incentives, vehicle engine requirements, sustainability standards, and trading of carbon credits. (Figueiredo 2024).

However, as shown in Figure 3, Brazil’s rise to leadership in biofuels and biofuels diplomacy was far from a smooth, linear process. Over more than 50 years, critical government programs faced interruptions due to various fiscal and political crises, as well as shifting government energy priorities. As the State’s role shrunk through the late 1990s, the ethanol industry in Brazil seemed on the brink of collapse, evidenced by near cessation of ethanol-powered automotive engine production and the decline of the biofuels industry.

The early 2000s saw a resurgence in Brazil’s biofuels industry, largely stimulated by private sector initiatives rather than government subsidies, along with advancements in agricultural research and extension that promoted sustainable sugarcane cultivation. Over the decades to follow, Brazil succeeded in consolidating the legal, regulatory, and technological foundations for a modern biofuels industry, one that has national reach and that has gained significant experience in the global biofuels market.

Figure 3. Biofuel energy production in Brazil, 1990-2023[10]



Throughout this period of rapid biofuel growth, Brazil has promoted international collaboration through "biofuel diplomacy," with an emphasis on finding new markets for its ethanol and biodiesel, while also fostering South-South cooperation, a particular goal of then President Luis Inácio (Lula) Da Silva. In the mid-2000s, the government's foreign economic policy encouraged the production of biofuels in Mozambique, Senegal, and Angola, although these early diplomatic efforts and pilot industrial ventures failed and were eventually abandoned. More recently, and with somewhat more success, Brazil has encouraged a regional biomass market with Argentina and Colombia, both countries characterized by suitable climate

[10] Source: Our World in Data. (2024). Accessed at: https://ourworldindata.org/grapher/biofuel-production?tab=table

conditions, advanced agricultural sectors, and available water and land necessary for biofuels production.

Lessons from Brazil

Several institutional foundations led to Brazil's successful rise to global biofuels leadership that can inform the GBA's efforts to assist other countries in their own biofuel expansion.

(1) A sound legal and regulatory framework. Brazil's comprehensive national biofuels policy, known as *Renovabio*, was enacted in 2017, and aligned with Brazil's Nationally Determined Contribution (NDC) to cut GHG emissions under the Paris Agreement[11]. Its main purpose was to decarbonize Brazil's transportation sector by promoting the production and use of biofuels. Since its enactment, *Renovabio* has been used to set annual national targets to reduce carbon intensity, which are then translated into mandates for fossil fuel distributors based on their market shares. Failure to adhere to the mandate results in significant financial penalties.

A particularly innovative aspect of this legislation was the creation of a market-based system through which biofuel producers can generate decarbonization credits, known as *Créditos de Descarbonização* (CBIOs), calculated based on careful measurement of the carbon intensity of their production processes. While still relatively new, the CBIO market is growing with the potential to generate an increasingly important source of revenue for biofuel producers and investors in Brazil. Listed on Brazil's main stock exchange, CBIOs are available for purchase by investment funds, individuals, fossil fuel distributors, and companies seeking quality carbon offset instruments[12].

[11] For more on *Renovabio,* see: Gilio, Seabra Santos, *et al.* (2018).
[12] Rodrigues and Gilio. (2022).

Additionally, Brazil advanced its bioenergy legislation by introducing its *Fuel of the Future* program in 2017, which was signed into law in 2024[13]. This initiative established a foundation for government policy and private investment in advanced biofuels, including biogas, biomethane, green diesel, and SAF, among other emerging technologies.

(2) Support to advance technology. From the earliest days of its entrance into biofuels, Brazilian government support for research and innovation has been a key growth factor, particularly through support for the government's main research and extension agency, known as EMBRAPA[14]. Investments and innovation have improved feedstock productivity without deforestation. Sugarcane yields are two and, in some cases, three times global averages and intercropping has led to production of sugarcane and corn on the same land with increased productivity[15].

Marginal land is being recovered to increase sugarcane production and new methods, including improved fermentation processes and recycling of bagasse, the fibrous residue remaining after sugar is extracted from cane, are being implemented to produce feedstocks from agricultural waste and residues. Brazil has more than 100 million hectares of degraded pastureland, 40% of which can potentially be used for agricultural purposes, including growing feedstocks for biofuels. Hence, Brazil's ability to increase biofuel production using existing technology is significant. According to the IEA, for example, sustainable ethanol production in Brazil can expand by 55% and biodiesel by 85%, by 2030[16].

(3) Creation of sustainability standards and certification. Brazil gradually put into place tighter standards to reduce emissions from deforestation and agricultural land use. The

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[14] *Empresa Brasileira de Pesquisa Agropecuaria..*
[15] Gilio, Borges, et al. (2024).
[16] IEA, "Biofuel Policy in Brazil, India, and the United States. 2023.

Renovabio legislation created an innovative certification system for biofuel producers to assure that production of bioenergy meets, or exceeds, energy and carbon efficiency standards. An updated measurement system considers a lifecycle approach, whereby emissions are calculated from the initial extraction of raw material to the final fuel combustion.

(4) Promotion of cross-learning. One of the obstacles to broader adoption of biofuels use has been the lack of globally accepted sustainability standards, as evident in the recurring controversy of "food for fuel"—that the land needed for food security will be diverted instead for biofuel production. Brazil participates in international bioenergy forums, including those organized under the IEA, that promote sustainable biofuel use standards and advocate for broad international acceptance, while accounting for local conditions in new producer countries. Brazil is a member of the mandate-granting institutions being established to certify advanced biofuels, including the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) for SAF.[17]

Brazil's experience and leadership in sustainable bioenergy production demonstrate how the challenges of stimulating biofuels demand and increasing sustainable production can be overcome. Of course, adaptations are necessary to meet unique circumstances in other countries. For example, biofuel production is dependent on natural resource endowments, credibility of the legal and regulatory environment, the dynamics of domestic politics, and changing government energy priorities. Technologies that are effective in Brazil may not easily transfer to other countries, nor do Brazilian biofuel firms have the financial capital to stimulate production and consumption in the Global South. While Brazil's ability to stimulate a global biofuels market is limited, it can still make valuable contributions to the greater global collaboration needed. This,

[17] Another is the Biofuture Platform Initiative: https://biofutureplatform.org/

in turn, highlights the critical role of the GBA in providing leadership to advance global biofuels collaboration.

Conclusions: The GBA and the need for international cooperation in biofuels

At present, biofuels are not a major focus in global energy markets, with rare exceptions such as in Brazil and India. A re-examination of biofuels is warranted as the planet inexorably continues to warm and as feasible solutions for the Global South are needed. With just four national/regional markets currently accounting for more than 87% of biofuel production, new markets are needed if we are to meet, or even approach, the IEA NZE targets for 2030. A broad swath of countries across the Global South, including some of the nations that have joined the GBA, are in regions characterized by high sun exposure and the potential to harvest biofuel feedstocks two to three times annually, as opposed to a single annual harvest that is the case in more temperate zones. This means that many countries in the Global South can potentially grow feedstocks quickly to supply their own biofuel needs and potentially export surpluses to a global market.

Finally, growth of the biofuels market can serve as a model of enlightened multilateralism for the twenty-first century. New biofuel producer countries lack a concerted international effort to help them to overcome institutional obstacles so that firms, markets, and industries can develop and grow. The GBA can play this critical, catalyzing role by promoting global dialogue and collaboration on, for example, national bioenergy legislation. In addition to collaborating with the many international fora that already exist to promote bioenergy worldwide, the GBA could be instrumental in identifying and channeling the international financial resources that many countries, firms, and industries will need to participate in the biofuels market in the future.

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