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Kickstarting a global, advanced bioeconomy

Creating the Biofuture: A Report on the State of the Low Carbon Bioeconomy

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DISCLAIMER:

This report was prepared in collaboration with Biofuture Platform and Mission Innovation's Sustainable Biofuels Innovation Challenge national focal points, as well as selected experts. Considerations, opinions, conclusions and recommendations expressed in this report do not necessarily represent a consensus among consulted experts on any given point. Although the information presented is the best available to the authors at the time, Biofuture Platform and its collaborators cannot be held liable for its accuracy and correctness. Although ample opportunity for review and suggestions was given to all countries, and best efforts were made to reflect all inputs with respect to the reported findings and facts, recommendations and conclusions in this report do not necessarily reflect the views of the consulted countries and the European Commission.

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FOREWORD: ABOUT THIS REPORT AND KEY DEFINITIONS

Nature of this report

The report on *Creating the BIofuture* is part of the original mandate and work plan of the Biofuture Platform. The intention is to offer a comprehensive "birds-eye view" of the state of the low carbon bioeconomy and the policies being implemented to advance it.

It is hoped that the report will help enhance policy debate among the Platform countries and partners, define priorities, make policy and investment gaps more visible as opportunities to spur change, and inform next steps for the Platform.

The report shows how different nations, facing different objective circumstances, are dealing with the emerging advanced bioeconomy. It also assesses what could change to scale-up a sustainable low carbon bioeconomy. It relies on four main sources of information:

I. the collection of publicly available information, databases, and literature;
II. data and information shared by participating agencies and other actors;
III. country responses to the online survey; and
IV. follow up interviews with country experts.

Several steps have led to the present report. In the context of a joint activity with the Mission Innovation Sustainable Biofuels Innovation Challenge (SBIC/MI), assisted by a working group of the Biofuture Platform and SBIC/MI members and international agencies, a draft survey model was designed. The model was refined and implemented with the use of an online survey tool, supported by the Brazilian Energy Research Office (EPE) and the Center for Strategic Studies (CGEE), a Brazilian think tank affiliated to the UNFCCC. The survey was then distributed to designated focal points in the Biofuture Platform and SBIC/MI countries, and 19 out of 22 countries plus the European Commission responded.

The survey´s result fed into a draft report,commissioned by the Brazilian government — in its role as the Biofuture Platform interim Facilitator — through the Brazilian Trade and Investment Promotion Agency (Apex-Brasil), in partnership with the Ministry of Foreign Affairs (MRE). Once prepared by the Carbon Trust and the WayCarbon consultancies, the report was twice submitted for international expert review by the Biofuture Platform and SBIC/MI member countries and partner agencies, such as the IEA, IRENA, and FAO, as well as further revised by the interim facilitation team.

In this sense, while this report does not represent a consensus view of BfP members it is a best effort reflection of how different member countries see themselves in the low carbon bioeconomy going forward. Its conclusions and recommendations on how to address the identified barriers to scaling-up a low carbon bioeconomy are not necessarily endorsed by all countries and consulted experts, but rather represent a technical independent view based on the country-supported diagnosis and literature.

A brief note on definitions

As befits an international report on a relatively new and fast evolving sector, this work employs some key terms that do not yet find a universally accepted definition. Two of them merit a specific note: the "low carbon bioeconomy" and "advanced biofuels".

The low carbon bioeconomy

Bioeconomy, a term that has only recently received wide attention and use, can be defined in a number of different ways. The broadest one, and the most literal, is to equate it to all economic activity that involves a biologic feedstock, including the entirety of the traditional and already established food, feed, and pharma sectors. Such an all-encompassing definition is simply not useful for the purposes of this report, which purports to focus on the more recent developments that, with the help of technology, uncover the potential of renewable, low carbon, bio-based alternatives to fossil-based sources.

Therefore, the concept of bioeconomy employed by the Biofuture Platform, according to the Vision Declaration endorsed by 19 Member Countries in the UNFCCC COP23 (Biofuture Platform, 2017a), is defined as a set of economic activities related to the invention, development, production and use of biological products and/or processes for the production of renewable energy, materials and chemicals. This definition is closer to the one used by the OECD, although more focused, according to which the bioeconomy must involve biotechnological knowledge, renewable biomass, and integration across applications (OECD, 2009).

In this sense, the Biofuture Platform intends to promote an advanced bioeconomy, conceived as low carbon, bio-based alternatives to fossil sources derived either from innovative feedstocks and/or from novel technologies and conversion processes, constituting the outputs from biorefineries (biofuels and non-energy bioproducts). This bioeconomy must necessarily be based on sustainable practices, to ensure unequivocal carbon savings and avoid detrimental environmental, social and economic impacts.

Advanced biofuels

Biofuels can be classified as either "conventional" or "advanced" according to different approaches, taking into account criteria such as the feedstock used, the type of technology employed (and its readiness level), and/or its environmental performance in terms of GHG emissions reduction, including potential impact on the sustainability of ecosystems, such as those derived from an assumed Indirect Land Use Change (ILUC). It should be noted that the definition of advanced biofuels is not universally agreed; for example, while the USA defines advanced biofuels mainly on the basis of their assessed GHG-mitigation performance, the EU favors technology and feedstock-type factors. Some argue that binary or artificial classifications of biofuels should be discarded in policymaking in favor of direct environmental performance assessment and GHG emissions mitigation potential of pathways. Regardless, the distinction remains important for discussing markets and technological development.

In this report, conventional biofuels - also known as first-generation (1G) biofuels - are defined as biofuels converted from either agricultural food or feed crops or from lipids and residues, using technologies and conversion routes that are well established and fully available at commercial scale.

Advanced biofuels are derived from lignocellulosic feedstocks, non-food crops/dedicated crops and industrial waste and residue streams - second-generation (2G) biofuels -, as well as from algae - third-generation (3G) biofuels -, using novel technologies that may not be well established at full commercial scale in an operational and competitive environment yet. Furthermore, ethanol can be upgraded to produce biojet fuel, sometimes as a mix of 1G (sugar or starch crops) and 2G feedstocks, and therefore, in this case, can be considered an advanced biofuel.

EXECUTIVE SUMMARY

The Biofuture Platform (BfP) was launched in Marrakesh during the 22nd Conference of the Parties (COP22) to the United Nations Framework Convention on Climate Change (UNFCCC), as a joint commitment from twenty countries to increase the use of sustainable biomass as feedstock for the production of energy, chemicals and materials. The platform is a government-led, multi-stakeholder initiative designed to promote international coordination on advanced low carbon fuels and bioeconomy development, and to provide a forum to support this collaborative effort. Underlying the BfP commitment is the acknowledgement that an increased penetration of biomass in the energy and material sectors is a linchpin to enable the achievement of the goal set-out in the Paris Agreement of limiting the increase in global average temperature to well below 2°C above preindustrial levels.

This report presents an assessment of the state-of-play of two key bioeconomy sectors - biofuels and non-energetic bioproducts[1] - within the BfP member countries and selected countries/regions from the Sustainable Biofuel Innovation Challenge from Mission Innovation (SBIC/MI), whose members provided relevant inputs as part of the activities of this international initiative. Its goal is to provide a picture of the departing point for the BfP, serving as a reference to where member and non-member countries stand, a sense of scale for the challenge ahead, along with the barriers facing countries. The report also delves into solutions to such barriers, providing an indication on where and how countries could collaborate to achieve common goals using tangible examples where possible.

Current status of the bioeconomy and the challenge ahead

The bioeconomy plays an essential role in the low carbon development scenarios in tandem with a range of complementary mitigation efforts across all these sectors. The International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA) indicate that the shares of bioenergy and biofuels must increase substantially over the next three decades to meet the world's growing energy demands in line with long-term climate goals. Within the materials sectors, the world will face unprecedented growth in demand for materials, driven by the rapid industrialization of emerging economies and continued high levels of material consumption in developed countries.

Some 131 billion liters of biofuels are produced annually around the world, generating ~USD 170 billion/year (Zion Market Research, 2017), primarily from 1G ethanol and biodiesel. 1G biofuels are on course to meet the IEA's 2°C scenario (2DS)[2] targets for 2025, but major support will

1 Bioproducts can replace a range of fossil-based products that are routinely used across all economic sectors.

2 The 2DS is the main focus of the International Energy Agency's annual publication: Energy Technology Perspectives (IEA, 2018). The scenario lays out an energy system pathway and a CO2 emissions trajectory consistent with at least a 50% chance of limiting the average global temperature increase to 2°C by 2100 (IEA, 2017a). Annual energy sector emissions are reduced by 70%

be required to put 2G and 3G biofuels on course. Global investment in biofuels production has sharply declined in recent years due to a combination of factors, including low oil prices, political ambivalence towards biofuels in certain regions, and an unstable policy framework. Nevertheless, almost all countries in the BfP and SBIC/MI have targets to reduce GHG emissions, which can support low carbon biofuels going forward if translated into biofuel targets or market value for their carbon emissions reduction.

With respect to non-energetic bioproducts, most respondents and consulted experts did not have comprehensive, in-depth data regarding investments and developments. The scarcity of information may be a symptom of the fact that there is still much to be learned and much more policy attention should be devoted to this area for it to be developed *in tandem* with bioenergy, taking into account, in particular, the economic gains of combining fuels and valued-added bioproducts in biorefineries.

Production and consumption of biofuels and bioproducts

Patterns of biofuel production and consumption vary widely, depending on countries' economic and social structures, environmental policies, climate, land availability, food and wood supply chains and regulatory incentives. The USA (43.5%) and Brazil (22.5%) are responsible for 65.5% of the world's biofuel output, followed by the EU (16.7%) and China (2.5%) (BP Global, 2017). Consumption trends do not always follow production geographies; prominent net importers of biofuels include China, Canada and France.

Key feedstocks for global ethanol production are sugarcane, sugarbeet, corn and wheat. Key feedstocks for global biodiesel production are rapeseed, sunflower soybean, palm, animal fats and waste greases. Different feedstocks can result in widely different environmental, GHG-mitigation and energy-balance performance for ethanol and biodiesel, although there are no simple rules of thumb, performance being also strongly dependent on local context, agricultural policies and practices, supply-chain processes and conversion technology used.

Advanced, second-generation biofuels production is increasing within and beyond the BfP, although still largely concentrated in the USA and the EU. Countries' responses to the questionnaire totaled a number of 86 projects, from pilot to commercial facilities, in different implementation stages.

Barriers to growth

A range of barriers limits the development and deployment of biofuel and bioproduct markets. Central barriers are:

- Risk perception and availability of financial resources: Advanced biofuels and bioproduct projects have substantial costs and risks rendering investment decisions inherently difficult. Public funding is typically limited in its capacity to reach multiple projects and catalyse private investments. It should be noted that the availability and costs of financial resources is only a secondary barrier. The main financial barrier is related to high capital costs associated with investments in biofuel plants/biorefineries, as well as to the perceived risks associated with investments in the sector, which - at least partially - can be considered as consequences of the other identified barriers. In addition, perceived risks and high investment costs may hinder additional funding in RD&D necessary to tackle remaining technical challenges and scale-up production and use of advanced biofuels at full commercial scale.

from today's levels by 2060 with cumulative emissions of around 1,170 gigatons of CO_2 ($GtCO_2$) between 2015 and 2100 (including additional industrial process emissions). To stay within this range, CO_2 emissions from fuel combustion and industrial processes must continue to decline after 2060 and carbon neutrality in the energy system must be reached by 2100.

- Lack of competitiveness against fossil fuel-based alternatives without appropriate incentives: Biofuels and non-energetic bioproducts competitiveness against fossil fuels-based products is highly dependent on subsidies, incentives, or mandates. Biofuel blends are mandated in several countries, yet the balance remains in favor of fossil fuel alternatives. Fossil alternatives benefit from several decades of industrial maturing, lower production costs, and a number of subsidies worldwide.
- Unfavorable policy frameworks: The complex web of interconnected mandates, subsidies, tax incentives, grants or other instruments often work directly or indirectly against the bioeconomy, or in favor of competing new technologies. Due to the necessarily crosscutting nature of biofuels and non-energetic bioproducts policies, which concerns energy, environment and agriculture agendas, among others, the lack of or inadequate coordination among different governmental agencies and ministeries may also hinder the adoption of favorable policy frameworks.
- Limitations surrounding sustainable feedstock supplies: Feedstock supplies are often reported to be insufficient, expensive, or unreliable. There is is a great deal of questioning the ability to sustainably scale up feedstock (biomass), including concerns over indirect land use change. However, there is growing consensus on what constitutes sustainable best practices for biomass feedstock production and use. In other cases, the issue does not concern feedstock availability, being rather related to inadequate supply chain networks at required scales. Moreover, feedstock supply may be inconveniently located with respect to processing facilities, all of which affect the business case for advanced biofuel developments.

Support for innovation efforts towards the advanced bioeconomy must be substantially strengthened to achieve the goals laid out by the BfP. An overview of countries' existing support instruments for the bioeconomy reveals three main patterns. First, a lot more support is available for biofuels than bioproducts. Second, support is mostly focused on boosting demand through market pull instruments. Third, there is limited support on the supply side.

Conclusions and recommendations

To fulfill its role in low carbon development scenarios, the advanced bioeconomy will require an unprecedented effort in support instruments and suitable policies, as well as technology innovation and diversification to be set forth worldwide in tandem to complementary mitigation efforts such as vehicle electrification and other renewable energy technologies. Acknowledging the global and regional status of the advanced bioeconomy; the challenge posed by BfP's aspirational collective goals; barriers reported by countries; and drawing from the existing experience of policy support to the bioeconomy and to low carbon innovation more broadly, a set of seven recommendations is put forward to policymakers[3]:

1. To establish clear goals and identify technologies with potential to achieve such goals.
2. To map the local market for biofuels and bioproducts production technologies, the potential to develop this market, and technologies needed to fulfill national goals.
3. To understand the support needs for priority technologies and available policies to meet these needs.
4. To compare the costs and benefits of alternative policy support package options, by running scenarios of alternative policies to address barriers identified.

3 These reccomendations are put forward by the technical drafters of the present Report as a contribution to future policy debate and exchange among Biofuture member governments and other stakeholders.

5. To decide on a pathway forward involving the appropriate stakeholders and assigning ownership of activities.
6. To deploy a package of interventions in each country, supported by adequate public budgets, to address identified barriers holding back the advanced bioeconomy.
7. To collaborate with existing international initiatives, such as BfP, SBIC/MI and other initiatives, to identify common interests, advance agendas, share knowledge, engage stakeholders, and disseminate results, while enhancing communication and avoiding duplication of efforts.

1. INTRODUCTION: SCOPE, OBJECTIVE AND STRUCTURE

About the Biofuture Platform

The Biofuture Platform (BfP) was launched in Marrakesh, on November 16, 2016, during the 22nd Conference of the Parties (COP22) to the United Nations Framework Convention on Climate Change (UNFCCC), as a joint commitment from twenty countries[4] to increase the use of sustainable biomass as a feedstock for the production of energy, chemicals, and materials. The platform is a government-led, multi-stakeholder initiative designed to promote international coordination on low carbon biofuels and bioeconomy development and provide a forum to support this collaborative effort and monitor progress towards the achievement of the targets laid out below (Biofuture Platform, 2016). As such, it intends to:

- Promote international collaboration and dialogue between policy makers, industry, academia, and other stakeholders;
- Facilitate an enabling environment for advanced low carbon fuel and bioeconomy-related investments;
- Raise awareness and share analysis on the current status, potential, and advantages of low carbon biofuels and other advanced bioeconomy developments.
- Promote research and development and share analysis, policy practices and information on R&D activities and needs.
- Facilitate discussions on how to effectively evaluate, share and promote sustainable practices for bio-based value chains.

The Biofuture Platform also seeks to leverage existing international initiatives from institutions such as the Clean Energy Ministerial (CEM), the United Nations Food and Agriculture Organization (FAO), the Global Bioenergy Partnership (GBEP), IEA Bioenergy, the International Renewable Energy Agency (IRENA) and Mission Innovation (MI) and Sustainable Energy for All (SE4All), reinforcing its cooperative feature. In fact, twelve member countries[5] from the BfP are also part of MI, which aims to accelerate innovation in clean energy, including biofuels, through its 'Sustainable Biofuels Innovation Challenge' (SBIC).

Underlying the Biofuture Platform's commitment is the acknowledgement that an increased penetration of biomass in the energy and material sectors is a linchpin to enable the achievement of the goal set-out in the Paris Agreement - to limit the increase of the global average temperature to well below 2°C above preindustrial levels - justifying such efforts to advance an expanded bioeconomy. It is also recognized that the increased use of biomass as the basis for production can help avoid many

4 Argentina, Brazil, Canada, China, Denmark, Egypt, Finland, France, India, Indonesia, Italy, Morocco, Mozambique, Netherlands, Paraguay, Philippines, Sweden, United Kingdom, the United States and Uruguay.

5 Brazil, Canada, China, Finland, France, India, Indonesia, Italy, the Netherlands, Sweden, the United Kingdom and the United States.

other —non-climate— social and environmental impacts of fossil fuels and can contribute to the achievement of the SDGs.

Within the energy sector, assessments by the International Energy Agency (IEA) and the International Renewable Energy Agency (IRENA) demonstrate that sustainable bioenergy is an indispensable component to meet the world's growing heat, fuel and electricity demands in line with long-term climate goals (IEA, 2017a) & (IRENA, 2016a). In particular, bio-based alternatives can offset fossil fuels to meet heating needs in industrial, residential, and commercial sectors; to meet fuel demands in the freight, maritime, and air transport sectors; and to meet power generation needs in circumstances where sustainable feedstocks are available as alternatives to fossil-fuel power generation.

Within the materials sectors, the world is set for unprecedented growth in demand for raw materials, driven by the rapid industrialization of emerging economies and continued high levels of material consumption in developed countries. Meeting global materials demand sustainably will require great advances in resource efficiency and the substitution of carbon intensive materials for low carbon renewable alternatives, such as bioplastics, biomass-based construction materials, and natural fibre textiles, sourced adequately. The Vision Declaration, "Scaling up the low carbon bioeconomy: an urgent and vital challenge", endorsed in Bonn[6] by nineteen out of twenty BfP member countries, on November 16, 2017, during the UNFCCC COP23, envisages a world in which half of the chemicals and materials could be produced from renewable resources by 2050, with the necessary political and financial measures put into place (Biofuture Platform, 2017a).

6 All Biofuture Platform countries but the USA have endorsed the declaration. All twenty Biofuture Platform countries currently endorse the November 2016 Biofuture Launch Statement.

Acknowledging the challenges posed by the need to advance the bioeconomy globally, 19 countries composing the BfP are determined to lead the way forward by contributing, according to their own national circumstances, policies, targets, and points of departure, to the following aspirational, collective goals for 2030, as expressed in the declaration (Biofuture Platform, 2017b):

- Significantly increase the contribution of sustainable modern bioenergy to final energy demand.
- Significantly increase the share of sustainable, low carbon biofuels, including biogas, as a percentage of transport fuels (including sea and air transport).
- Progressively increase the average lifecycle carbon savings from biofuels production compared to fossil fuels.
- Spur bioeconomy innovation and the commercial advancement for the production of low carbon biofuels at scale so that they become broadly cost competitive with fossil fuels when the value of the carbon savings is taken into account.
- Significantly increase global investments in the sustainable low carbon bioeconomy, including on advanced, flexible biorefineries capable of producing energy and bio-based products.
- Multiply the expenditure by governments and industry on research and innovation in the bioeconomy.

Having established those goals, the Biofuture Vision Declaration then calls for the development of more specific targets; the preparation of an action plan to support the realization of such targets; and the development of a reporting mechanism to track progress over the coming years. The present "Creating the Biofuture" report will serve, along with other key national and international studies and publications on the topic, as a valuable input to the development of those steps.

Report scope and structure

This report assesses the state-of-play of two key bioeconomy sectors - biofuels and non-energy bioproducts -, encompassing a set of economic activities related to the invention, development, production and use of biological products and/or processes for the production of renewable energy, materials and chemicals. Each of these sectors involves the transformation of biomass feedstock to finished products through biorefineries.

The study had collaboration and inputs from Mission Innovation's Sustainable Biofuels Innovation Challenge (SBIC/MI). SBIC/MI members[7] include the European Commission, as well as some countries that are not members of of the Biofuture Platform, such as Mexico and Norway. SBIC/MI, not being policy-oriented, but rather a dialogue and cooperation initiative on sustainable biofuels RD&D, contributed to the survey and provided technical inputs. Therefore, information regarding SBIC/MI were also included in the report. BfP and SBIC/MI bioeconomies are assessed through literature review, countries' responses to a standard questionnaire, and interviews with selected country experts.

The remainder of this report is broken down into the following sections:

I. Section 4 lays out the challenge ahead of the BfP and presents the current status of the biofuel and bioproduct markets from a global and country/region perspective, including key country targets;
II. Section 5 provides detail into production and consumption figures for biofuels and bioproducts for countries and regions in individual country profiles, along with a comparison of feedstocks for biofuels, detail into existing advanced biofuel facilities;
III. Section 6 investigates the barriers limiting the advance of these markets, seeking to better understand and categorize such barriers as well as to observe their similarities and differences across countries;
IV. Section 7 discusses how support instruments can be utilized to overcome such barriers and looks into how countries have dealt with such barriers, classifying support mechanisms according to their format to provide a sense of which may be most suitable for different circumstances;
V. Section 8 provides concluding remarks gathering key take-away points from each of the sections above; and
VI. Section 9 provides objective recommendations for countries to overcome barriers and harness opportunities.

7 Announced on November 2015, Mission Innovation (http://mission-innovation.net) is a global initiative of 23 countries and the EU to dramatically accelerate global clean energy innovation. Its plan of work includes eight "Innovation Challenges", which are global calls to action aimed at accelerating research, development and demonstration (RD&D) in technology areas - one of them being focused on sustainabl biofuels (SBIC). SBIC members include Brazil, Canada, China, EC, Finland, France, India, Indonesia, Italy, Mexico, Norway, Sweden, The Netherlands, UK, and USA.

2. CURRENT STATUS OF THE BIOECONOMY AND THE CHALLENGE AHEAD

The role of the bioeconomy in a 2-degree world

Bio-based outputs are an indispensable component among the portfolio of low carbon technologies that need to be deployed in order to limit global warming to 2ºC.

Bioenergy and bioproducts can play a major role in the transition towards a low carbon economy and are an indispensable component within the portfolio of low carbon technologies that need to be deployed to limit global warming to 2º C. Bioenergy can provide low carbon alternatives to: multiple transport modalities complementing the role of electric vehicles; electricity generation complementing the role of other renewables and low carbon sources; and renewable heat generation within industries or buildings, again complementing other renewable or non-renewable heat sources. Bioproducts can be an alternative to a range of fossil-based products that are routinely utilized across all economic sectors. To do so, biofuels and bioproducts must be deployed sustainably, with economically sound business models that reduce greenhouse gas (GHG) life-cycle emissions while generating benefits for society. Different feedstocks can result in widely different environmental, GHG-mitigation and energy-balance performance for biofuels and bioproducts. There are, however, no simple rules of thumb, performance being also strongly dependent on local context, agricultural policies and practices, supply-chain processes and conversion technology used. There is, however, a growing consensus about the ability of a combination of best practices in agriculture and sourcing, conversion routes and final use to allow for sustainably scaling up the bioconomy based on a wide range of feedstocks (IEA Bioenergy; FAO; IRENA, 2017) (IRENA, 2017).

Unsurprisingly, bioenergy plays an essential role in the low carbon development scenarios of the IEA and IRENA. It will provide 17% cumulative carbon savings by 2060 in the IEA's 2ºC scenario (2DS) (IEA, 2017a) and further mitigation in optimistic scenarios in which biorefineries deploy Carbon Capture and Storage (CCS) to remove atmospheric carbon. Delivering deep greenhouse gases (GHG) emissions reductions will require a huge effort in bio-based technology innovation and diversification worldwide, presenting a daunting challenge. The IEA's 2DS estimates that bioenergy must double its participation in global final energy consumption between 2015 and 2030, from ~18 EJ to ~35 EJ. This includes an absolute threefold increase in the transport sector and two-fold in the industrial sector. Complementary mitigation efforts will be needed across these sectors, such as a major presence of electric vehicles in the transport sector combined with a growing share of renewable energy in generating the electricity they run on. A range of low carbon alternatives must be developed in each economic sector to realize long-term decarbonization objectives. By 2060, projections require even higher contributions of modern bioenergy, reaching ~71 EJ globally.

The scale of biofuels output projected in the 2DS will require a steep scaling-up in the production of advanced biofuels. By 2025, the IEA's 2DS estimates a ~222 billion liters[8] of biofuels global production need (IEA, 2017a). By 2050, (IRENA, 2017) estimates that 1,120 billion liters of biofuels would be required per year for countries to cost-effectively limit global warming to 2-degrees - as detailed below. In the case of bioenergy, the IEA states that it "has an essential and major role to play in a low carbon energy system (…) modern bioenergy in final global energy consumption should increase four-fold by 2060 in the IEA's 2°C scenario (2DS)," (IEA, 2017e). Similar projections for mitigation potential and deployment requirements are not available for the bioproducts market, although bio-based alternatives to fossil fuel-based chemicals and non-renewable materials are growing in number.

Overcoming remaining technical challenges is necessary to reduce perceived risks of advanced biofuels projects among stakeholders and pave the way to widespread commercial deployment.

Paving the way to such a scenario will be a challenging endeavor. Widespread commercial deployment of advanced biofuels will demand overcoming relevant remaining technical barriers (IEA, 2017b). Increased funding of R&D efforts is necessary to accelerate the development of innovative solutions to the unresolved technical issues, including, among others, feedstock handling and feedstock pre-treatment technologies. Addressing these challenges is of significant importance to reduce perceived risks of advanced biofuels projects among stakeholders and boost production and use. Encouraging signs to that effect have been appearing throughout 2017/18, with some of the "first-of-a-kind" commercial scale lignocellulosic biorefineries in Brazil and the US moving their production towards nominal capacity, after significant retooling and reengineering over the last three years.

Global markets

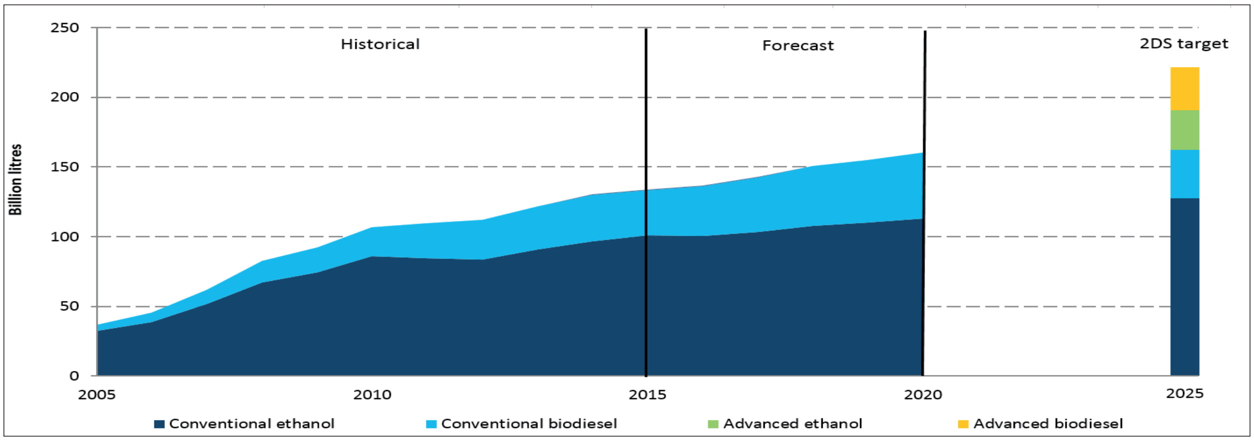
Approximately 131 billion liters of biofuels are produced annually around the world, representing a market worth ~USD 170 billion/year (Zion Market Research, 2017), primarily from first-generation ethanol and biodiesel. Whilst a number of estimates indicate significant growth perspectives for first and second generation biofuel markets, a daunting challenge lies ahead and major support will be required to push the global output of second generation biofuels to the level required to achieve 2DS emission mitigation targets.

Approximately 130 billion liters of 1G biofuels were produced in 2016 (of which 98 billion liters of 1G ethanol and 30 billion liters of biodiesel) primarily in the USA (47%) and Brazil (27%) (AFDC, 2017); (IRENA, 2016a); (GRFA, 2017a). Whilst a range of 2G conversion technologies exists, such as 2G ethanol, most of them are not yet fully commercial (HVO being a notable exception), yielding a modest global output of ~1 billion liters/year (IRENA, 2016a).

Figure 1 illustrates the global output of 1G and 2G biofuels up until 2015 along with a projection onto 2020 and the 2DS target for 2025. Whilst 1G biofuels are on course to meet the IEA's 2DS targets for 2025, a significant boost in the production of second and third generation biofuels will be required to meet such targets.

8 Including 128 billion liters of 1G ethanol; 35 billion liters of 1G biodiesel; 29 billion liters of 2G ethanol; and 31 billion liters of 2G biodiesel.

Figure 1. Global output of liquid biofuels, historic and projected

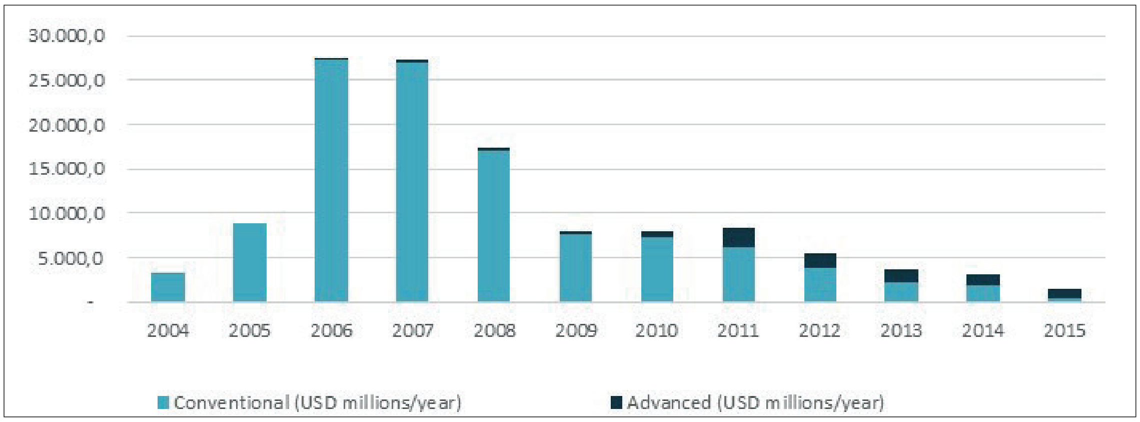


Source: Adapted from (IEA, 2017a).

Beyond 2025, IRENA's Renewable Energy Roadmaps (ReMap) scenario foresees that a global output of 500 billion liters of biofuels would be needed by 2030 (of which 124 billion liters in advanced biofuels) and 1,120 billion liters per year by 2050 to most cost-effectively contribute to the achievement of the Paris Agreement's goals (IRENA, 2017). That represents a four-fold and a nine-fold increase with the current market size as baseline by 2030 and 2050, respectively, and would require the deployment of 12,500 plants with average annual installed capacity of 40 million liters over the next 12 years.

However, the world has witnessed a decline in investments in the biofuel markets recently - illustrated in Figure 2 - chiefly due to low oil prices. Global investments in biofuels peaked at over USD 27 billion in 2006 and 2007 but declined to less than 2 billion by 2015. During 2013-2016, investments averaged around USD 1.7 billion, but declined to USD 0.25 billion in 2016 (IRENA, 2018a). New biofuel plants have financially struggled due to the prices of traditional fuels, forcing policy-makers to reflect on how to level the playing field between fossil fuels and biofuels.

Figure 2. Declining global investment in advanced and conventional biofuels



Source: (IRENA, 2016b). Notes: IRENA analysis based on Bloomberg New Energy Finance (2015), Global Trends in Clean Energy Investment.

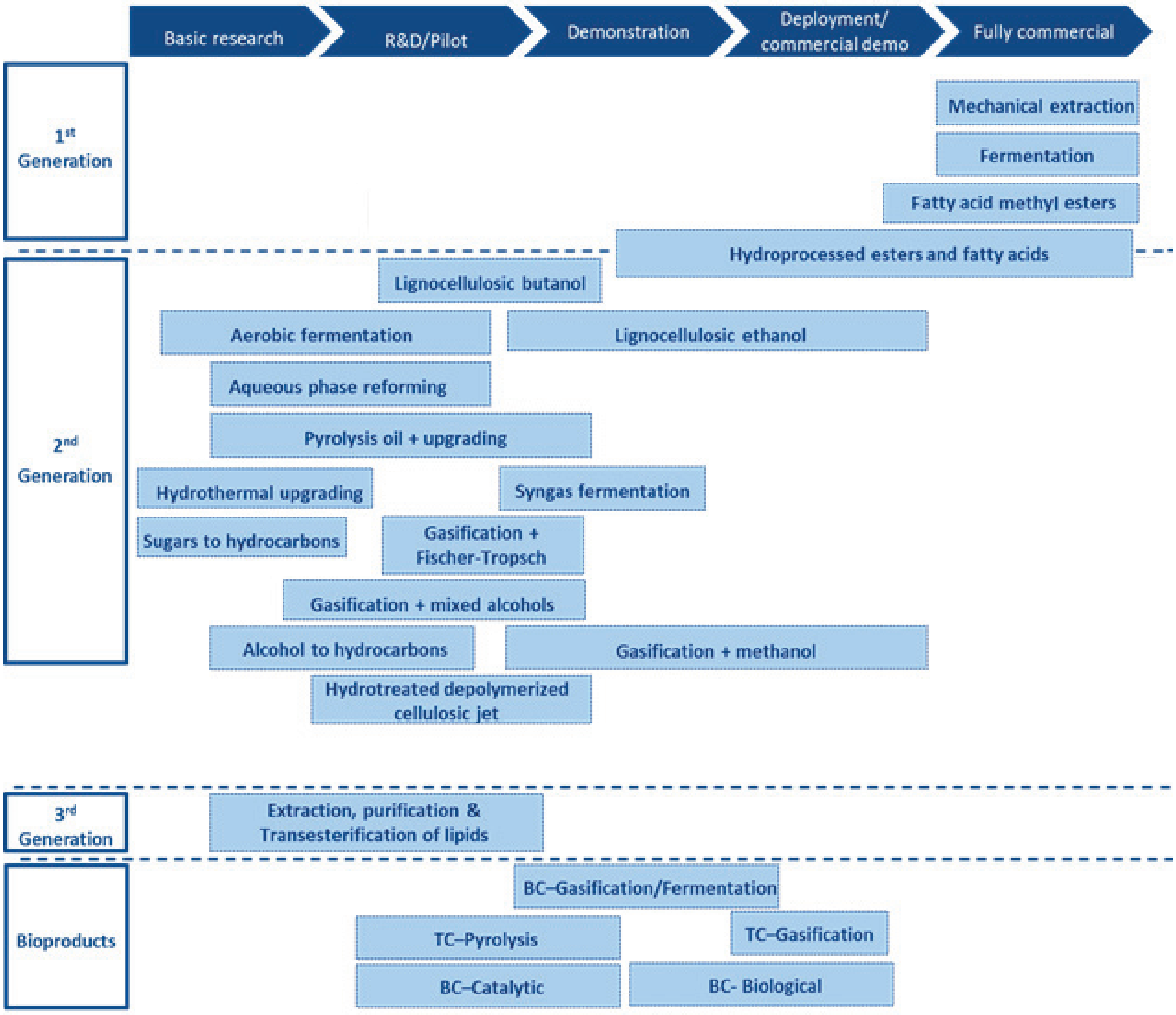
Bioproducts

On the non-energetic front of the bioeconomy, biorefineries are developing on the back of long-standing industries such as pulp and paper, chemical plants, starch processing and conventional biofuel processes, to the extent that bioproducts enhance business profitability. This is a fast-moving segment, worth USD 467 billion in 2016 (Research and markets, 2017) including chemicals and materials that can displace and complement fossil-derived products. As a relatively novel market, it requires significant investments and its products typically struggle to compete against fossil-based alternatives, that benefit from more than 100 years of learning curves and locked-in markets, technology and systems, a scenario that emphasizes the need for favorable regulatory environments, adequate finance and other mechanisms that level the playing field for bioproducts. Limited information is available on the potential for this market to contribute to climate goals or on its overall perspective. Most respondents and consulted experts did not have comprehensive, in-depth data regarding investments and developments. The scarcity of information may be a symptom of the fact that there is still much to be learned and much more policy attention should be devoted to this area if it is to be developed *in tandem* with bioenergy to flexibly combine fuels and valued-added bioproducts in biorefineries.

The global outlook for biofuels and bioproducts indicates that advanced biomass conversion routes are moving along the technology readiness journey towards commercialization, but remain well behind 1G routes. Figure 3 depicts the readiness level of key biofuel and bioproduct conversion technologies, ranging from early research and development (R&D) stages (e.g. direct sugars to hydrocarbons that produce alkane-type fuels without an alcohol intermediate) to commercially proven or near commercial technologies (e.g. sugarcane ethanol from fermentation and 2G lignocellulosic ethanol).

2G and 3G biofuel conversion routes lag behind and will require major support to be deployed at the scale needed to achieve 2DS targets.

Figure 3. Technology readiness levels (TRL) of biofuel and bioproduct conversion technologies



Source: Adapted from (Carbon Trust, 2012); (IEA Bioenergy Task 39, 2018); (IRENA, 2016b); and (Mawhood, Gazis, Jong, Hoefnagels, & Slade, 2016).
Note: This is a non-exhaustive list of technologies. TRL are defined as:
Basic Research: basic principles observed, technology concept formulated, experimental proof of concept;
R&D/Pilot: technology tested and validated in lab, technology validated in relevant environment;
Demonstration: technology demonstrated in relevant environment, system prototype demonstration operational;
Deployment/commercial demonstration: system complete and qualified;
Fully commercial: actual system proven in an operational and competitive environment.

Regional markets

Countrywide climate policy targets underline local bioeconomy markets and are presented in Table 1. Almost all BfP and SBIC/MI members have targets for GHG emissions reductions by 2030, and a few have longer-term targets. Several countries aim to reduce the emission intensity of their Gross Domestic Product (GDP), increase the share of renewables in their energy sector, or raise the share of bioproducts in their national industrial output.

Table 1. Key climate policy targets per country/region

Region / Country	Targets	Unit	Period
Africa			
Egypt			
Morocco	17-42%	Absolute GHG emission mitigation	2030
Mozambique	76.5% reduction	Absolute GHG emission mitigation	2020-2030
	between 31% and 50%	Share of bioproducts in national market	2030
Asia			
China	60-65% reduction	GDP emissions intensity	2005-2030
	20%	Share of non-fossil fuels in primary energy	2030
	13 billion	Liters of biofuel output	2020
India	33-35%	GDP emissions intensity	2005-2030
	40%	Share of non-fossil power installed capacity	2030
Indonesia	29%	Absolute GHG emission mitigation	Baseline vs. 2030
	between 11% and 30%	Share of bioproducts in national market	2030
Philippines	70%	Absolute GHG emission mitigation	Baseline vs. 2030
Europe			
Denmark	40%	Absolute GHG emission mitigation	1990-2030
EU	40%	Absolute GHG emission mitigation	1990-2030
Finland	40%	Absolute GHG emission mitigation	1990-2030
	30%	Share of transport biofuels	2030
	38%	Share of renewables in final energy consumption	2020
France	40%	Absolute GHG emission mitigation	1990-2030
	15%	Share of transport biofuels	2030
	32%	Share of renewables in final energy consumption	2030
Italy	40%	Absolute GHG emission mitigation	1990-2030
	between 5% and 10%	Share of bioproducts in national market	2030
Netherlands	49%	Absolute GHG emission mitigation	1990-2030
	between 11% and 30%	Share of bioproducts in national market	2030
Norway	40%	Absolute GHG emission mitigation	1990-2030
Sweden	40%	Absolute GHG emission mitigation	1990-2030
	100%	Share of renewables in electricity supply	2040
UK	80%	Absolute GHG emission mitigation	1990-2050

1/2

2/2

Region / Country	Targets	Unit	Period
South and Central America			
Argentina	20%	Share of renewables in final energy consumption	2025
	15%	Absolute GHG emission mitigation	Baseline vs. 2030
Brazil	43%	Absolute GHG emission mitigation	2005 - 2030
	45%	Share of renewables in final energy consumption	2030
	18%	Share of biofuels in final energy consumption	2030
Paraguay	20%	Absolute GHG emission mitigation	Baseline vs. 2030
	less than 5 %	Share of bioproducts in national market	2030
Uruguay	24-29%	CO_2 reduction per unit of GDP	2025
	27-31%		2030
	57-59%	CH_4 reduction per unit of GDP	2025
	62-63%		2030
	48-52%	N_2O reduction per unit of GDP	2025
	51-57%		2030
North America			
Canada	30%	Absolute GHG emission mitigation	2005 – 2030
Mexico	25%	Absolute GHG emission mitigation	Baseline vs. 2030
	less than 5 %	Share of bioproducts in national market	2030
USA[9]	26-28%	Absolute GHG emission mitigation	2005 – 2030

Source: Countrie´s responses to the questionnaire, UNFCCC, and interviews with selected country representatives.

Underlying these targets, there are different motivations behind biofuel and bioproduct markets. In response to the questionnaire that forms the basis of this report, European and North American countries indicate they are primarily driven by GHG mitigation commitments, whereas Asian and Latin American countries report key drivers are the need to enhance energy security and reduce fossil-fuel dependency. Intentions to establish national bio-based industries to generate added value and jobs also permeate across all countries, linking the biofuel and bioproduct markets. Bioproduct markets are less connected to national GHG mitigation but rather to countries´ intentions to strengthen bio-based industries, particularly in Europe and North America, and by the private sector's efforts to enhance business profitability in South America, Europe and the USA, where biofuel industries are mostly settled.

Across the BfP and SBIC/MI, there is a common sense of importance attributed to the biofuel and bioproduct markets. In spite of the inherent subjectivity in countries responses, as depicted in Table 2, they provide a sense of comparison between the perceived importance of such markets and actual market figures. Generally, there is a weak correlation between the perceived importance of such markets and actual production and consumption. On the energy front, many countries that do not produce or significantly consume biofuels attach significant importance to such fuels. On the non-energetic front, responses indicate less perceived importance for bioproducts, seemingly aligned with the scarce market data available. Notably, countries such as Mozambique, Indonesia, Italy, Netherlands, Argentina, Brazil and Canada already have significant shares of bioproducts in use.

9 GHG emissions reduction targets as originally presented by the United States in its 2016 NDC submission: http://www4.unfccc.int/ndcregistry/PublishedDocuments/United%20States%20of%20America%20First/U.S.A.%20First%20NDC%20Submission.pdf.

Table 2. Perceived importance of biofuels and bioproducts compared to biofuel output and share of biofuels in transport sector energy consumption

Region / Country	Perceived importance of the bioeconomy according to consulted representatives		Yearly biofuel output (billion liters)		Current share of biofuels in transport sector energy consumption (%)	Current share of bioproducts in local product output (%)
	biofuel	bioproducts	ethanol	biodiesel		
Africa						
Egypt						
Morocco						
Mozambique			0.01	0.001		more than 50%
Asia						
China			3.16	0.5	2%[10]	
India			1.5	0.1	1.2%	
Indonesia			0.05	3.7		between 5% and 10%
Philippines			0.23	0.22		
Europe						
Denmark					6%	between 5% and 10%
EU			4.1	11.5	4.1%	
Finland			0.1	0.4	11.8%	
France			0.85	2.21	7.6%	
Italy				0.95	6.4%	less than 5 %
Netherlands			0.14	1.81		less than 5 %
Norway			0.02		4.8%	
Sweden					14.7%	
UK			0.49	0.16	3%	
South and Central America						
Argentina			0.84	2.97	10%	between 5% and 10%
Brazil			28.3	3.8	20%	less than 5 %
Paraguay			0.25	0.01	10.5%	
Uruguay			0.08	0.05	6%	
North America						
Canada			1.74	0.47	3%	less than 5 %
Mexico						
USA			55.74	8.31	5.1%	

KEY:
Unknown or unanswered
Irrelevant
Little importance
Important
Very important

Source: Countries´ responses to the questionnaire; interviews with selected country representatives; (AFDC, 2017); (ANP, 2016); (European Commission, 2017a); (IEA, 2015a); (IEA, 2017a); (REN21, 2016); and (SENER, 2016). Yearly outputs consider 2015 for all countries and 2014 for the EU, with very few exceptions for those where data was available for 2016-2018. Global shares of biofuels in the transport sector are approximations created with the latest available for each country within sources above. Hydrotreated vegetable oil (HVO) and 2G biofuel outputs are not included as columns due to their relatively minor global outputs of 4.9 billion liters/year and ~1 billion liters/year respectively (it should be noted that, though, specifically for Canada, HVO represents c. 40% of the total renewable content blended in diesel). Ethanol figures are for fuel ethanol only.

Across BfP and SBIC/MI countries, there is a common sense of importance attributed to the biofuel and bioproduct markets.

10 Ethanol accounts for 2% of gasoline consumption in China. Overall statistics on share of biofuels in transport sector are not available.

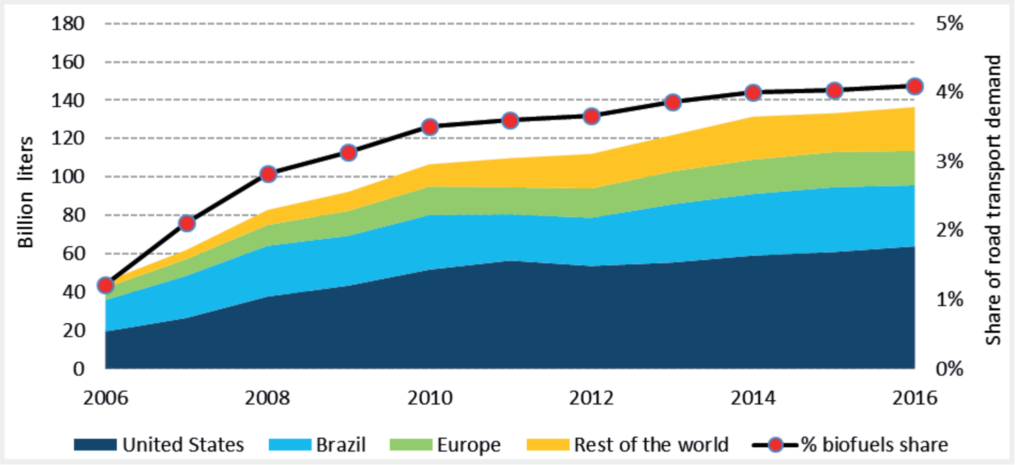
3. PRODUCTION AND CONSUMPTION OF BIOFUELS AND BIOPRODUCTS

Production and consumption of biofuels and bio-products is heterogenous across countries, underpinned by variables such as their historic economic, social or environmental drivers, climate, availability of land, existence of supply chains and regulatory incentives. This section provides further insights into the state of such markets within countries and regions, although somewhat limited by the lack of data around non-energetic bioproduct markets. Global biofuel production and consumption figures are broken-down per country and regions, followed by a comparison of feedstocks for ethanol and biodiesel production; an assessment of biofuel costs against fossil fuels; a summary of the state-of-play of advanced biofuel facilities around the world; and a deeper dive into regional and country profiles for BfP and selected SBIC/MI countries to illustrate the latest status of the bioeconomy and specific challenges in each geography.

Breakdown of biofuel production and consumption per country and regions

Biofuels for transportation have an important role in a restricted number of markets. In 2016, only six countries had fuel ethanol production levels over 1 billion liters and another ten countries presented this production level for biodiesel (IEA, 2017b). Among BfP and SBIC/MI countries, the mean share of biofuels in transport sector is 14%, an expressive value compared to the global mean of 4%. The USA leads the liquid biofuels production sector accounting for 43.5% of the world production, followed by Brazil, with a 22.5% world share (BP Global, 2017). Figure 4 depicts the production figures per region over the past decade, revealing the growing yet modest output from countries other than the USA, Brazil and the EU.

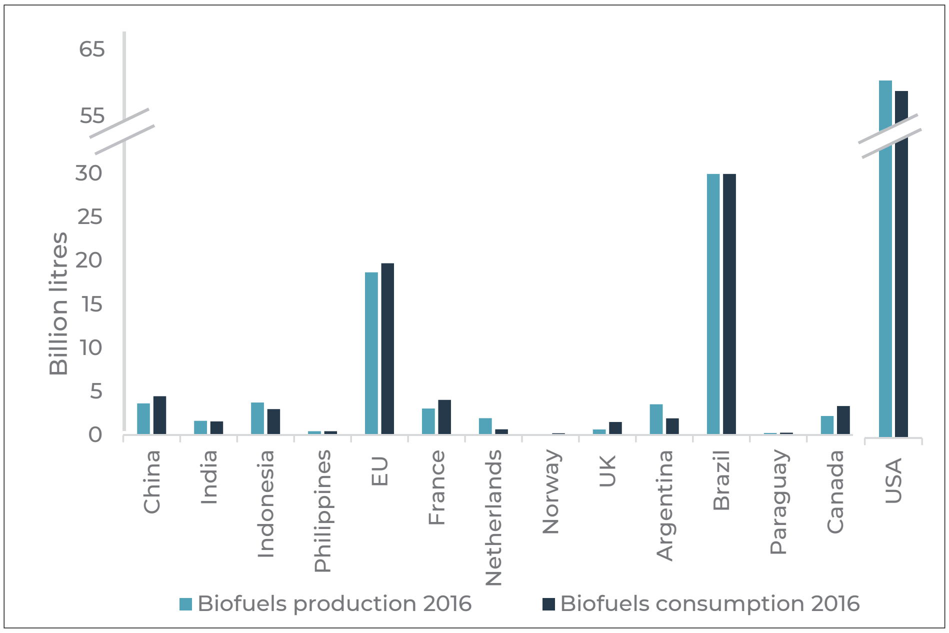
Figure 4. Biofuel production by region



Source: (IEA, 2017b).

Consumption trends do not always follow production geographies, especially outside of the USA and Brazil. Besides Brazil and USA, among BfP and SBIC/MI countries, Argentina, China, France and Indonesia were the most prominent countries on biofuels production, while Canada, China, France are significant importers of biofuels, as shown in Figure 5. Notably, consumption patterns for ethanol and biodiesel are projected to approximately double by 2040 in the USA and Brazil, and witness four-fold and higher increases in China and the EU, if the Platform member countries are to achieve standards projected in the IEA's New Policies Scenario.

Figure 5. Biofuels production and consumption for Biofuture Platform and SBIC/MI countries in 2016



Source: Countries´ responses to the questionnaire and (GAIN, 2017a).

State-of-play of advanced biofuel facilities

Advanced biofuels are increasingly produced within and beyond the BfP, from pilot to commercial facilities, although still largely concentrated in the USA and the EU. Although conversion routes and feedstocks vary across existing plants, most produce cellulosic ethanol. The classification of such facilities follows the TRL logic presented in Figure 3, allowing us to classify these between commercial, demonstration and pilot plants, as defined below.

Commercial plants, where technologies are proven in an operational and competitive environment, exist since 2012 and are slowly increasing from 19 in 2013 to 40 currently reported across the BfP and SBIC/MI, including operational and under construction sites. Of these, 16 are in North America, 17 in Europe, three in Asia and another four in South and Central America. Demonstration projects, where technologies are not fully economical but serve to test the continuous production of biofuels to a valid specification, decreased within this timeframe, going from 27 in 2013 to 21 reported in 2017. Of these, ten facilities are in Europe, seven in Asia, three in North America, and one in South and Central America. Finally, pilot plants are those that operate within a specified timeframe and are not part of a material supply chain. The number of such facilities remained the same as in 2013, with 25 reported pilot plants, of which 20 in Europe, four in Asia and one in South and Central America. Table 5 provides a summary of the existing facilities, as reported by countries.

Table 5. Summary of reported advanced biofuels commercial, demonstration and pilot facilities by region

Region	Commercial	Demonstration	Pilot
North America	16	3	0
Europe	17	10	20
Asia	3	7	4
South and Central America	4	1	1
Africa	0	0	0

Source: Countries´s responses to the questionnaire; (IRENA, 2016b).

Regional and country profiles

AFRICA

The continent demonstrates a suitable environment for the growth of a number of different feedstocks, yet, as a whole, countries' individual governments have moved relatively slow with the introduction of biofuel development initiatives. This is possibly due to a variety of different bottlenecks, such as lack of expertise, financial constraints, land issues, lack of targets and lack of biofuel incentive policies.

With the growing global interest in biofuels, several African countries are increasing their production and use of biofuels, resulting in a positive outlook for expansion of the sector within the next two decades. During the upcoming years, these countries are expected to formulate policies that promote and regulate biofuels, which have the potential to contribute to the continent's infrastructure development program and economic growth (Sekoai & Yoro, 2016).

Africa is increasingly viewed as the future global powerhouse for biofuel feedstock production, requiring countries to position themselves strategically by assessing international developments and biofuel initiatives that could act as catalysts for economic growth, infrastructure development and rural development. Nevertheless, without strong government positioning, with clear policies and incentives, biofuel development may be regarded as threatening, and may cause the displacement of small-scale farmers, the favoring of multinational companies and deforestation. This reasoning follows the same trend that other commodities have experienced, where policy favors a few at higher levels whilst exploiting the lower classes (Biofuel Org, 2012a). Another concern over biofuels is the adequacy of supply, where land for biofuels cultivation can compete with other uses, as well as require water and fertilizers that may be limited.

African countries with favorable climate conditions and land potential have a natural advantage to produce biofuels and develop their agricultural regions sustainably (Sekoai & Yoro, 2016). However, while acknowledging the need for adequate land distribution in order to ensure food security and curb inequalities, African governments must carefully plan and regulate the eminent growth of biofuel outputs keeping the broad view of how biofuel agriculture may impact other priorities. Governments must prevent negative social impact, particularly on small-scale farmers, and environmental externalities that may arise from biofuel markets if best practices are not utilized. A useful approach for doing so may be to encourage smallholder planting of nitrogen-fixing wood crops alongside food crops, enhancing food yields and revenues, obviating the need for costly artificial fertilizer, and providing wood for energy. Small-scale models for farming sugar cane and other high-yielding grass species could also prove of great value.

A study on the feasibility of biofuel production in the West African Economic and Monetary Union (WAEMU[11]), published as part of a cooperation agreement between Brazil's Development Bank (BNDES) and the Brazilian Ministry of External Relations (MRE), highlighted the importance of an integrated framework for local rural development and biofuels production in African countries (Bain & Compay; ESALQ/USP; Machado, Meyer, Sendacz and Opice Advogados, 2014). Despite the difficulties in the implementation of biofuel production in the region (due in part to the low agricultural productivity observed), the sustainable use/production of bioenergy (especially biofuels) can provide great opportunities to strengthen agricultural sectors and enhance income generation in the field. Hence, the progress of policies that reassure the use of ethanol or biodiesel in a cost-effective manner must consider the benefits brought by the development of the industry in a broader sense, such as job creation, the strengthening of agriculture, impact on the trade balance and environmental benefits.

The study also indicates that the WAEMU region has much to benefit from the development of the agriculture and biofuel sectors in tandem. Together, these can address countries' needs to achieve food and energy self-sufficiency, to the extent that crop and biofuel industries can co-exist with respective economic and social benefits, and to the extent that biomass can be used in cogeneration plants to enhance the reliability of power supply. Nevertheless, despite the advantages of biofuels to countries in the region, it was observed that the efforts for the introduction of biofuels in the energy mix in the region lost momentum after the reduction of international oil prices in the second half of 2008.

As of February 2018, Egypt, Morocco, and Mozambique are the only African members of the Biofuture Platform. Amongst these countries, only Mozambique reports the existence of an active agenda for biofuel production and policy development. Regarding advanced biofuels, no African country Member reports any existing or planned pilot, demonstration or commercial plants.

EGYPT

Biodiesel		Ethanol	
Consumption	0	Consumption	0
Production	0	Production	0
Main feedstock for production	0	Main feedstock for production	0
Area used (10^3 hec)	0	Areas used (10^3 hec)	0
Price (USD/L)	N/A	Price (USD/L)	N/A
Totals			
Total volume of biofuels consumed			0
Total volume of biofuels produced			0
Share in the transport sector (%)			0

Source: (UNFCCC, 2016), (Open data for Africa, 2015).

Egypt did not complete the country questionnaire on which this report is based, and, according to available data, there is no indication of production or consumption of ethanol or biodiesel.

The Egyptian NDC has not yet defined numerical targets, only the intention to reduce GHG emissions. For the transport sector, the objective is to use advanced locally, appropriate and more efficient and lower-emission fossil fuel technologies but there is no mention to biofuels.

11 This Union comprises Benin, Burkina Faso, Ivory Coast, Guinea-Bissau, Mali, Niger, Senegal and Togo.

MOROCCO

Biodiesel		Ethanol	
Consumption	0	Consumption	0
Production	0	Production	0
Main feedstock for production	0	Main feedstock for production	0
Area used (10^3 hec)	0	Areas used (10^3 hec)	0
Price (USD/L)	N/A	Price (USD/L)	N/A
Totals			
Total volume of biofuels consumed			0
Total volume of biofuels produced			0
Share in the transport sector (%)			0

Source: (UNFCCC, 2016) and (Open Data for Africa, 2015).

Morocco did not complete the questionnaire on which this report is based, and, according to available data, there is no indication of production or consumption of ethanol or biodiesel.

The Moroccan NDC sets a 42% business as usual (BAU) GHG emission reduction by 2030, conditioned to substantial support from the international community. Morocco also presented an unconditional target of 17% below BAU levels by 2030. It is expected that the NDC GHG emission reduction targets will be achieved by measures taken in all sectors of the economy. For energy and transport, efficiency measures and the elimination of fossil fuel subsidies are foreseen, but the expansion of biofuels production and consumption is not mentioned.

MOZAMBIQUE

Biodiesel		Ethanol	
Consumption	N/A	Consumption	0
Production	0.001	Production	0.01
Main feedstock for production	Jatropha	Main feedstock for production	Sugarcane
Area used (10^3 hec)	N/A	Areas used (10^3 hec)	0
Price (USD/L)	N/A	Price (USD/L)	0
Totals			
Total volume of biofuels consumed			0
Total volume of biofuels produced			0.01
Share in the transport sector (%)			0

Source: Country responses to the questionnaire, (IRENA 2013) and (Sekoai & Yoro, 2016).Notes: Figures for 2016. All volumes are expressed in billion liters.

Mozambique's NDC documents a mitigation contribution based on policy actions and programs. A Biofuel Policy and Strategy is listed among the contributing policies to reduce GHG emissions. By 2030, Mozambique has targets ranging from 5% to 10% of biodiesel and from 11% to 30% of ethanol for transportation in the national market. The country´s Biofuels Blending Regulation (Decree No. 58/2011 of November 2011) establishes a mandatory blending of 10% biodiesel and 3% bioethanol in diesel and ethanol, respectively. Over the past years, some biofuels production initiatives have been implemented in Mozambique. For biodiesel, jatropha oil seeds have been gaining an increased attention due to its advantages, such as supporting harsh dry conditions. Although sugarcane is the main feedstock for ethanol production, the use of cassava is also evolving in the country.

ASIA

The rapid economic expansion in Asian countries comes with increasing energy needs and renders it the most likely epicenter of the bio-based revolution over the next 20 years, given its major biomass resource and lack of fossil fuel reserves (Biofuels Digest, 2017).

With the first and second largest populations in the world (China and India), the reduction of fossil fuels consumption in Asia has significant impact on global GHG emissions. Nevertheless, the increasing number of vehicles on the road in Asia calls for higher fuel consumption. In China alone, the number of vehicles has grown from 75 million in 2005 to nearly 250 million in 2012, and is expected to rise to over 700 million in 2035. India and other countries in Asia also present a similar trend.

As presented below, some Asian countries have begun to implement robust biofuels programs. For instance, China is now the fourth largest net producer of biofuel in the world if the EU is considered as a whole (Biofuel Org, 2012b).

INDIA

Biodiesel		Ethanol	
Consumption	0.08	Consumption	1.5
Production	0.15	Production	1.5
Main feedstock for production	Palm Stearin	Main feedstock for production	Sugarcane based molasses
Area used (10^3 hec)	N/A	Areas used (10^3 hec)	4.96
Price (USD/L)	0.65 ~ 0.70	Price (USD/L)	0.60
Totals			
Total biofuels volume consumed			1.58
Total biofuels volume produced			1.65
Share in the transport sector (%)[1]			1.2%

Source: Ministry of Petroleum & Natural Gas, Government of India (2018). Notes: Figures for 2018. All volumes are expressed in billion liters.

India's climate target is to reduce its GDP's emission intensity between 33 to 35% below 2005 levels before 2030. A low carbon transportation infrastructure plan was included in their submission, and among other measures, it includes a National Biofuels Policy. Such policy sets an aspirational biofuel blending target of 20%, for both biodiesel and bioethanol. With the intention of further promoting biofuels, India has begun consultations on allowing a 5% blending of biofuels in diesel (NDC INDIA).

During 2015-16, 3.5% of ethanol was blended with petrol. Oil Marketing Companies procured 1.11 billion liters of ethanol during this period. For 2017-2018, it is expected that Oil Marketing Companies in India may procure around 1.5 billion liters of ethanol. By 2022, the Government of India proposes to reduce its dependence on crude oil imports by 10%. The main concern over biofuels is availability of indigenous feedstocks for 1G biofuel production and uncertainty of biomass supply, due to the absence of supply chain logistics network at required scales.

In India, ethanol sourced from sugarcane based molasses is the main biofuel used for blending in gasoline. For biodiesel, the majority of the production comes from palm stearin, a non-edible by-product of palm oil. With the announcement of the National Policy on Biofuels - 2018, India has expanded the scope of feedstock for biofuel production and envisions to achieve 20% of ethanol blending in petrol and 5% biodiesel blending in diesel by 2030.

The Government of India demonstrates growing interest in developing the biofuels sector in the country. The Ministry of Petroleum and Natural Gas (MOPNG) has prepared a road map to accelerate the implementation of its Bio-fuel program by increasing their consumption in India. A Working Group has been constituted to create synergies among various Ministries, develop awareness and implement the biofuels programme in the country. The National Policy on Biofuels – 2018 is expected to boost the biofuel sector and may contribute to help achieve higher ethanol blends. Another measure to support biofuels development and the ethanol blending program (EBP) program is the setting up of twelve 2G ethanol biorefineries in eleven states of the country for supporting the rural economy by creating employment opportunities and providing remunerative income to farmers for their otherwise discarded agricultural residues.

Mandates, subsidies and quotas were pointed out as specific policies, which ensure a market for biofuels. To encourage investment in advanced biofuels, mechanisms such as investment grants, loan guarantees and tax incentives are presently being explored in the country. Energy security and the promotion of the use of sustainable local resources are the main drivers for deployment.

ADVANCED BIOFUEL FACILITIES IN INDIA

In India, there are two operational advanced biofuel facilities - one pilot and one demonstration plant - with a production capacity of 1.75 million liters per year. Indian Glycols built the first plant in the country in 2016, in their Kashipur site in Uttarakhand. The cellulosic pilot plant uses 2G-Alcohol Technology developed by the Center for Energy Biosciences at the Mumbai Institute of Chemical Technology (DBT-ICT). It has a 750 thousand liters annual capacity. Praj Biofuels built the country's second facility in 2017 - a 2G integrated bio-refinery, which will produce 1 million liters of ethanol per year once ready, from agri-residue such as rice, wheat straw, cotton stalk and bagasse.

In 2018, Shell Bangalore completed a demonstration plant which will use an innovative waste to fuels technology, and is expected to produce 50 million liters/year. Moreover, in early 2018, Chempolis, Fortum and Numaligarh Revinery formed a joint venture and announced plans to build a biorefinery in Assam that will convert bamboo into ethanol, furfural, acetic acid and biocoal.

Owner/Date	Biofuel	Feedstock	Capacity	Type of Plant	Status
Indian Glycols Kashipur/ 2016	Cellulosic ethanol	Wood chips, cotton stalk, cane bagasse, corn stover and bamboo	750 thousand liters/year	Pilot	Operational
Praj Biofuels/ 2017	Cellulosic ethanol	Agri-residues (e.g.rice, wheat straw, corn cobs, stover, cotton stalk and bagasse	1 million liters/ year	Demonstration	Operational
Shell Bangalore/2018	Drop-in fuels	Agricultural and municipal waste	50 million liters /year	Demonstration	Completed
Chempolis/Fortum/NRL Numaligarh/2018	Ethanol	Bamboo	60 million liters /year	Commercial	Planned

Source: Country responses to the questionnaire.

The Ministry of Science and Technology, through its Department of Biotechnology (DBT), has been supporting feedstock development and improved biofuel production technology, with major focus on second generation ethanol. DBT is also promoting cutting edge research and innovation in biofuels for the last eight years through its Center of Excellence, fellowships, training and international collaboration. It focus on topics such as lignin valorization, algal biofuel, biorefinery, waste biomass to energy (value added bioproducts), biobutanol and biohydrogen, life cycle analysis, among others. More than USD 30 million have been invested in biofuel research & development, and second generation ethanol technology has been successfully demonstrated by one of the bioenergy centers supported by the Government of India. Many cost effective biofuel production technologies are being developed and demonstrated at pilot scale.

BIOPRODUCTS

Currently, non-energetic bioproducts in India are produced mostly in dedicated plants. India Glycols produces more than 220,000 ton/year of green monoethylene glycol derivatives. Godavari Biorefineries also produce more than 100,000 ton of green biobased products. The main drivers to foster bioproducts development in India, according to the country´s response to the questionnaire, are the integration with biofuel production to make businesses profitable, and the development of new markets and a new biobased industry. The main challenges for production are the lack of financial resources and of specific policies to ensure a market for bioproducts or even support mechanisms to encourage investments in the sector.

CHINA

Biodiesel		Ethanol	
Consumption [1]	0.48	Consumption[1]	4.01
Production [1]	0.50	Production[1]	3.16
Main feedstock for production	Used cooking oil	Main feedstock for production	Corn
Area used (10^3 hec)	N/A	Areas used (10^3 hec)	N/A
Price (USD/L)	N/A	Price (USD/L)	N/A
Totals			
Total volume of biofuels consumed			4.49
Total volume of biofuels produced			3.66
Share in the transport sector (%)			N/A

Source: Country responses to the questionnaire, [1] (GAIN, 2017a). Notes: Figures for 2016. All volumes are expressed in billion liters.

According to their NDC, the Chinese goals by 2030 are, among others, to lower emissions per unit of GDP between 60% and 65% below 2005 levels; and to increase the share of non-fossil fuels in primary energy consumption to around 20%. The plan lists a number of initiatives China intends to pursue (without providing details) and includes “To proactively develop geothermal energy, bio-energy and maritime energy”.

Although blending biofuels into fossil fuels would support government initiatives to manage goals at the national level, there is still no blending mandate nationwide, only at the provincial level at varying degrees. Nine Chinese provinces have already required an E10 blend to date; nevertheless, the Expansion of Ethanol and Reform Plan is in place since 2017, and it calls China to achieve nationwide use of 10% ethanol (E10) by 2020, and commercial scale cellulosic ethanol (GAIN, 2017a). The reduction of GHG emissions, the promotion of energy security and the creation of jobs are listed as the main drivers to foster advanced biofuels development and deployment, while fossil fuels competition, feedstock supply, as well as regulation and policies, are perceived as main challenges.

Accumulation of substantial corn stockpiles contributed to the expansion of ethanol production in China in recent years. While the major feedstocks for ethanol production in China are corn (70%) and wheat, there are public subsidies for biofuel production using cellulosic biomass and cassava (which, in China, is considered non-food grain). Nevertheless, high operating costs have limited its production capacity as China depends on imported cassava. Such subsidies are planned to phase out by 2018.

While the Chinese ethanol sector is evolving, supported by the Expansion of Ethanol and Reform Plan, the national market for biodiesel has collapsed to a small number of regional brokers or direct marketers who service transportation fleets and farmers (GAIN, 2017a). There is underutilized biodiesel refinery capacity, and the government has been attempting to make better use of this infrastructure by encouraging production. However, underdeveloped policies for biodiesel consumption and lack of financial support for farmers are attributed to the stagnation of biodiesel feedstock production in the country. Since 2010, Hainan province has maintained a trial program requiring a biodiesel-diesel blend rate of two to five percent. Industry sources report that when available biodiesel blend rates can reach as high as 20 percent (GAIN, 2017a).

In 2018, biodiesel production is forecast at 500 million liters, unchanged from 2017 due to limited government support and stagnant capital investment. The majority of the biodiesel is produced from UCO and is used by industry, with only about 30% being used for transport (IEA Bioenergy, 2016). Biodiesel from this feedstock can obtain 0.8 RMB/L tax exemption (introduced in 2013 to stimulate biodisel production).

ADVANCED BIOFUEL FACILITIES IN CHINA

In Asia, China is the country with the greatest number of advanced biofuels facilities, with eight projects. There is currently one operating commercial scale plant, producing 220 million liters of butanol per year, and the remaining operational projects are either pilot or demonstration plants, including Tian Guan Fuel Ethanol Co Nanyang, Shandong Longlive and COFCO lignocellulosic ethanol plants, which have a joint capacity of 135 million liters per year. Beta Renewables announced plans to build a commercial scale cellulosic ethanol facility in 2016, however low oil prices delayed its construction along with other planned facilities.

Owner/Date	Biofuel	Feedstock	Capacity	Type of Plant	Status
Laihe Rockley Biochemicals, Songyuan /2012	Biobutanol	NA	220 million liters/year	Commercial	Operational
Beta Renewables/ 2016	Lignocellulosic ethanol	Wheat straw, corn stover, popular residuals and straw	253 million liters/year	Commercial	Planned
Tian Guan Fuel Ethanol Co, Nanyang / 2011	Lignocellulosic ethanol	NA	12 million liters/year	Demonstration	Operational
Shandong Longlive / 2012	Lignocellulosic ethanol	Corncob and straws	60 million liters/year	Demonstration	Operational
Green Biologics / 2013	Lignocellulosic butanol	Residual corn waste	0	Pilot	Complete
Kaidi Biomass Gasification Plant / 2012	FT Diesel	Biogenic waste	4 million liters/year	Pilot	Operational

1/2

2/2

Owner/Date	Biofuel	Feedstock	Capacity	Type of Plant	Status
Henan Tianguan Group / 2009	Lignocellulosic ethanol	Wheat, corn stover and straw	4 million liters/year	Pilot	Operational
COFCO Heilongjiang / 2007	Lignocellulosic ethanol	Corn stover	63 million liters/ year	Demonstration	Operational

Source: Country responses to the questionnaire.

The existing pilot projects began in 2009 with the Henan Tianguan Group followed by Kaidi Biomass Gasification Plant (2012) and by Green Biologics (2013). The Green Biologics' facility trialled lignocellulosic butanol from residual corn waste and was completed, with commercial scale production of n-butanol becoming operational in 2012, in Songyuan, through Laihe Rockley Biochemicals, a partner company. The other pilot projects produce 4 million liters per year each. The Kaidi Biomass Gasification Plant uses biogenic waste as feedstock, while the Henan Tianguan Group produces lignocellulosic ethanol from wheat, corn stover and straw.

BIOPRODUCTS

In China, bioproducts are produced mostly in dedicated plants, and country representatives see drop-in bioproducts as the most promising opportunities. According to the country´s response to the questionnaire, the main drivers to foster bioproducts development in China are the promotion of biomass and the reduction of GHG emissions, followed by the development of new markets and a new biobased industry. The main identified challenges for the development of the sector are fossil-based products competition and market development, together with downstream value chain structuring.

INDONESIA

Biodiesel		Ethanol	
Consumption	3.0	Consumption	N/A
Production	3.7	Production	0.05
Main feedstock for production	palm oil	Main feedstock for production	sugarcane
Area used (10^3 hec)	11672	Areas used (10^3 hec)	N/A
Price (USD/L)	0.9	Price (USD/L)	N/A
Totals			
Total volume of consumed			3.01
Total volume of produced			3.75
Share in the transport sector (%)			17%

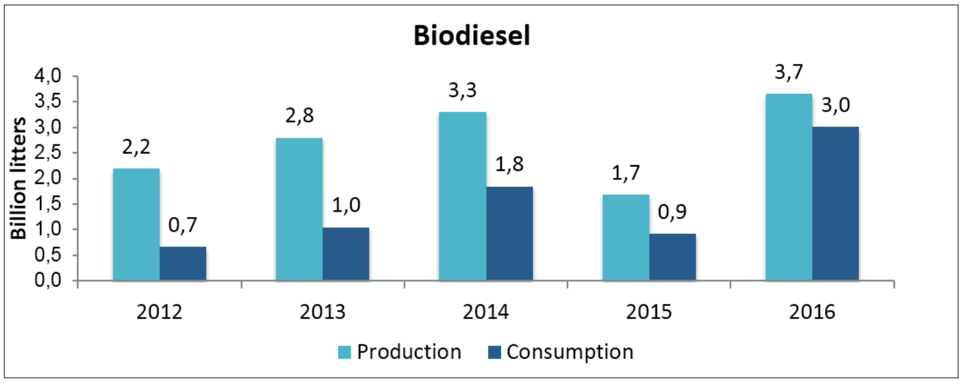
Source: Country responses to the questionnaire, (GAIN, 2017c) and (ICCT 2017). Notes: Figures for 2016. All volumes are expressed in billion liters.

According to their NDC, Indonesia intends to reduce its greenhouse gas emissions by 29% compared to the BAU scenario by 2030. The document does not specify any biofuels policy, although there is a national program and a blend mandate in place.

Indonesia's biofuels program is centered on palm oil-based biodiesel. This industry is supported by a program, which is funded via a levy on palm oil exports. Revenues from the levy are used to offset the difference between fossil diesel and biodiesel prices for Indonesian consumers.

Biodiesel consumption steeply increased in 2016 following the implementation of a national biodiesel mandate that currently requires 20% biodiesel blending. Total 2016 biodiesel consumption reached 3 billion liters from 915 million liters in 2015, as shown in Figure 7.

Figure 7. Biodiesel production and consumption in Indonesia 2012-2016 (billion liters)



Source: Country responses to the questionnaire, (GAIN, 2017c).

Exports have fallen as fossil fuel prices have become more competitive. For 2018, exports are projected to remain at 200 million liters, assuming that the fossil fuel/biodiesel price differential remains unchanged, and that importing countries do not make significant changes to their biodiesel incentive programs.

BIOPRODUCTS

According to the country´s responses to the questionnaire, the current share of bioproducts in the national market is less then 5% and Indonesia is aiming to increase that share to a percentage between 11% and 30% by 2030. The main drivers to foster bioproducts development in Indonesia are the association with biofuels to make the businesses profitable, the development of new markets and a new biobased industry, along with GHG emissions reduction and job creation. The feedstock supply is considered the greatest challenge for bioproduct production.

THE PHILIPPINES

Biodiesel		Ethanol	
Consumption	0.22	Consumption	0.23
Production	0.22	Production	0.23
Main feedstock for production	coconut	Main feedstock for production	sugarcane
Area used (10^3 hec)	3517	Areas used (10^3 hec)	413
Price (USD/L)	0.90	Price (USD/L)	0.94
Totals			
Total volume of biofuels consumed			0.45
Total volume of biofuels produced			0.45
Share in the transport sector (%)			N/A

Source: Country responses to the questionnaire and (GAIN, 2017d). Notes: Figures for 2016. All volumes are expressed in billion liters.

According to its NDC, the overall policy goal of the Philippines is to reduce its greenhouse gas emissions by about 70% by 2030 in comparison with its BAU scenario. The intention of promulgating complementary sectoral laws, such as the country's Biofuels Act, has been documented.

The Philippines was the first country in Southeast Asia to have a biofuels legislation in place, when the Biofuels Act was signed in January 2007. Petrol is mandated to be blended with 10% bioethanol and diesel with 2% biodiesel. Both petrol and diesel are mostly used by the transportation sector.

Inadequate investments in new distilleries and distribution infrastructure, lack of tax policy and other types of support favoring biofuels over fossil fuel consumption are pointed as key factors for a poor industry development. The scenario for biofuels is not expected to improve due to lower oil prices since 2014 and increased demand for coconut oil exports.

Tax incentives were pointed out as support mechanisms to encourage investment in biofuels, while lack of financial resources, competition with fossil fuels and technological expertise deficiencies were indicated as greater challenges for biofuels production in the country.

ADVANCED BIOFUEL FACILITIES IN THE PHILIPPINES

Owner/Date	Biofuel	Feedstock	Capacity	Type of Plant	Status
Roxas Holdings Inc./ 2016	Cellulosic ethanol	Sugarcane bagasse and agriculture residue	NA	Demonstration	Operational
Nippon Steel & Sumikin Engineering CO., LTD/ 2016	Cellulosic ethanol	Nipa Sap	NA	Demonstration	Operational

Source: Country responses to the questionnaire.

Advanced biofuels facilities in the Philippines are also in the pilot-demonstration stage, with two projects being reported by the country, with starting dates in 2016. Roxas Holdings Inc. and Nippon Steel & Sumikin Engineering CO., LTD. built a demonstration plant to trial cellulosic biomass to ethanol technology up to January 2018. Feedstock included sugarcane bagasse and agriculture residue, both widely available in the Philippines. The second project resulted from a community-based bioethanol industry study on the feasibility of hydrous bioethanol from nipa sap for biofuel blend. The demonstration element was scheduled for completion by February 2018. There is little information available on these projects and their results.

BIOPRODUCTS

The Philippines' responses to the questionnaire reveal a tendency to favor drop-in bioproducts since bioproduct and biofuel production are currently integrated. Tax incentives were pointed out as the main support mechanism to encourage investments in bioproducts; nonetheless, financial resources, competition with fossil fuels and lack of technological expertise were identified as the greatest challenges in bioproducts production in the country.

EUROPE

The EU Renewable Energy Directive was first published in 2009 to promote the use of energy from renewable sources in European countries. It establishes that EU-member countries must fulfill its energy needs with at least 20% of renewables by 2020 - to be broken down into individual national targets -, and 32% by 2030 (EU-wide target). The targets consider the starting point and overall country potential and range from 10% in Malta to 49% in Sweden. EU countries must also ensure that at least 10% of their transport fuels come from renewable sources by 2020 and must publish their progress towards national targets every two years (European Commission, 2016a).

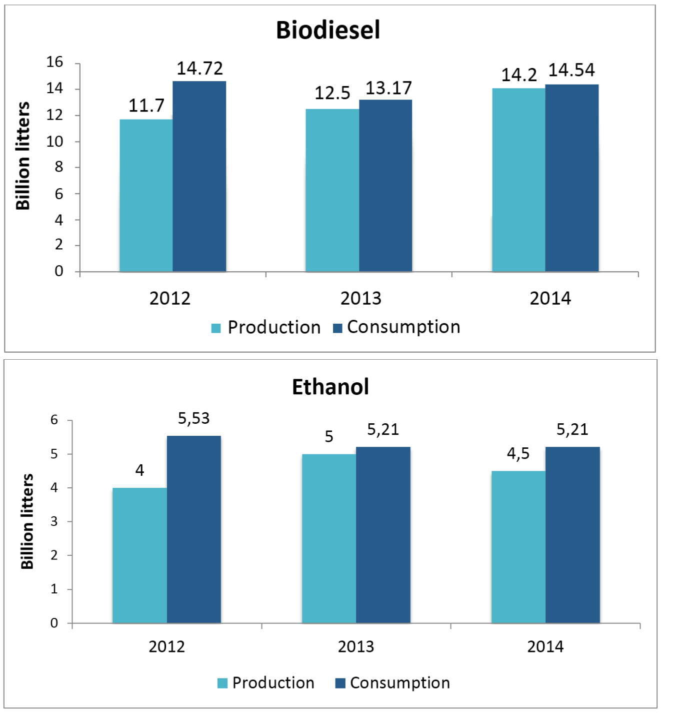
The new Renewable Energy Directive (REDII) for the period between 2020 and 2030 is currently being formulated. The regulatory uncertainty surrounding the preparation and negotiation of the Directive discouraged new investments in the biofuels sector beyond what was already in place. It aims to promote the decarbonization and energy diversification of transport fuels, while addressing Indirect Land Use Change (ILUC) associated with food-based biofuels. A progressive reduction of food-based biofuels and their replacement by more advanced biofuels will realize the potential for decarbonising the transportation sector. On June 14, 2018, a provisional political agreement for REDII has been reached. Although formal adoption is still pending (as per mid 2018), its main elements are unlikely to change: i) 14% target for renewable energy in the transport sector by 2030; ii) cap of crop-based biofuels at a maximum of 7% per Member State by 2020; iii) standstill of current levels of biofuels from palm oil, to be phased out by 2030; iv) progressive minimum targets for advanced biofuels (0.2% in 2022; 1% in 2025; 3.5% in 2030).

In that respect, a public consultation on main barriers to increase RE in transport was conducted in the EU and the main results include inter alia the lack of stable policy framework for the period after 2020, the long debate on biofuels sustainability, and the high price of electric vehicles (European Commission, 2016a).

The EU and its Member States are committed to a reduction of at least 40% in absolute GHG emissions by 2030 compared to 1990. The following countries from the EU are part of this report : Denmark, France, Italy, Netherlands, Finland, Sweden, and United Kingdom (Latvian Presidency of the Council of the European Union, 2015).

Biodiesel consumption in the EU reached 14.54 billion liters in 2016, with 14.2 billion being self-produced – see Figure 8. The main feedstock for that year was rapeseed oil. For ethanol, consumption reached 5.21 billion liters and production reached 4.5 billion liters, mainly from corn or wheat (according to the questionnaire). In 2016, biofuels accounted for 4.1% in transportation sector energy consumption.

Figure 8. Biofuels production and consumption 2012-2014 in the EU (billion liters)



Source: EU responses to the questionnaire.

Biofuels are essential for EU countries to meet their 10% renewable energy target for transportation, even considering the significant projected expansion of electric vehicles. By 2030, electric vehicles could potentially account for 16% of the overall car stock in Europe. However, renewable power would only account for 3%

of energy consumption in the sector. Liquid biofuels – both advanced and conventional – will still be of central importance (IRENA, 2018b).

To ensure environmental responsibility, accountable carbon savings and biodiversity protection, the EU defined a set of sustainability criteria for the production and use of biofuels. According to the criteria, biofuels had to achieve GHG savings of at least 35% GHG until 2017, rising to 50% GHG savings in 2017 when compared to fossil fuels. If a biofuel production installation started operations after 2014, then the compulsory savings to comply with the directive rise to 60%. All life cycle emissions must be accounted for, including cultivation, processing and transport. In addition, biofuels cannot be produced from primary forests raw materials or using land with previous high carbon stock (wetlands or forests) (European Commission, 2016a).

Typically, the European Union political project sets central objectives with flexibility for member states to achieve them according to their baseline, potential and realities. This characteristic is present in the Renewable Energy Directive framework for EU member states and allows a divergence in overall targets for biofuel usage and a wide scope in the specifics of how policy is implemented. Such flexibility has resulted in a complex environment presenting different standards and peculiar specifications, where national programs are difficult to link and market participants have to deal with potentially different requirements in each individual member state.

For example, while Germany's mandate is based on GHG savings, other states have targets for energy or volume from biofuels, creating large disparities in blending economics for end-users. Moreover, Spain has a quota system for producers that limits the number of non-Spanish sellers and France grants a tax cut for purchases from local producers (Bartlett, 2016).

When it comes to advanced biofuels facilities, Finland and the UK lead in the number of projects among consulted European countries, followed by France, Sweden, Denmark and the Netherlands.

FINLAND

Biodiesel		Ethanol	
Consumption	0.5	Consumption	0.1
Production	0.4	Production	0
Main feedstock for production	Waste oils, fats, UCO	Main feedstock for production	N/A
Area used (10^3 hec)	N/A	Areas used (10^3 hec)	N/A
Price (USD/L)	N/A	Price (USD/L)	N/A
Totals			
Total biofuels volume consumed			0.6
Total biofuels volume produced			0.4
Share in the transport sector (%)			11.8%

Source: Country responses to the questionnaire, (GAIN 2015a), (REN21, 2016). Notes: Figures for 2014. All volumes are expressed in billion liters.

In Finland, fuel distributors are required by law to provide biofuels to the market. The target for 2016 was 10% (energy share), and a 20% incremental increase is proposed by 2020. Biofuels production is also supported by fuel and vehicle taxation.

A recent study on the 2030 EU climate targets concluded that the most cost-efficient way to reduce emissions in Finland is to invest in the production and uptake of domestic, advanced, drop-in biofuels as they do not require changes to the vehicle fleet or fuel distribution system. Biogas and electric vehicles are also complementary options, but these would require additional infrastructure investments. An expansion of advanced biofuel production capacity was announced in Finland and it is expected to reach 100 million liters in 2020.

Tax incentives ensure a market for advanced biofuels in Finland, and investment grants are the primary support mechanism to encourage investment. The reduction of GHG emissions and establishment of a domestic bioindustry are pointed out as the main drivers to foster biofuel deployment, whereas regulation and policies are perceived as main challenges.

ADVANCED BIOFUEL FACILITIES IN FINLAND

Owner/Date	Biofuel	Feedstock	Capacity	Type of Plant	Status
UPM, Lappeenranta/ 2015	HVO	Tall oil	120 million liters year	Commercial	Operational
UPM, Kotka/2018	N/A	Wood waste, waste oil, brassica carinata	602 million liters/ year	Commercial	Planned
Neste, Porvoo/ 2007	HVO	Oil	200,000 t/ year	Commercial	Operational
Neste, Porvoo/ 2009	HVO	Oils and fats	200,000 t/ year	Commercial	Operational
Fortum, Joensuu/ 2009	Pyrolysis oil	Wood	50 million liters/ year	Commercial	Operational
Ajos, Kemi/ 2019	FT diesel and Naphtha	NA	500 tones/day	Commercial	In Development
Chempolis Ltd/ 2008	Lignocellulosic ethanol	Straw, reed, empty fruit bunch, bagasse, corn stalks, wood residues	6 million liters/ year	Pilot	Operational
St1 Etanolix/ 2016	Lignocellulosic ethanol	Sawdust and wood	10 million liters/ year	Pilot	Operational

Source: Country responses to the questionnaire.

Finland reported eight facilities, with six commercial and two pilot plants supplied by feedstock varying among oil, wood, straw, and forest residue. Taken together, the total production capacity equals 294 million liters year, and there are six companies involved in these projects. One pilot facility from Chempolis Ltd – commissioned in 2008 – that produces 6 million liters of cellulosic ethanol per year (from straw, corn stalks, reeds, and wood residues) and a second pilot facility from St1 Etanolix (2016) that produces 10 million liters of cellulosic ethanol (from saw dust and wood). There are two facilities operated by Neste, in Porvoo, commissioned in 2007 and 2009, which each producing 200,000 tons per year of HVO. The Fortum's Joensuu facility, commissioned in 2013, produces 50 million liters per year of pyrolysis oil. The Biofore Company (UPM) Lappeenranta's facility became commercially operational in 2015; producing 120 million liters of renewable diesel per year from wood-based residue and tall oil. In early 2018, UPM announced plans to develop a second biorefinery, in Kotka. The facility would use wastes and residues as feedstocks, as well as Brassica carinata, a winter crop.

BIOPRODUCTS

In Finland, bioproducts are produced mostly in dedicated plants; and the development of new markets and a new bio-based industry are seen, by country representatives, as the main drivers to foster their deployment. On the other hand, the main challenges to incentivize bioproducts deployment are regulation and policies.

ITALY

Biodiesel		Ethanol	
Consumption	1.32	Consumption	0.285
Production	0.95	Production	N/A
Main feedstock for production	Rapeseed	Main feedstock for production	Cereals
Area used (10^3 hec)	N/A	Areas used (10^3 hec)	N/A
Price (USD/L)	N/A	Price (USD/L)	N/A
Totals			
Total biofuels volume consumed			1.61
Total biofuels volume produced			N/A
Share in the transport sector (%)			6.4%

Source: Country responses to the questionnaire, (GAIN, 2017e), (GAIN 2015b), (REN21, 2016). Notes: Figures for 2016. All volumes are expressed in billion liters.

Italian fuels must meet an increasing share of biofuel content. In 2018, a 7.5% ethanol blend with gasoline must be met, reaching 10% in 2020. Diesel must also contain biodiesel. Biodiesel in Italy is exclusively used in blends with traditional diesel for transport or for heating. Rapeseed oil, the main feedstock for biodiesel production, is mostly imported from other EU countries.

Investments in biofuels are generally encouraged by venture funds, and the main drivers for the development of a national market are the reduction of GHG emissions and the establishment of a domestic bioindustry. Country representatives identify the supply of feedstock as the main challenge.

ADVANCED BIOFUEL FACILITIES IN ITALY

Italy is one of the main players when it comes to advanced biofuels. The world's first commercial-scale cellulosic ethanol plant is in this country. Moreover, Italy was the first EU Member State to mandate the use of advanced biofuels. The Decree (250, 27 October 2014) requires gasoline and diesel to contain at least 1.2% of advanced biofuel made of waste and non-food feedstocks as of January 2018, reaching 2% by 2022.

Owner/Date	Biofuel	Feedstock	Capacity	Type of Plant	Status
Beta Renewables Crescetino/ 2013	Lignocellulosic ethanol	Straw and energy grasses	75 million liters/ year	Commercial	On hold
ENI Venice/ 2014	HVO	UCO, animal fats and oils	325 million liters/ year	Commercial	Operational
ENI Gela / 2015	HVO	UCO, animal fats and oils	900 million liters/ year	Commercial	In development

Source: Country response to the questionnaire.

Beta Renewables' commercial cellulosic ethanol plant in Crescentino became operational in 2013, with 75 million liters of lignocellulosic ethanol per year, made from straw and energy grasses, but the biorefinery is currently on hold, as part of a restructuring effort of its parent company. The ENI Venice facility, a conventional refinery converted into a biorefinery, became operational in 2014, producing 325 per year million liters of HVO from vegetable and animal fats and oils. ENI is also developing a HVO facility in Gela, Sicily, which is expected to produce up to 900 million liters of HVO per year.

BIOPRODUCTS

According to Italy's responses to the questionnaire, the current share of bioproducts in the national market is less than 5% and there are no specific targets for bioproducts until 2030. Promising opportunities are usually linked to drop-in products, and currently, bioproducts are produced mostly in dedicated plants. The main drivers to foster bioproducts development in Italy are biomass promotion, development of new markets and a new bio-based industry, GHG emissions reduction, and job creation. Feedstock supply is considered the greatest challenge for bioproduct production.

Labelling, subsidies and quotas are specific policies, which ensure a market for advanced biofuels in Italy. This production usually depends on financial support, such as investment grants, preferential finance, and tax incentives.

DENMARK

Biodiesel		Ethanol	
Consumption	0.22	Consumption	0.09
Production	0	Production	0
Main feedstock for production	N/A	Main feedstock for production	N/A
Area used (10^3 hec)	N/A	Areas used (10^3 hec)	N/A
Price (USD/L)	N/A	Price (USD/L)	N/A
Totals			
Total volume of biofuels consumed			0.31
Total volume of biofuels produced			N/A
Share in the transport sector (%)			5.0%

Source: Country responses to the questionnaire and (Olsen, Klitkou e Eerola 2013).Notes: Figures for 2015. All volumes are expressed in billion liters.

Denmark has been proactive in developing a clean energy policy. Environmental legislation has been playing an important role in the country, with taxes on CO_2 emissions in place since the 1990s, and biofuels exemption from fuel taxes since 2005. The Danish government foresees that all energy supply in the Danish transport sector will be made up of renewable energy by 2050.

Since January 2010, fuel companies are obliged to ensure that biofuels make up at least 5.75% of total annual fuel sales. The Danish Biofuel Act is to be amended in order to enable a 10% blend of biofuels by 2020. Concerning advanced biofuels, the country has a mandate for biofuel blending (0.9%) in transportation in 2020.

Country representatives' claim that financial resources, fossil fuel competition and regulation are the main challenges to further develop and deploy biofuels in Denmark. Market sector is guaranteed by mandates and tax incentives, while other support mechanisms encourage further investments.

ADVANCED BIOFUEL FACILITIES IN DENMARK

Denmark reported five advanced biofuels facilities, two in demonstration and three in pilot stage. The current production of all plants totals 11 million liters per year. Inbicon, a fully owned subsidiary of DONG Energy, commissioned three plants in 2003, 2005 and 2009 to test lignocellulosic ethanol from straw and wheat. Their flagship project is the Kalundborg demonstration plant with a production of 5 million liters per year of lignocellulosic ethanol from wheat and straw, the other two being pilot projects. BioGasol demonstration plant – BornBioFuel2 – became operational in 2013 to convert straw and lignocellulosic residues into ethanol. It produces 5 million liters of ethanol per year. The final pilot project is owned by Aalborg University Copenhagen and was commissioned in 2009 to trial lignocellulosic ethanol from wheat straw, cocksfoot grass and straw.

Owner/Date	Biofuel	Feedstock	Capacity	Type of Plant	Status
Inbicon/ 2003	Lignocellulosic ethanol	Straw	0	Pilot	Operational
Aalborg University Copenhagen/ 2009	Lignocellulosic ethanol	Wheat straw and cocksfoot grass-straw	0	Pilot	Operational
Inbicon/ 2005	Lignocellulosic ethanol	Straw	1 million liters/ year	Pilot	Operational
BioGasol/ 2013	Lignocellulosic ethanol	Straw, various grasses and garden waste	5 million liters/ year	Demonstration	Planned
Inbicon/ 2009	Lignocellulosic ethanol	Wheat straw	5 million liters/ year	Demonstration	Operational

Source: Country responses to questionnaire.

BIOPRODUCTS

The current percentage of bioproducts in national market account for 5-10%. Denmark's questionnaire response revealed that the most promising opportunities for production are generally non-drop in. Financial resources, competition with fossil fuels and regulation were pointed out as the main challenges for production deployment in the country.

FRANCE

Biodiesel		Ethanol	
Consumption	3.27	Consumption	0.78
Production	2.21	Production	0.85
Main feedstock for production	rapeseed	Main feedstock for production	beetroot/ wheat / corn
Area used (10^3 hec)	N/A	Areas used (10^3 hec)	N/A
Price (USD/L)	N/A	Price (USD/L)	N/A
Totals			
Total volume of biofuels consumed			4.05
Total volume of biofuels produced			3.06
Share in the transport sector (%)			6.4%

Source: Country responses to the questionnaire, (GAIN, 2017e) and (REN21, 2016). Notes: Figures for 2016. All volumes are expressed in billion liters.

Other than the overall European climate target, France´s own strategy includes The Energy Transition Bill, published in August 2015. The complete target is to reach 32% of energy share generated from renewable sources in gross final energy consumption by 2030. For transportation, it means that 15% of energy demand must be met by renewable energy sources.

France is the second largest biodiesel producer in EU, and the major consumer within EU countries. Its consumption is driven almost exclusively by mandates and tax incentives. Second generation biofuels are also incentivized in France by being double-counted towards the blend mandate since 2014.

Due to the increased number of gas stations selling E10 and E85 and to the lower price of these fuels when compared to petrol, bioethanol consumption is growing. In January 2016, the French tax for energy products, was reduced for E10 and increased for petrol. Also, since the beginning of 2016, ED95 (95% ethanol), consumed exclusively by buses and trucks, is being commercialized. As per biodiesel production, it is expected to remain flat through 2018.

Such mandates and regulations ensure a market for biofuels, especially ethanol. Country representatives also point out investment grants as another support mechanism to encourage investments. Major challenges identified were scientific/technological bottlenecks and technological expertise.

ADVANCED BIOFUEL FACILITIES IN FRANCE

Owner/Date	Biofuel	Feedstock	Capacity	Type of Plant	Status
UPM/ 2018	FT Diesel	Forest biomass	108 million liters/ year	Commercial	Planned
Abengoa Bioenergy	Lignocellulosic ethanol	Straw	51 million liters/year	Demonstration	Closed
IFP Futurol Demonstration, Bucy le Long / 2016	Bioethanol	Wood	180 million liters/ year	Demonstration	Operational
Total/ 2014	FT Diesel	Wood	n.a.	Pilot	Operational
PROCETHOL 2G IFP Futurol Pilot plant/ 2011	Bioethanol	Straw and wood	3.5 million liters/ year	Pilot	Operational
BioTFuel/ 2016	Jet fuel and Diesel	Wood	254 million liters/ year	Pilot	Under construction
Total/2015	HVO	N/A	500,000 t/ year	Commercial	Planned

Source: Country responses to the questionnaire; (Total, 2018).

France reported seven facilities, with three in pilot stage, two in demonstration stage (one of them is currently closed) and two in commercial stage. The main feedstocks are straw and wood. Currently, there are three operational facilities. The Procethol 2G – Futurol pilot plant, near Remis, was inaugurated in 2011 to pilot bioethanol technology from a consortium of companies (IFP Energies Nouvelles, Inra and Lesaffre and ARD). It has a production capacity of 3.5 million liters per year and uses lignocellulosic biomass feedstock, such as wood and straw. As part of the Futurol project, a demonstration plant was built in Bucy-Le-Long in 2016 to test their bioethanol technology at industrial scale. The expected production capacity is of 180 million liters. Abengoa Bioenergy owned a demonstration plant, with a production capacity of 51 million liters per year of lignocellulosic ethanol from straw, but the company sold its bioenergy assets as part of a bankruptcy plan. BioTfuel is building a pilot plant with production capacity of 254 million liters per year. Planned projects include the UPM FT diesel commercial plant, which should become operational in 2018 and produce 108 million liters per year of capacity. Moreover, in 2015, Total announced plans to convert its La Mède conventional refinery into a biorefinery.

BIOPRODUCTS

France's questionnaire response revealed a tendency to favor drop-in bioproducts in the country. Currently, bioproducts and biofuels production are integrated. Investment grants were pointed out as the main support mechanism to encourage investment in bioproducts, while scientific/technological bottlenecks and lack of technological expertise were indicated as the greatest challenges for bioproducts production in the country.

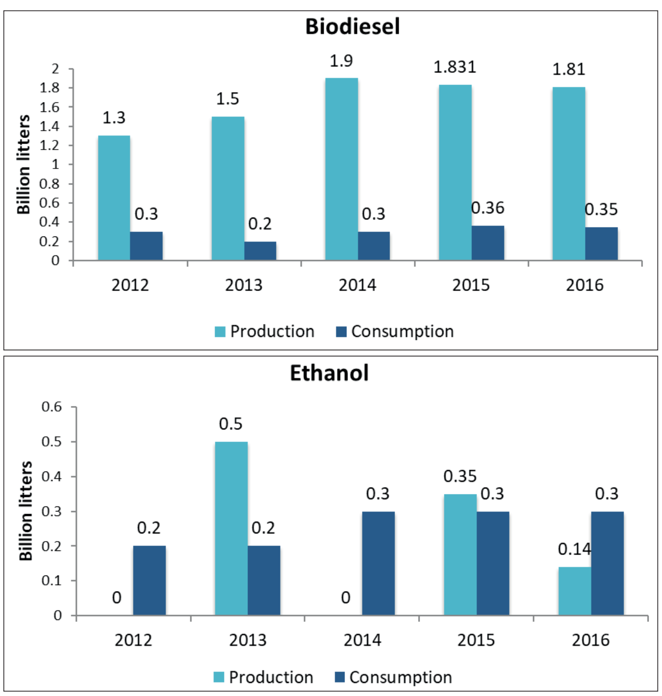
NETHERLANDS

Biodiesel		Ethanol	
Consumption	0.35	Consumption	0.3
Production	1.81	Production	0.14
Main feedstock for production	UCO / Palm	Main feedstock for production	Wheat
Area used (10^3 hec)	N/A	Areas used (10^3 hec)	N/A
Price (USD/L)	0.4	Price (USD/L)	0.40
Totals			
Total biofuels volume consumed			0.67
Total biofuels volume produced			1.95
Share in the transport sector (%)			4%

Source: Country responses to the questionnaire, (CE Delft, 2015) and (Govenment of Netherlands, 2018). Notes: Figures for 2016. All volumes are expressed in billion liters.

As illustrated in Figure 9, biodiesel is the main biofuel product for Netherlands, with 1.81 billion liters in 2016, placing the country as one of the main exporters in Europe.

Figure 9. Biofuels production and consumption 2012-2016 in the Netherlands (billion liters)



Source: Country responses to questionnaire

The main feedstock, palm, is predominantly originated in Indonesia and Malaysia. Although it is still a recent player in biofuels scenario compared to the USA and Brazil, the Netherlands has goals to increase the participation of renewables (including biofuels) by 14% in the national energy matrix and 10% for transport sector by 2020.

Since 2013, an Agreement on Energy for Sustainable Growth is in place in the Netherlands (SER, 2015). The agreement is between the private and public sector, and signatories share responsibility to increase national energy efficiency and the share of renewable energy.

Mandates are indicated as specific policies, which ensure a market for biofuels, and the main support mechanisms to encourage further investments are loan guarantees, and preferential finance. While GHG emissions reduction and the willingness to establish a domestic bioindustry are the main drivers for the establishment of a biofuels market, the main challenges are fossil fuel competition, regulation, and policies.

ADVANCED BIOFUEL FACILITIES IN THE NETHERLANDS

Owner/Date	Biofuel	Feedstock	Capacity	Type of Plant	Status
BioMCN/ 2009	Methanol	Biogas	252 million liters/ year	Commercial	Operational
Woodspirit/ 2017	Methanol	Waste and wood	464 million liters/ year	Commercial	Cancelled
Neste HVO Rotterdam/ 2010	HVO	HVO	1.000 million liters/ year	Commercial	Operational
Empyro plant (Hengelo)/ 2015	Pyrolysis oil	Waste wood	20 million liters/ year	Commercial	Operational
Enerkem/ 2018	Methanol	Waste	28 million liters/ year	Demonstration	Planned

Source: Country responses to the questionnaire.

The Netherlands reported five advanced biofuels facilities, four in commercial stage and one in demonstration stage. Together, they account for 1,009 million liters per year. Here, the main feedstock has been wood, oil and waste. The five companies leading these projects are BioMCN, Woodspirit, Neste, Empyro and Enerkem. BioMCN plants became operational in 2009 and produce 252 million liters of methanol per year. The Woodspirit facility, commissioned in 2017, and the Enerkem demonstration facility, commissioned in 2018, also produce methanol. The former has a 464 million liter-capacity and the latter a 28 million liter-capacity. The other two plants, owed by Neste and Empyro, produce 245 million liters of HVO and 20 million liters of pyrolysis oil, respectively.

BIOPRODUCTS

According to the Netherland's response to the questionnaire, bioproducts have less than 5% national market share, with a target between 11% and 30% by 2030. Promising opportunities are usually linked to drop-in products, and bioproducts are currently being produced mostly in dedicated plants. The main drivers to foster bioproducts development in the Netherlands are biomass promotion, development of new markets and a new biobased industry. Fossil fuel competition and regulations/policies are considered the greatest challenges for bioproduct production.

Labelling, biobased procurement for biobased products and quotas for advanced biofuels were identified as specific policies to ensure market in the Netherlands. The production counts primarily on financial support, with loan guarantees, preferential finance (Green Funds) and tax incentives (WBSO for R&D).

UNITED KINGDOM

Biodiesel		Ethanol	
Consumption	0.73	Consumption	0.79
Production	0.16	Production	0.49
Main feedstock for production	UCO / animals' fat	Main feedstock for production	corn / wheat
Area used (10^3 hec)	N/A	Areas used (10^3 hec)	N/A
Price (USD/L)	N/A	Price (USD/L)	N/A
Totals			
Total volume of biofuels consumed			1.53
Total volume of biofuels produced			0.65
Share in the transport sector (%)			3%

Source: Country responses to the questionnaire, (GAIN, 2017e) and (REN21, 2016). Notes: Figures for 2016. All volumes are expressed in billion liters.

The UK is part of the EU's 2030 climate and energy framework, adopted before the UK´s decision to leave the EU. The framework requires a cut of at least 40% in GHG emissions (from 1990 levels); a share of at least 27% of renewable energy; and an improvement of at least 27% in energy efficiency. In addition, the UK's current long-term target is to reduce GHG emissions in at least 80% by 2050, relative to 1990 levels (Climate Change Act 2008).

There are currently five carbon budgets set in legislation (up to 2032), and they are designed to set a cost-effective trajectory for the delivery of the 2050 target. The Government has indicated that it intends to set a UK target for reducing domestic net emissions to zero in the future.

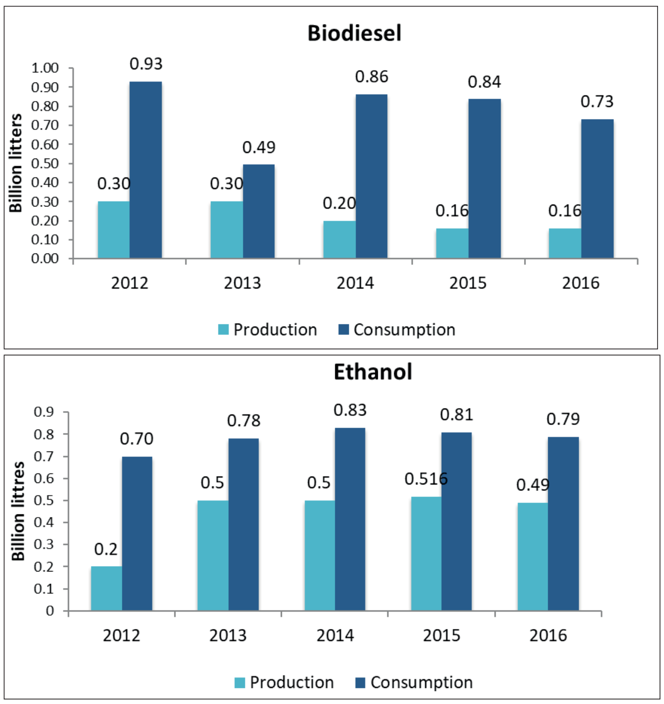
The UK is among the three largest European producers of biodiesel from UCO, together with the Netherlands and Germany. The use of UCO has increased particularly after the country introduced double-counting for non-crop-based biofuels to achieve mandated biofuel blends.

The petrol market is declining in the UK, and bioethanol consumption is projected to decline slightly, if the current biofuel mandate remains unchanged, although production is projected to increase due to improved use of the existing plant capacity. In 2015/16, biofuels made up 3% of the UK´s transport fuel volume. In this context, the Renewable Transport Fuels Obligation (RTFO) was updated in 2017, and is set to increase the current biofuel mandate of 4.75% to 7.25%.

Since the beginning of 2016, ED95 (95% ethanol), consumed exclusively by buses and trucks, is being commercialized. As per biodiesel production, it is expected to remain flat through 2018. Figure 10 highlights the country's biodiesel and ethanol production and consumption from 2012 to 2016, already showing a slight decrease in consumption.

The UK's Committee on Climate Change published a Bioenergy Review in 2011 summarizing the best available data and knowledge on the biomass feedstocks supplies available to the UK, as well as how these feedstocks should be used to deliver further carbon savings at a whole energy system level. It highlighted the importance of bioenergy in meeting the UK's climate targets, concluding that the best uses of biomass were in industrial heat, liquid biofuels for aviation and shipping (preferably with Carbon Capture and Storage (CCS)), and combined with CCS to produce heat, power or hydrogen. Using biomass to generate power without CCS, or liquid transport fuels for surface transport were seen as undesirable uses of biomass in the long term as alternative, lower carbon options were anticipated to be widely available. The Commitee on Climate Change is currently revising its 2011´s Bioenergy Review, following a Call for Evidence in early 2018. The review is expected to be published in late 2018.

Figure 10. Biofuels production and consumption 2012-2016 in the UK (billion liters)



Source: Country responses to the questionnaire.

Mandates were identified as the most important specific policy (namely the RTFO), ensuring a market for biofuels in the UK, and investment grants are considered the main support instrument to encourage investments in biofuels production facilities. The main challenges of the sector are financial resources, and regulation/policies.

ADVANCED BIOFUEL FACILITIES IN THE UK

Owner/Date	Biofuel	Feedstock	Capacity	Type of Plant	Status
Advanced Plasma Power/ 2018	Biomethane	Waste	0	Demonstration	Under construction
Nova Pangaea Technologies/ 2018	Ethanol	Pyrolysis products	0	Demonstration	Under construction
Enerkem/ 2019	Ethanol/methanol	Waste	0	Demonstration	Planned
Future Blends	Pyrolysis oil		0	Pilot	Operational
TMO Guildford/ 2008	Polyacide acide and Cellulosic ethanol	NA	5 million liters/ year	Pilot	Operational
Gogreen gas project/ 2016	Bio Sng	Biomass feedstocks	0,05MW	Pilot	Operational
Betamax/ 2011	Butanol	NA	0	Pilot	Moth balled
BioMara project/ 2009-2012	Ethanol	Algae	0	Pilot	Complete

Source: (ETIP Bioenergy, 2018) and country responses to the questionnaire. Note: Although the UK is leaving the EU, it is included in for comparative purposes as analysed data goes from 2009 to 2018.

The UK reported 8 advanced biofuel facilities, with three demonstration and five pilot projects. The demonstration plants of Advanced Plasma Power (biomethane) and Nova Pangaea Technologies (ethanol) are under construction and should become operational in 2019, and Enerkem's (Ethanol/methanol) plant is planned for the same year. Regarding the UK's pilot projects, one has been completed and the other mothballed, with three operational facilities testing pyrolysis oil, cellulosic ethanol, polyacide, bio substitute natural gas (SNG) and butanol.

BIOPRODUCTS

Country representatives pointed out that the most promising opportunities for bioproducts in the country are drop-in products, currently being made in dedicated plants. The association of bioproducts with biofuels to increase profitability may help foster its deployment. The development of new markets and a new biobased industry, GHG emission reductions and the creation of jobs are presented as drivers to foster bioproducts. Regulation, policies and financial resources are found to be the main challenges.

SWEDEN

Biodiesel		Ethanol	
Consumption	1.10	Consumption	0.30
Production	N/A	Production	N/A
Main feedstock for production	N/A	Main feedstock for production	N/A
Area used (10^3 hec)	N/A	Areas used (10^3 hec)	N/A
Price (USD/L)	N/A	Price (USD/L)	N/A
Totals			
Total biofuels volume consumed			1.4
Total biofuels volume produced			N/A
Share in the transport sector (%)			14.7%

Source: Country responses to the questionnaire, (SVEBIO 2016), (GAIN, 2017e), (Sekretariatet 2015), (REN21, 2016). Notes: Figures for 2015. All volumes are expressed in billion liters.

In Sweden, biofuel policy is strongly based on tax exemptions. Additionally, the country is succeeding with the 10% blending of biofuels in the transport sector.

Nevertheless, the Swedish government enforced a tax on E85 in 2016, which until then had been set at zero, and new taxes for flex-fuel vehicles were implemented. Consequently, the E85 sales dropped, as petrol prices are relatively declining, while the new government-imposed taxes that hinder the use of flex-fuel cars and E85. In 2016, Sweden´s consumption of E85 halved to 45 million liters. Based on energy content, biofuels accounted for 18.6% of all fuel supplied to vehicles operating in Sweden in 2016. Lastly, Sweden´s political target is to reduce the emissions in the transport sector by 70% by 2030 (base year 1990).

ADVANCED BIOFUEL FACILITIES IN SWEDEN

Owner/Date	Biofuel	Feedstock	Capacity	Type of Plant	Status
Varmlands Methanol/ 2016	Methanol	Forest residue	126 million liters/ year	Commercial	Planned
ST1 Biofuels (Gothenburg)/ 2015	Cellulosic ethanol	Wood	5 million liters/ year	Pilot	Operational
Swedish Biofuels/ 2019	Ethanol	ATJ-Wood and municipal solid waste	6 million liters/ year	Pilot	Planned
KTH/ 2009	Jet fuel/biodiesel / Alcohols	NA	0.015MW	Pilot	Operational
BioDME plant (Pitea)/ 2005	Methanol/DME	Black Liquor	1.8MW	Pilot	Operational
Go Biogas project/ 2013	SNG	Wood	20MW	Pilot	Operational
SEKAB/ 2005	Ethanol	Wood	2 million liters/ year	Pilot	Operational

Source: Country responses to the questionnaire.

Sweden reported seven facilities, and similarly to the UK, most existing projects are in the pilot stage, with only one commercial plant. Their total production capacity equals 139 million liters, and the main feedstock used in the country is wood. The pilot plants were built in 2005, 2009, 2013 and 2015 to test jet fuel, methanol, Dimethyl ether (DME), SNG from wood and black liquor. Another plant (wood to ethanol and solid waste to gas) is planned for 2019. Varmlands owns the commercial facility, which was built in 2016, and produces 126 million liters of forest-residue methanol.

NORWAY

Biodiesel		Ethanol	
Consumption	0.17	Consumption	0.05
Production	0	Production	0.02
Main feedstock for production	N/A	Main feedstock for production	Forest residues
Area used (10^3 hec)	N/A	Areas used (10^3 hec)	N/A
Price (USD/L)	N/A	Price (USD/L)	N/A
Totals			
Total biofuels volume consumed			0.22
Total biofuels volume produced			0.02
Share in the transport sector (%)			N/A

Source: Country responses to the questionnaire, (GAIN, 2017e), (Biofuture Platform, 2017a) and (Norway Today, 2018). Notes: Figures for 2016. All volumes are expressed in billion liters.

Norway is committed to a climate target of a minimum 40% of GHG emissions reduction by 2030 (compared to 1990 levels), and intends to fulfill this commitment through a collective delivery with the EU and its Member States.

In Norway, the government's 20% biofuel by 2020 policy had already been reached in 2017, well ahead of the 8% planned for 2017 and 10% for 2018. Such increase in biofuel blending is helping reduce the carbon intensity coming from road traffic.

Mandates and quotas were singled out as the most significant policies to ensure a market for biofuels in the country, and investment grants and loan guarantees comprise the main support instruments to encourage investments into biofuel production facilities. The most important driver for biofuel deployment is the political concern over GHG emission reductions, and the main challenges are financial resources and competition from fossil fuels.

ADVANCED BIOFUEL FACILITIES IN NORWAY

Owner/Date	Biofuel	Feedstock	Capacity	Type of Plant	Status
Borregaard/ 1938	Lignocellulosic ethanol	Spruce wood	20 million liters/ year	Commercial	Operational
Borregaard/ 2012	Lignocellulosic ethanol	Sugarcane bagasse, straw, wood and energy crops	110 t/y	Demonstration	Operational
Weland Bergen	Lignocellulosic ethanol	NA	NA	Pilot	NA

Source: Country responses to the questionnaire.

Norway reported three facilities, one commercial, one demonstration and one pilot plant. There are two companies leading these projects: Borregaard, and Weland. Borregaard owns the only commercial plant, which has been producing bioethanol from wood (spruce) since 1938, and its current production capacity is of around 20 million liters per year. The company also operates the BALI demonstration plant, which is partially funded by the government through Innovation Norway and The Research Council of Norway. Operations began in 2012 with ethanol, lignin performance chemicals, and sugar-based chemicals produced from sugarcane bagasse, straw, wood and energy crops. No figures were identified for the Weland pilot plant. Further noteworthy are the efforts in the country for the expansion on cellulosic ethanol; such a cellulosic ethanol plant, with a 50 million liter- capacity, is expected to be operational in 2021.

BIOPRODUCTS

Norway indicated, in the questionnaire, that the most promising opportunities for bioproducts in the country are drop-in products, with current production mostly integrated with that of biofuels. The association of bioproducts with biofuels to increase profitability may help foster its deployment. Integration with biofuel production to make the business profitable, biomass promotion and GHG emissions reduction are identified as drivers to help foster bioproducts. Financial resources and fossil fuel competition are found to be the main challenges.

SOUTH AND CENTRAL AMERICA

South and Central America has a long tradition of biofuel use mostly due to efforts from Brazil, which began an extensive bioethanol program following the fuel crisis in the mid-1970s. Brazil is the second largest producer of ethanol fuel in the world, after the US, with about 25% of the world´s total ethanol used as fuel.

Argentina and Brazil are among the world's largest producers of Biodiesel, but via distinct strategies: Brazil focuses on supplying its internal market blend requirements, while Argentina is the world's largest exporter (primarily to Europe). Therefore, although Argentina does enforce mandatory and specific sustainability criteria for biofuels, its production must comply with the requirements and regulations of destination countries.

Advanced biofuels are primarily produced in South and Central America by Brazil, although Uruguay also has a pilot plant for pre-treatment of biomass feedstocks within the context of new a lignocellulosic ethanol project. Propelled by two rounds of a tailored finance program launched by BNDES in 2011 and 2014 (discussed below), four facilities are currently operational in Brazil, adding to a production capacity of 172 million liters per year.

ARGENTINA

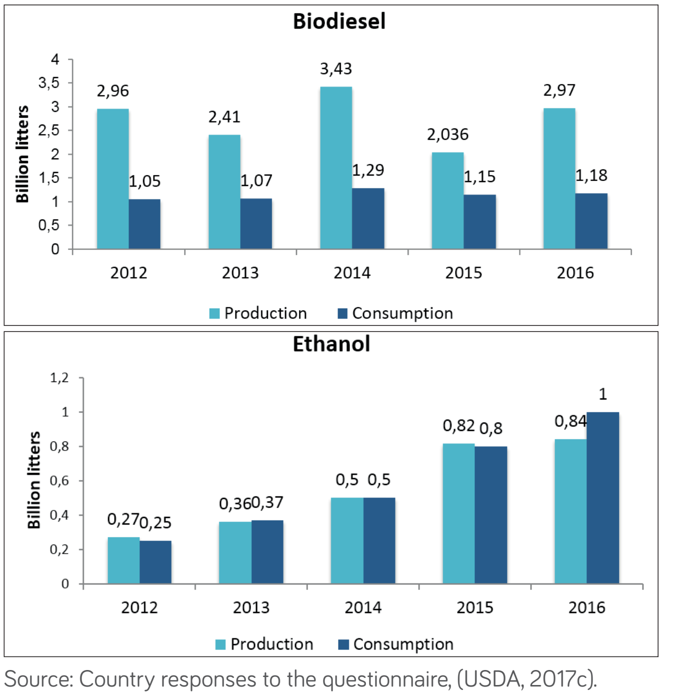
Biodiesel		Ethanol	
Consumption	1.18	Consumption	1
Production	2.97	Production	0.84
Main feedstock for production	Soybean	Main feedstock for production	Sugarcane
Area used (10^3 hec)	N/A	Areas used (10^3 hec)	N/A
Price (USD/L)	N/A	Price (USD/L)	N/A
Totals			
Total volume of biofuels consumed			1.94
Total volume of biofuels produced			3.55
Share in the transport sector (%)			20%

Source: Country responses to the questionnaire, (USDA, 2017c). Notes: Figures for 2016. All volumes are expressed in billion liters.

According to the country's NDC, Argentina has an unconditional goal to reducing GHG emissions by 15% in 2030 with respect to projected BAU. Since 2010, Argentina has mandate mixes for biofuels. Currently, it is 12% for bioethanol in gasoline and 10% for biodiesel in diesel. The Argentinian government is discussing with stakeholders the introduction of a plan to progressively increase its biodiesel and ethanol-blending mandate.

The domestic demand for biofuels is growing slowly, as the mandate continues unchanged in the past few years. There is practically no international trade in bioethanol and, for biodiesel, approximately 60% of 2016 production was exported.

Figure 11. Biofuels production and consumption 2012-2016 in Argentina (billion liters)



Source: Country responses to the questionnaire, (USDA, 2017c).

Specific sustainability criteria are not in place for biofuels in Argentina. However, being a major exporter of biodiesel, the government closely monitors other countries' criteria and regulations in order to avoid restrictions on its exports. The USA government recently enforced duties on Argentinian biodiesel imports, with a direct negative impact on the traded volume[12].

The encouragement of sector investment, preferential finance, tax incentives, and loan guarantees were pointed out as necessary biofuel support mechanisms in the country´s questionnaire. Nonetheless, the main challenge for the sector is the competition with fossil fuels.

BIOPRODUCTS

According to Argentina's responses to the questionnaire, the current share of bioproducts represents between 5% and 10% of the domestic market. Promising opportunities are usually linked to drop-in products, and current production is mostly associated with biofuels.

PARAGUAY

Biodiesel		Ethanol	
Consumption	0.010	Consumption	0.28
Production	0.010	Production	0.25
Main feedstock for production	Soybean	Main feedstock for production	Sugarcane / Corn
Area used (10^3 hec)	N/A	Areas used (10^3 hec)	129.6
Price (USD/L)	0.89	Price (USD/L)	0.71
Totals			
Total volume of biofuels consumed			0.28
Total volume of biofuels produced			0.26
Share in the transport sector (%)			10.5%

Source: Country responses to the questionnaire, (GAIN 2017g). Notes: Figures for 2016. All volumes are expressed in billion liters.

Paraguay approved the Biofuels Promotion Law in 2005, and the use of biofuels is now vital for the country to comply with its NDC target of reducing GHG emissions by 20% before 2030.[12]

The low mix of biodiesel with diesel is mainly due to the fact that the government regulates diesel price, which drives distributing companies opposition to an increase of the blend percentage.

To allow local businesses to scale up, initiatives should focus on a viable price scheme, product quality improvement, production scale increase, new technology and logistics improvements. As long as the government maintains the current minimum blending mandate for ethanol (24%) and the growth of flex-fuel cars expands slowly, the total consumption in the short term will essentially be tied to the increase in petrol demand.

BIOPRODUCTS

In Paraguay, developing drop-in products that are identical to fossil-based products is the only opportunity for bioproducts market growth. Production of bioproducts is currently integrated with that of biofuels and country representatives pointed out biomass promotion, improvement of the country´s trade balance, and reduction of chemicals import as the main drivers to foster bioproducts use in Paraguay. However, fossil fuels competition, regulation and policies, as well as scientific/technological bottlenecks, are seen as the main challenges.

12 In recent years, both US and Europe sought to defend their markets against biodiesel imports through anti-dumping duties. While the US is on track to increase its duties to Argentinian and Indonesian biodiesel, the EU recently lifted its duty after decisions from the World Trade Organization and the European Court of Justice. However, the European Parliament has recently passed a ban on counting biodiesel made from palm oil for the RED targets.

URUGUAY

Biodiesel		Ethanol	
Consumption	0.05	Consumption	0.08
Production	0.05	Production	0.08
Main feedstock for production	Tallow, soybean and canola	Main feedstock for production	Grain sorghum, sugarcane and sweet sorghum
Area used (10^3 hec)	63.79	Areas used (10^3 hec)	32.79
Price (USD/L)	N/A	Price (USD/L)	N/A
Totals			
Total volume of biofuels consumed			0.13
Total volume of biofuels produced			0.13
Share in the transport sector (%)			6.0 %

Source: Country responses to the questionnaire, (GAIN 2017h). Notes: Figures for 2016. All volumes are expressed in billion liters.

Uruguay's NDC includes, as an unconditional mitigation measure, the use of biodiesel and bioethanol at 5% of the total vehicle fleet, both entirely from domestic production, as part of its current efforts to reduce emissions in the transportation sector and in accordance with the national agro-fuels law. Furthermore, the country intends to increase its biofuels consumption, as part of the Paris Agreement, which includes the goal of adopting 7% of biodiesel and 10% of bioethanol blends as conditional measures, and the National Energy Policy 2005-2030, in which Uruguay set a goal to lower fossil fuels consumption in the transportation industry by 15%.

Since 2015, the transportation sector in Uruguay has lowered CO_2 emissions by a rough average of 7% each year, as a direct result of increased use of biofuels. This relevant consumption is due to compliance to agro-fuels mandates, which require a 5% mix of biodiesel in diesel since 2012 and 5% of bioethanol in gasoline since 2015. Between 2013 and 2015, biofuels output increased approximately 50%, further contributing to preventing the emission of 270,000 tons of CO_2.

Uruguay's investment promotion law, although not specific for advanced biofuels and bioproducts, promotes investments in technological innovation by national and foreign investors via tax incentives, which are the main support instruments for investments in advanced biofuels in the country. The main drivers for biofuels and bioproducts development pointed out in Uruguay's questionnaire are the establishment of a domestic bioindustry, job creation and the promotion of sustainable local resources use. The lack of financial resources is mentioned as the main challenge.

ADVANCED BIOFUEL FACILITIES IN URUGUAY

Owner/Date	Biofuel	Feedstock	Capacity	Type of Plant	Status
CIDEB/ 2016	Lignocellulosic ethanol	Eucalyptus wood, among others	NA	Pilot (biomass pre-treatment)	Operational

Source: Country responses to the questionnaire.

Uruguay currently has one pilot plant for lignocellulosic biomass pre-treatment, which was commissioned in 2016 by *the Centro de Investigación y Desarrollo en Biocombustibles de Segunda Generación (CIDEB*) and can produce up to 10 kg/h of bioethanol from eucalyptus wood at a laboratory level, with ongoing investigation on the use of other feedstocks, such as switchgrass. Argentina and Paraguay did not report any existing pilot, demonstration or commercial facilities and further research found no additional information on current or potential developments.

BRAZIL

Biodiesel		Ethanol	
Consumption	3.81	Consumption	27.6
Production	3.80	Production	28.3
Main feedstock for production	Soybean	Main feedstock for production	Sugarcane
Area used (10^3 hec)	33,177	Areas used (10^3 hec)	9,049
Price (USD/L)	0.70	Price (USD/L)	0.42
Totals			
Total biofuels volume consumed			31.4
Total biofuels volume produced			32.1
Share in the transport sector (%)			20%

Source: Country responses to the questionnaire, (EPE, 2017b). Notes: Figures for 2016. All volumes are expressed in billion liters.

Brazil is the world's second largest bioethanol producer, with a well-established supply chain initiated in the 1970s, boosted by the Pro-Alcohol program. Nowadays, every Brazilian gas station is required to offer petrol-ethanol blends containing 27% ethanol and the majority also offers pure ethanol. Since 2006, cars with flex-fuel technology have surpassed half of the total number of registered cars in Brazil, and until December 2017, 88,7% of new registered cars were flex-fuel (ANFAVEA, 2017).

Sugarcane is the main feedstock for the production of both ethanol and sugar in Brazil, manufactured in tandem, given the significant overlap in the production process of both outputs. The destination of sugarcane is therefore largely driven by sugar prices and consists in one of the main bottlenecks for substantial replacement of fossil fuels with ethanol in the country's transportation sector. In fact, ethanol shortages led by high sugar prices have created market insecurity in the country's overall biofuel supply.

The viability of ethanol production in Brazil was driven by the use of sugarcane bagasse (a residue of the ethanol production) to generate vapor and electricity (cogeneration system). Nowadays, the main focus in this area is the use of other sugarcane residues (such as straw and vinasse) for the production of value-added products. Sugarcane straw and bagasse are lignocellulosic materials, i.e., residues that can only be converted into ethanol through second generation routes.

Investment in corn ethanol has been rapidly growing, especially in the Midwest region of the country; with most production being currently exported and dependent on foreign investors, such as the USA. At least six plants are expected to be built or expanded in the region in 2018, which will demand more than 3 million tons of corn per year, or about 6% of the total harvested in said region. The State of Mato Grosso, the main corn ethanol producer, is also the major national grain producer. There are four ethanol plants in the State, three of which can produce ethanol from corn and sugarcane. Such development is driven by the abundance of corn, interest rates and the good prospects for ethanol consumption in the country. This sector's growth, coupled with the incentive offered by the RenovaBio program, will boost the consumption of fuels as a whole (Zaia & Souza, 2018).

Ethanol consumption and production fluctuated in the last few years - as shown in Figure 12; in most years, a positive or near neutral balance between production and consumption was reached, indicating self-sufficiency and a solid national market.

In 2015, national ethanol production increased, a positive result especially in light of the delicate situation of the sugar and alcohol industries, which have been marked by the closure of several mills in the last eight years (UNICA, 2016). Despite the price liberalization of oil products in the early 2000s, the Brazilian government had an indirect influence on petrol, diesel, and LPG prices through the shareholding control of Petrobras. In recent years, petrol price has been kept artificially low, aiming to control inflation. This has led to an artificial competitive advantage of petrol over ethanol, generating losses for the industry over the last few years (Oliveira and Almeida, 2014).

Ethanol production is expected to expand to 45 billion liters in 2025 and 54 billion liters in 2030 (EPE, 2016). Moreover, according to the National Petroleum Agency (ANP), there are currently 352 authorized ethanol production plants. Sugarcane is the raw material used in 97.1% of the plants in operation (Pinto, 2016).

Biodiesel was established in the Brazilian energy matrix in 2005 by a regulation, which defined the addition of 2% biodiesel to conventional diesel (called B2). The regulation contemplates a progressive increase, and since March 2018, the required blend is 10% (B10).

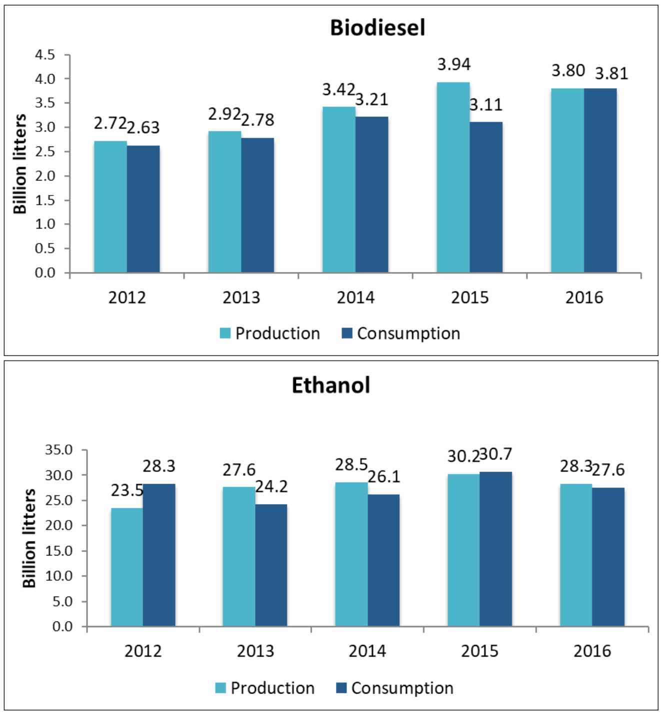
There are 51 biodiesel production plants authorized by ANP to operate in Brazil, corresponding to a total authorized capacity of 19,976.81 m^3/ day (Pinto, 2016). The main raw material for biodiesel production has been soybean, and there is room for the use of other feedstocks.

A model that has demonstrated positive results for socially responsible production is the Social Fuel Label (*Selo Combustível Social*, in Portuguese). To incentivize social inclusion in fuel-based agriculture, the Label assembles specific measures to guarantee this goal. The Label considers the potential of social inclusion, employment generation and income that the biodiesel value chain presents to family farmers. It helps guide the advancement of public policies focused on the decentralization of development, mainly for the North and Northeast regions of Brazil. Cooperativism among farmers has been consolidated as an important tool for strengthening the program. Biodiesel resulting from the program is eligible for fiscal incentives and tax exemptions.

Technology improvements are leading a respectable rise in the production. In 2007, it amounted to 0.4 billion liters compared to 3.8 billion liters in 2016, approaching a 10-fold increase in less than 10 years (BEN, 2017). As shown in Figure 12, the country is self-sufficient regarding biodiesel production.

In order to support the biodiesel production sector in Brazil, there are several fiscal incentives currently in place regarding the acquisition of raw materials, as exemption from the Industrialized Product Tax (IPI), as well as reductions in Income Tax for companies that make or market green fuels. BNDES offers investment grants and financing for all phases of biodiesel production and use in Brazil, including storage and logistics for production outflow. The Bank works towards financing up to 90% of projects with social impact, or up to 80% of other eligible projects (CEBDS, 2017).

Figure 12. Biofuels production and consumption 2012-2016 in Brazil (billion liters)



Source: Country responses to the questionnaire.

BIOKEROSENE

The aviation sector is rapidly growing in Brazil and is heavily dependent on fossil kerosene (ANAC, 2015). That dependence might increase in the next decades, followed by GHG emissions.

Currently under discussion, the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) will presumably be approved as a result of International Civil Aviation Organization (ICAO) negotiations for a global scheme aiming to the compensation and reduction of GHG emissions in international civil aviation. It addresses ICAO's global aspirational goal of carbon neutral growth from 2020 onwards. The aviation industry is committed to technology, operations and infrastructure advances to continue to reduce the sector's carbon emissions, including the use of aviation biofuels as one of the measures for CO_2 emissions reduction.

ICAO´s projections reveal the central role that the aviation biofuels market must have in the coming decades in order to achieve the goal of reducing CO_2 emissions in international civil aviation. In particular, the use of drop-in sustainable alternative fuels is an important means of reducing aviation emissions in the short and mid-term (ICAO, 2018).

As one of the leading countries in the development of new technology and policies associated with biofuels, Brazil could be one of the main leaders in biokerosene production. Carbon emission reductions in the aviation sector could be boosted in the next decades. With this purpose, the Brazilian Association for Biofuels in Aviation (ABRABA), comprised of important players such as LATAM, GOL and EMBRAER, was launched in 2010, to discuss the implementation of biofuels in the Brazilian aviation sector.

Since 2014, the State of Minas Gerais has counted on a collaborative platform for biofuels production, aiming at the integration of the players and sustainable production among the value chain. The "*Plataforma Mineira de Bioquerosene e Renováveis*" has been developing strategic partnerships for the implementation of a value chain with regional processes of river basin revitalization using oilseeds species (for example, the *Acrocomia aculeate*, known as Macaúba) to obtain sustainable biomass. Agricultural waste and urban waste are also used for biodiesel production.

Currently, the main routes to produce biokerosene (in the research phase) use soybean, palm, cotton, sunflower and canola as feedstock (EMBRAPA, 2015). Further research is necessary to implement production in Brazil, but it is also necessary to establish incentive policies, and a solid logistics system. The ethanol market structure that the country has today is a seamless example of how the use of biokerosene could be implemented.

CLIMATE POLICIES AND TARGETS

The Paris Agreement lays the groundwork for international cooperation, starting in 2020, by adopting national commitments – NDC – and a systematic process to increase the ambition of these commitments. The Brazilian contribution, submitted to the United Nations (UN) General Assembly in September 2015, includes a reduction of 37% in Brazilian greenhouse gas (GHG) emissions by 2025 (equivalent to 1,346 million tons of carbon equivalent - tCO2e), in addition to an indication of a 43% reduction in national emissions by 2030 (equivalent to 1,208 million tCO2e), based on 2005 levels.

The NDC's goal corresponds to an effort of the Brazilian economy as a whole. However, it presents indications of commitments for specific sectors, one being the energy sector, with mentions to the increase of bioenergy participation in the matrix:

> "increasing the share of sustainable biofuels in the Brazilian energy mix to approximately 18% by 2030, by expanding biofuel consumption, increasing ethanol supply, including by increasing the share of advanced biofuels (second generation), and increasing the share of biodiesel in the diesel mix" (Federative Republic of Brazil , 2016).

Estimates from the Sugarcane Industry Association (UNICA) - indicate that the Brazilian NDC presents opportunities for the productive sector, which will almost double ethanol production and build approximately 75 new production units. Moreover, this increase has the potential of generating 250 thousand new direct jobs. This would require investments of USD 40 billion by 2030 (UNICA, 2016).

The Brazilian experience with the infrastructure required for the production and distribution of ethanol and biodiesel, along with local climatic factors that allow diversity and abundance of feedstock, are elements that contribute to the replacement of fossil fuels in the matrix with low additional investments (CEBDS, 2017).

Another recent opportunity to reach the NDC targets for biofuels is the RenovaBio program, an innovative federal effort to reduce the carbon intensity of Brazil´s transport sector and develop the country's biofuels sector. Inspired by elements of California´s Low carbon Fuel Standard (LCFS) and the US Renewable Fuel Standard (RFS), RenovaBio establishes annual decarbonization targets for a minimum 10-year period, to be met by transport fuel distributors. To ensure the targets are met, biofuels producers are authorized to issue tradeable GHG emissions reduction certificates, named "CBios". Project level certification of biofuels producers, through carbon life cycle analysis and sustainability requirements, leads to the most carbon-efficient producers being able to issue more CBios in exchange for their fuel.

ADVANCED BIOFUEL FACILITIES IN BRAZIL

Owner/Date	Biofuel	Feedstock	Capacity	Type of Plant	Status
Amyris/ 2012	Jet Fuel/ Farnesene	Sugarcane	45 million liters/year	Commercial	Operational
Raizen/ 2014	Lignocellulosic ethanol/ Straw-Ethanol	Sugar Crop Residue	42 million liters/year	Commercial	Operational
GranBio/ 2014	Cellulosic Ethanol	Sugarcane Residue	82 million liters/year	Commercial	Operational
CTC/ 2014	Cellulosic Ethanol	Sugarcane	3 million liters/year	Demonstration	Operational
Ensyn/Fibria/2016	Biocrude	Wood (eucalyptus) residues	83 million liters/year	Commercial	Planned

Source: Country response to the questionnaire and (EPE, 2017a).

Among commercial facilities, Amyris operations in Brazil began in 2008, with a pilot plant to test its Biofene technology for the production of farnesene, in Campinas, São Paulo (Brazil's main sugar-cane producing state). In 2013, the company built its first local commercial facility in Brotas, also in São Paulo, with an installed capacity of 45 million liters year. Early in the decade, Raizen - a joint venture between Royal Dutch Shell and Brazilian Cosan - invested BLR 237 million (USD ~71 million) in R&D and infrastructure, largely financed by BNDES, to develop its advanced biofuel technology in Canada in partnership with Iogen Energy (Raizen, 2018) and launch a commercial facility in 2014, in Piracicaba, São Paulo. The plant currently produces 42 million liters of lignocellulosic ethanol per year from sugarcane straw and bagasse. By 2024, the company plans to build another seven cellulosic ethanol facilities in Brazil. Finally, GranBio also began its production in 2014 with the country's largest facility, boasting an installed capacity of 82 million liters per year in São Miguel dos Campos, in the State of Alagoas. Limited information is available regarding its production process, although the company announces plans to build 10 new advanced biofuel plants in Brazil by 2022.

More recently, Ensyn and Fibria formed a partnership for the construction of a biocrude facility, which is expected to deliver up to 83 million liters per year.

The Sugarcane Technology Center (CTC) owns the only existing demonstration facility in Brazil, located in São Manoel, also in the State of São Paulo. It converts sugarcane bagasse into 2G ethanol using a self-developed patented process, reaching 3 million liters per year - although announcements indicate a scale-up is likely to occur in 2018.

BIOPRODUCTS

Bioproducts can replace a number of products that are currently derived from carbon-intensive fossil sources. There are several opportunities to take advantage of bioproducts in the already well-established Brazilian biofuels production chain. For instance, ethanol production generates other co-products that can be exploited for energy purposes, such as bagasse, sugarcane straw and vinasse. The energetic use of the bagasse is already well established for cogeneration purposes. Sugarcane straw is an agriculture residue generated in the harvest, and as the bagasse, it can be used as combustion feedstock for electricity and to produce second generation ethanol, as they are both made of lignocellulosic material. The vinasse is another byproduct of bioethanol production that contains high organic matter concentration, therefore presenting an opportunity to generate energy from biogas.

On the non-energetic front, biorefineries are being developed on the back of long-standing industries such as pulp and paper, chemical plants, starch processing and conventional biofuel processes, to the extent that bioproducts can enhance business profitability. Biorefineries alone could lead to USD 400 billion of direct and indirect investments for Brazil by 2020 (Estadão, 2018).

The current market of bioproducts represents less than 5% of market share and there are no specific targets for bioproducts by 2030. The most promising opportunities are mostly drop-in and at present, integrated with biofuels. The main driver to foster bioproducts development is the association with biofuels to give profitability to the business, whereas the main challenges are fossil fuel competition and regulation/policies.

Brazilian Green Plastic

The main player in green plastic production in Brazil is Braskem, a company that carries innovative research on alternative technologies leading to products made from renewable sources. In September 2010, Braskem´s green ethylene plant was commissioned for bioplastic production on a commercial scale, securing the company´s leading position in the global market. 290 million US dollars were invested in the plant that has an annual capacity of 200,000 tons of green plastic (I'm greenTM Polyethylene) (BRASKEM, 2017).

NORTH AMERICA

North America is the largest biofuels producer due to U.S. ethanol. Canada has been supporting biofuels production and consumption over the last five years, and has a modest capacity of first generation biofuel production, importing significant amounts from the U.S.

The sub-continent is the most active of all regions in terms of deploying advanced biofuel technology (cellulosic ethanol, isobutanol for fuels, and chemicals and renewable chemicals plants). The main drivers of progress concerning the biofuel industry, especially in the USA, are: i) a robust and continued technology development that counts on public R&D support; ii) the availability of all sorts of biomass resources (waste, grains, and wood) and; iii) long-term public policy, incentivizing markets and investments (Advanced Biofuels USA, 2018).

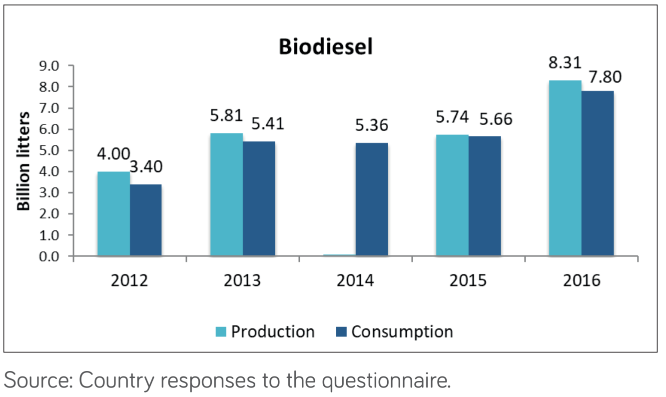
UNITED STATES OF AMERICA

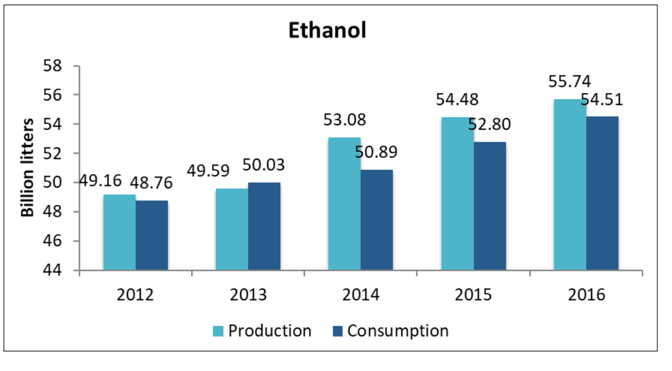
Biodiesel		Ethanol	
Consumption	7.8	Consumption	54.51
Production	8.31	Production	55.74
Main feedstock for production	Soybean	Main feedstock for production	Corn
Area used (10^3 hec)	871	Areas used (10^3 hec)	12,688
Price (USD/L)	0.89	Price (USD/L)	0.55
Totals			
Total biofuels volume consumed			62.3
Total biofuels volume produced			64
Share in the transport sector (%)			5.13%

Source: Country responses to the questionnaire, (EPE, 2017a), (U.S. DOE, 2017), (EPA, 2018a). Notes: Figures for 2016. All volumes are expressed in billion liters.

Although the USA is the most prominent producer and consumer of biofuels in the world, according to the U.S. Energy Information Administration (EIA), 80.1% of the total primary energy consumed in the country in 2016 still derived from fossil fuels. In the last five years, ethanol production in the USA increased 11.8%, and biodiesel 36.8% - see Figure 13.

Figure 13. Biofuels production and consumption in the USA 2012-2016 (billion liters)





Source: Country responses to the questionnaire.

The RFS is a national program that plays a central role in biofuel expansion in the country and intends to raise biofuel output to 136 billion liters by 2022. The blend mandate for ethanol and biodiesel in fossil fuels is calculated yearly, according to production projections for the coming year.

The State of California counts on its own program, the LCFS, that uses a market-based cap and trade approach to lowering the GHG emissions from petroleum-based transportation fuels. The goal of the LCFS program is to reduce the carbon intensity of the transportation fuel pool by at least 10% by 2020 (California Air Resources Board, 2018).

The main drivers for biofuel development listed in the country´s questionnaire are energy security, the establishment of a domestic bioindustry, and job creation. However, the lack of financial resources, competition with fossil fuels, regulation and policies are considered the main challenges of the sector.

ADVANCED BIOFUEL FACILITIES IN THE USA

After the EU, the USA has the largest number of advanced biofuel facilities, with 12 being listed. Of these, 11 commercial and one demonstration plant. Around 50% of listed projects are directed towards the production of lignocellulosic ethanol. The U.S. response to the questionnaire included only demonstration or commercial advanced biofuel plants.

In the USA, of the 11 commercial plants, three are operational, five on hold (one of them was sold), two planned and one under construction. These projects produce 2G ethanol (from corn, straw, and municipal solid waste), HVO, jet fuel, biocrude and diesel. The two largest projects are Diamond Green Diesel HVO facility in Louisiana, with a production capacity of 567 million liters, and AltAir Fuels Biofuel Production Facility, with a production capacity of 151 million liters..

Owner/Date	Biofuel	Feedstock	Capacity	Type of Plant	Status
Red Rock Biofuels/ 2018	FT diesel	Forestry residues, sawmill waste and wood	61 million liters/year	Commercial	Planned - advanced
POET-DSM/ 2014	Lignocellulosic ethanol	Straw	76 million liters/year	Commercial	Operational
Beta Renewables/ 2016	Lignocellulosic ethanol	Miscanthus and switchgrass	76 million liters/year	Commercial	On Hold
Abengoa Bioenergy	Lignocellulosic ethanol	Corn stover, wheat straw, switch grass	95 million liters/year	Commercial	Plant was sold
ZeaChem	Lignocellulosic ethanol	Poplar trees, wheat straw and wood	95 million liters/year	Commercial	On hold
DuPont/ 2015	Lignocellulosic ethanol	Corn stover and straw	114 million liters/ year	Commercial	On hold
Beta Renewables/ 2016	Lignocellulosic ethanol	Lignocellulosic crops or residues	114 million liters/year	Commercial	On hold
Louisiana Diamond Green Diesel/ 2013	HVO	animal fats and oils	567 million liters/ year	Commercial	Operational
AltAir Project (Los Angeles) / 2016	Renewable jet fuel and renewable diesel	NA	151 million liters/year	Commercial	Operational
Fulcrum BioEnergy Reno/2017	FT syncrude, jet fuel and diesel	MSW	40 million liters/year	Commercial	Under construction
Ensyn, Roseburg/2016	Biocrude	Forest residues, wood residues	76 million liters/year	Commercial	Planned
Oberon Fuels, Brawley, California/2013	DME, methanol	Biogas	6 million liters/year	Demonstration	Operational

Source: Country responses to the questionnaire.

BIOPRODUCTS

In the USA, key drivers to foster bioproducts development are the association with biofuels to make the businesses profitable, the development of new markets and a new biobased industry, the improvement of the country´s trade balance (reducing chemicals imports) and the creation of jobs. The lack of financial resources, fossil fuel competition, and regulations/policies are considered the greatest challenges for bioproduct production.

CANADA

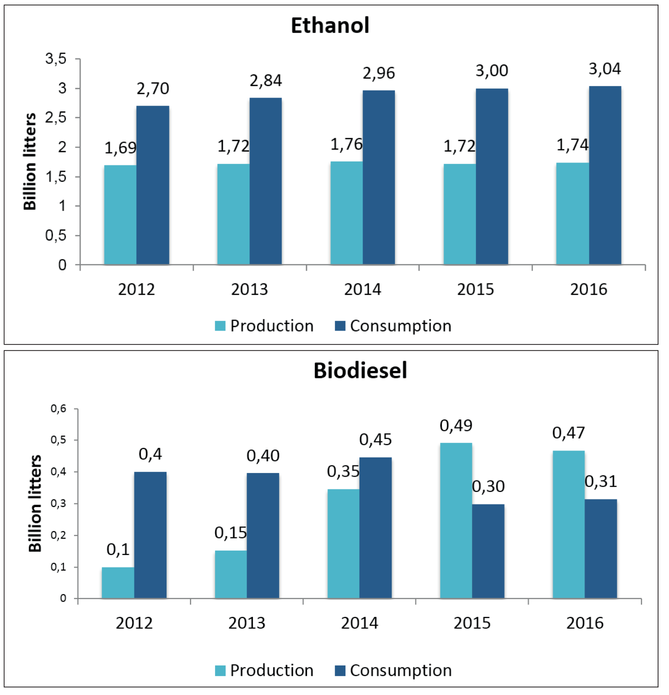
Biodiesel		Ethanol	
Consumption[13]	0.31	Consumption	3.04
Production	0.47	Production	1.74
Main feedstock for production	Canola	Main feedstock for production	Wheat / Corn
Area used (10^3 hec)	N/A	Areas used (10^3 hec)	N/A
Price (USD/L)	N/A	Price (USD/L)	N/A
Totals			
Total biofuels volume consumed			3.35
Total biofuels volume produced			2.22
Share in the transport sector (%)			3

Source: Country responses to the questionnaire, (Government of Canada 2017) and (GAIN 2016b). Notes: Figures for 2016. All volumes are expressed in billion liters.

Since 2010, it is mandatory that gasoline in Canada meets at least 5% of renewable fuel content (some provinces call for higher values), while diesel and heating distillate oil must contain a minimum of 2% renewable fuel, based on volume.

Canada signed the Paris Agreement in 2015 and pledged to cut its emissions by 30% below 2005 levels before 2030. As part of its Paris commitments, Canada announced, in late 2016, it would be developing a Clean Fuel Standard (CFS) to reduce GHG emissions by 30 megatons in 2030. In late 2017, a regulatory framework was published providing some details on the regulation scope, regulated parties, carbon intensity approach, timing, and potential compliance options such as credit trading. The government is currently consulting with industry and other stakeholders on the regulatory design.

Figure 14. Biofuels production and consumption 2012-2016 in Canada (billion liters)[14]



Source: Country responses to the questionnaire.

13 Including HVO, which represents c. 40% of Canada's total renewable content blended in diesel.

14 HVO consumption is 0.2 BL and represents approximately 40% of renewable diesel consumption.

The government of Canada estimates that almost 50% of biofuels (ethanol and biodiesel) consumed in the country are imported from other countries, mostly from the USA. The main drivers for biofuel deployment in the country are GHG emission reductions, the establishment of a domestic bioindustry, job creation, and the promotion of sustainable local resources.

ADVANCED BIOFUEL FACILITIES IN CANADA

Canada has a few operating commercial advanced biofuel facilities. Enerkem operates a waste-to-fuels facility in Edmonton, Alberta. This facility converts municipal solid waste to methanol and started ethanol production in 2017. Once it reaches full capacity, the facility will convert 100,000 tons of organic waste into 38 million liters of ethanol. Enerkem is expected to begin construction of its second commercial facility in 2018, partnering with GreenField. To be co-located at GreenField's existing ethanol facility in Quebec, this new cellulosic ethanol facility will have a production capacity of 35 million liters and is expected to become operational in 2020. Enerkem Inc. commissioned the first facility in 2009, in Westbury, to test and validate its methanol to ethanol technology. In 2012, it began production of cellulosic methanol currently reaching 5 million liters per year.The other operating commercial advanced biofuels facility in Canada is Ensyn's 11 million liter biocrude facility in Ontario. Ensyn is currently constructing its second facility (known as the Côte-Nord Project), in a joint-venture with Arbec Forest Products and Groupe Rémabec. The facility, located adjacent to Arbec's sawmill on the north shore of the St. Lawrence Seaway in Quebec, will produce 40 million liters of biocrude from approximately 65,000 dry metric tons per year of slash and other forest residues. The biocrude will be sold to customers in the U.S. and in Eastern Canada for heating purposes and as a renewable feedstock for petroleum refineries for the production of low carbon transportation fuels. Woodland Biofuels Inc. commissioned a demonstration plant in 2011. Located in the Bio-industrial Innovation Center, in Ontario, Woodland tests its biomass to ethanol technology. The facility produces 2 million liters of ethanol per year.

Owner/Date	Biofuel	Feedstock	Capacity	Type of Plant	Status
Enerkem/2017	Cellulosic ethanol	organic waste	38 million liters/year	Commercial	Operational
Enerkem/2009	Cellulosic ethanol	mixed feedstocks	5 million liters/year	Demonstration	Operational
Ensyn/2014	Biocrude	forestry biomass	11 million liters/year	Commercial	Operational
Enerkem/2020	Cellulosic ethanol	organic waste	35 million liters/year	Commercial	Under construction
Ensyn/2020	Biocrude	forestry biomass	40 million liters/year	Commercial	Under construction
Woodland Biofuels Inc/2011	Ethanol	Agricultural and forestry waste	2 million liters/year	Demonstration	Operational
Licella/CanforPulp Joint Venture/2016	Biocrude	Wood waste	63.5 million liters/year	Commercial	Planned

Source: Country responses to the questionnaire; (Biofuels Digest, 2018).

BIOPRODUCTS

According to the country´s questionnaire, the current share of bioproducts in the national market is less than 5%. Promising opportunities are usually linked to drop-in products and products with new functionalities (for example, biochemical, advanced biomaterials).

OVERVIEW OF ADVANCED BIOFUEL FACILITIES

While a significant number of countries across the BfP and SBIC/MI are producing advanced biofuels, less than half of the reported facilities are in commercial stage, and many of them are not yet operational. Pilot and demonstration plants represent the majority of projects – 46 altogether - indicating there are still technological and economic challenges to overcome to scale up these facilities and cement a 2G market. Other factors and barriers, such as regulatory frameworks and available financial resources, have also affected the development of advanced biofuels in selected countries. These issues will be further explored in the following section.

MEXICO

Biodiesel		Ethanol	
Consumption	N/A	Consumption	N/A
Production	N/A	Production	N/A
Main feedstock for production	N/A	Main feedstock for production	N/A
Area used (10^3 hec)	N/A	Areas used (10^3 hec)	N/A
Price (USD/L)	N/A	Price (USD/L)	N/A
Totals			
Total volume of biofuels consumed			N/A
Total volume of biofuels produced			N/A
Share in the transport sector (%)			N/A

Source: Country responses to questionnaire, (GAIN 2016a). Notes: Figures for 2016. All volumes are expressed in billion liters.

The Mexican NDC commits to unconditionally reduce 25% of the country's GHG and short-lived climate pollutants emissions by 2030 (to below BAU levels).

Currently, Mexico's advances in biofuels are primarily focused on designing and strengthening public policy to promote their production and use, in order to cope with climate change mitigation targets, and diversify the country´s energy matrix. The Mexican government estimates that the biodiesel industry can grow up to a 3.2 million m3/y supply.

4.

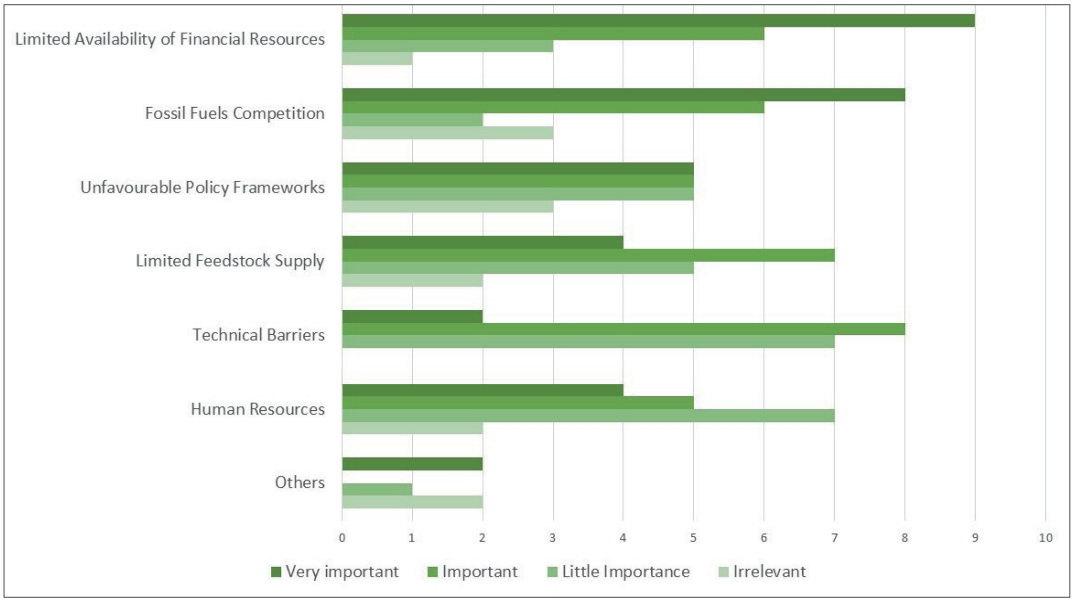
BARRIERS TO GROWTH

A range of barriers limits the development and deployment of biofuel and bioproduct markets, and hinders their capacity to contribute to a low carbon future. Throughout all regions, countries note two central factors holding back the bioeconomy: limited availability of financial resources (whether for R&D, demonstration support or investment support); and competition that biofuels and bioproducts face against fossil alternatives, which are often backed up by subsidies. North America, Brazil, specific EU countries, India and Indonesia note that unfavorable policy frameworks have also negatively affected some sectors of the bioeconomy. Finally, Mozambique, the EU, Mexico, Uruguay and North American countries indicate there are limitations around feedstock supplies, which can be insufficient, expensive or inadequate.

Technical barriers and human resources are not perceived as a key issue in most countries, noting difficulties in accessing technologies and building capacity are often related to limitations around local supply chains, which are in turn connected to inadequate policy frameworks, import tariffs, exchange rate risks, etc. Sustainability is also a relevant issue, and can be directly related to the barrier on limited feedstock supply, as the sustainable scaling up of adequate feedstock for the low carbon bioeconomy is viewed as a challenge by some countries.

Figure 15 summarizes countries' responses to barriers holding back biofuel and bioproduct markets, ranking these in order of importance. The highest ranked barriers hindering bioeconomy markets are discussed below along with specific examples and initial insights into the opportunities to overcome them.

Figure 15. Summary of barriers to the development of biofuel and bioproduct markets



Source: Countries responses to the questionnaire.

Limited financial resources

Advanced biofuels and bioproduct projects, whether at lab, pilot, demonstration or commercial scale, involve high investment costs and are frequently faced with significant uncertainties, often putting off private efforts towards the commercialization of such technologies. The availability and costs of financial resources, however, are only a secondary barrier, the primary one being the high capital costs associated with investments in biofuel plants/biorefineries, as well as the perceived risks associated with investments in the sector. At least partially, these risks can be linked to the other barriers mentioned in this report, inasmuch as the volatility of international oil prices, uncertainties regarding feedstock supplies and inadequate policy frameworks may all greatly increase the risks associated with investments in biofuels and biorefineries. Moreover, perceived risks and high investment costs may hinder additional funding in RD&D necessary to tackle remaining technical challenges and scale-up production and use of advanced biofuels at full commercial scale. Public funding therefore remains fundamental to catalyse private sector activity in advanced biofuels and the scarcity (or inadequacy) of finance or R&D support may keep technology developers from pushing technology boundaries towards reducing biofuel or bioproduct costs and scaling up production.

From a government perspective, a number of issues can limit the availability and/or effectiveness of grant or finance mechanisms, such as: constrained resources; competing priorities and public financiers' risk perception. Governments are challenged to deploy resources as cost-effectively as possible to change the risk perception for advanced bioeconomy projects and attract investments into commercial plants. Countries have been partially successful in doing so, as shown below.

Despite significant advances achieved in pilot and demonstration projects, these have struggled to be scaled-up in to commercial plants. In the USA for instance, the advanced bioeconomy benefitted from USD 1.7 billion between 2007 and 2014 (UNCTAD, 2016), with ~USD 200 million/year in grants provided mainly by the Department for Energy (DOE) between 2012-2016 and ~USD 66 million/year in loans provided by the United States Department of Agriculture (USDA) through Section 9003 of the Farm Bill (CRS, 2017). However, investments have gone mainly to pilot and demonstration projects, rather than commercial ones due to their high capital costs and risks. Despite major public support, only a small number of projects have managed to move into commercial scale in the USA.

Advanced biofuels and bioproduct projects have high investment costs, limiting the reach of public funding. Governments must use resources as cost-effectively as possible to tackle remaining technical challenges and change the risk perception for advanced biofuels and biorefinery projects, leading to investment decisions.

Scaling up projects is also a key gap in the EU, where the European Investment Bank (EIB) has identified that largest financial constraints are witnessed when moving projects along from pilot to demonstration scale; and from demonstration to commercial scale (EIB, 2017).

Brazil's Development Bank successfully catalyzed ~USD 300 million in private sector investments by providing BRL 2.5 billion (~USD 720 million) in concessional loans for 4 private companies to build commercial-scale advanced biofuel & bioproduct plants across the two editions of the Joint Plan for Supporting Industrial Technological Innovation in the Sugarcane-based Energy and Chemical Sectors (PAISS) in 2011 and 2014. BNDES representatives report the scheme was 6 times oversubscribed with highly qualified projects demanding BRL 15 billion (~USD 4 billion), most of which were not selected due to budget constraints, reinforcing the need for public support.

Public and private investments on conventional and advanced biofuels decreased globally since the mid-2000s - as shown in Figure 2 - namely in Brazil, EU and the USA. In the EU, public investments in biofuels as a whole decreased, following the global economic downturn, which tightened government budgets and reallocated funding to more established and cost-competitive technologies, such as wind and solar. Finally, in the USA, investments for conventional and advanced biofuel projects decreased in particular across the private sector, with companies becoming more risk adverse since 2007, although public support remained relatively stable throughout the past 5 years. However, the private trend is slowly reverting, with new 2G facilities from POET, Red Rock and Fulcrum expected to be inaugurated in the coming years. In Brazil, investments in advanced bioeconomy are picking-up since 2015 and are expected to do so more intensively to the extent the recently enacted RenovaBio mandate (Law 13,576/2017) induces demand for the lowest-carbon biofuels.

Remaining technical challenges to scale up advanced biofuels solutions and the need for an an enabling environment

The technology readiness level of different advanced biofuels pathways significantly vary, depending on a number of factors such as feedstocks' supply chains potential and costs, as well as the technological and economic maturity of the conversion process. While some technologies, such as renewable diesel (HVO), are already widely deployed commercially, most second generation biofuels are not yet fully commercialized. As a result, actual production of advanced biofuels is significantly lower than the installed capacity (IRENA, 2016b).

Upgrading pyrolysis oil to transport fuels such as diesel, jet fuel and gasoline still faces technical barriers related to the development of fast pyrolysis processes and demonstration of a stable intermediate pyrolysis oil suitable for storage and downstream processing. Similarly, hydrothermal upgrading of biomass feedstocks into bio-crude, an intermediate, energy-dense oil that can be further upgraded and refined to produce diesel, gasoline and jet fuel faces technical barriers related to problems in downstream processing of bio-crude and handling of large quantities of feedstocks. Conversely, while algal biofuels production in theory may use established conversion technologies, significant technical challenges are related to capital costs and energy intensity of feedstock production, as well as to issues regarding feedstock contamination from external sources.

Fermentation of sugars from agricultural residues such as corn stover, wheat straw and sugarcane bagasse to produce lignocellulosic ethanol have already reached early commercial stage, but many of the first-of-a-kind or flagship plants experienced technical difficulties related to feeding, handling and processing feedstock in large quantities. In the past few years, there has been progress in tackling remaining technical challenges in some crucial steps of the production process, such as pre-treatment of lignocellulosic biomass, enzyme costs and performance, and, while progress have been slower than initially expected, encouraging signs have been appearing in 2017/2018, with some of the 'first-of-a-kind' commercial lignocellulosic biorefineries moving towards nominal capacity.

Progress in tackling the unresolved technical barriers may vary among the array of novel advanced biofuels technologies, however, a key factor to address the issue is the implementation of supportive policies and market frameworks to reduced perceived investment risks and secure and expand financing in RD&D. Moreover, widespread adoption of the best-performing and technically mature bioenergy solutions can provide an enabling environment for further and swifter progress of novel technologies at a lower readiness level due to remaining technical barriers (IEA, 2017b).

Competition with fossil fuel-based alternatives

Biofuels and bioproducts necessarily compete against fossil fuels and products to the extent the utilization of bioeconomy outputs is not mandated. The competition typically favors fossil alternatives, since they benefit from several decades of industrial maturing, dependent (locked-in) markets, systems, infrastructure and technology and generally lower production costs seldom having costs of externalities embedded into their price and benefitting from a number of subsidies worldwide. Subsidies are particularly relevant to tilt the scale towards fossil-based products and are often linked to social and economic policies. Globally, these have been estimated at USD 548 billion/year by the IEA[15] and ~USD 5 trillion/year (6.5% of the world's GDP) in a more recent assessment by the International Monetary Fund (Coady, Parry, Sears, & Shang, 2017)[16] - depending on how subsidies are defined. Conversely, renewable energies broadly benefit from about a quarter of the subsidies provided to fossil fuels (REN21, 2017).

As an example, subsidies have traditionally been used in Latin American and Caribbean countries to keep local fossil fuel prices below international prices and hence mitigate the impact of global energy prices on inflation. Such policies have benefitted gasoline production and consumption, and hampered the development of local biofuel markets, leading to an increasing number of countries committed to phasing out fossil fuel subsidies. By the end of 2016, more than 50 countries had committed to phasing out such subsidies, including the G20 and Asia-Pacific Economic Cooperation (IISD, 2017). Although dismantling such incentives are inherently difficult due to the network of interconnected environmental, social and economic aspects involved, reviewing incentives presents an opportunity to best allocate public budgets according to each country's objectives and is hence a valid undertaking. Further guidance on reforming subsidies is provided by the Global Subsidies Initiative (GSI)[17].

Moreover, carbon pricing instruments can represent relevant measures to bridge the price gap between biobased and fossil resources. Unwanted carbon emissions from fossil fuels constitute a negative externality that can be effectively internalized by means of a price on GHG emissions.

Unfavorable policy frameworks

The complex web of interconnected mandates, subsidies, tax incentives, grants or other instruments that work directly or indirectly against the bioeconomy, or in favor of competing technologies and sectors, is hereby defined as unfavorable policy frameworks. Countries referring to this barrier in Figure 15 generally highlight policies that favor specific biofuels over others; conflicting policies among government departments; lack of long-term and stable support frameworks that provide certainty to investors; and an underlying lack of a common understanding of country priorities and bioeconomy development strategies. Due to the necessarily crosscutting nature of biofuels and non-energetic bioproducts policies, which concerns energy, environment and agriculture agendas, among others, lack of or inadequate coordination between different governmental agencies and ministeries may also hinder the adoption of favorable policy frameworks.

Policies aimed at incentivizing biofuels do not always create an overall enabling environment. Most blending mandates, subsidies and tax exemptions enacted, for example, are either fuel agnostic or focus on first generation

15 The IEA only considers the difference between a reference (market) price and the end-user price.

16 The IMF assessment includes the cost of consumption-related externalities in its "post-tax" subsidy estimations.

17 Led by the International Institute for Sustainable Development, the GSI supports international processes, national governments and civil society organizations to align subsidies with sustainable development.

biofuels and may thereby act against the deployment of advanced biofuels, which are typically less competitive. To level the playing field between 1G and 2G biofuels, policy makers can assess complementary policies such as specific mandates and tax credits for advanced biofuels, to provide investors with more certainty around demand and costs, respectively. Ultimately, investors will remain reluctant if there are no foreseeable profits and opportunities in the long-term.

Providing certainty to investors is a key challenge to policy makers, especially when trying to balance multiple sector and public interests. Crucially, biofuel investments rarely benefit from guaranteed volume and price commitments, e.g. from long-term purchase agreements, as is common for renewable electricity. Furthermore, biofuel investments are often susceptible to fluctuations in commodity prices (primarily oil prices and biofuel alternatives), and to fluctuations in policies, e.g. pricing control policies in Brazil or biofuel credits in the USA. Altogether, such volatility generates variability in a biofuel producer's revenue streams and renders biofuel investments considerably more uncertain and hence less likely to occur, when compared to other forms of renewable energy.

Brazil's commitment to control gasoline prices, described above, demonstrates the inherent difficulties in balancing interests of local biofuel industry against macro-economic inflation control strategy. The EU's 2015 Indirect Land Use Change (iLUC) Directive (EU/2015/1513), which introduced a non-mandatory 0.5% target for advanced biofuels in transport sectors of member countries by 2020 and spurred criticism around the feasibility of such targets, thus limiting investor certainty. Mandates and tax credits in the USA have gone through multiple revisions overtime, with major changes to mandated volumes and tax volumes levied. Existing volumetric requirements are high, but production capacity has not been sufficient to fulfill targets. Since current production of cellulosic biofuels is far below RFS statutory levels, EPA has recurrently reduced required volumes by means of the cellulosic waiver authority. In the 2018 update of percentage standards, for instance, actual required volumes for cellulosic biofuels is 0.288 bg, a significant waiver to the statutory level of 7,000 bg (EPA, 2017). Furthermore, the USA's current framework goes until 2022, adding to the uncertainty of plans beyond this timeframe.This, combined with the lack of success of 2G facilities, particularly due to early-stage technologies, reduces certainty to investors.

An underlying unfavorable circumstance to bioeconomy sub-sectors, witnessed in multiple Platform countries, is a common lack of a shared understanding of priorities for the bioeconomy in each country. Few countries have coordinated government departments and agencies to assess which technologies or outputs can best help deliver country objectives (e.g. emission mitigation, job generation, value add generated) or prioritized pathways and agreed on coherent plans to support such priorities. To that end, the UK's Low carbon Innovation Co-ordination Group (LCICG) and its Technology Innovation Needs Assessments (TINA)[18] stand as a global best practice example to be explored across the Platform.

On the non-energetic front, the Netherlands is the only country reporting unfavorable policy frameworks limiting bioproduct markets, where bioproducts utilize agricultural waste as feedstock and such waste must abide to the Waste Framework Directive (2008/98/EC). With strict transport, management and licensing rules, the waste directive increases the costs of feedstock collection and logistics, undermining the business case for bioproduct facilities.

18 Further detail is available at: https://www.carbontrust.com/resources/reports/technology/tinas-low carbon-technologies/

Biofuel tax conundrum in India

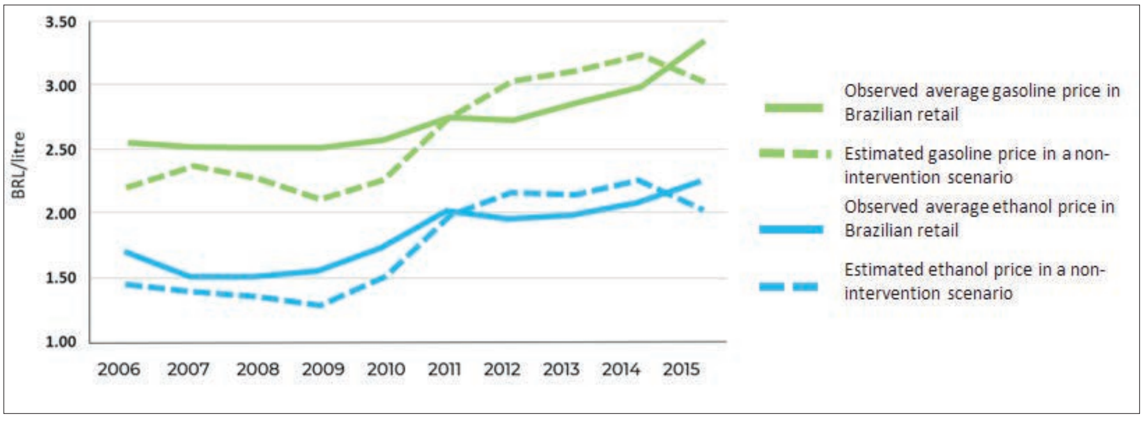
India's biofuel market is relatively nascent, as shown in Table 2, despite having benefitted from zero excise duty since 2007 and zero Value Added Tax (VAT) on states of West Bengal, Uttar Pradesh, Uttarakhand, Chhattisgarh and Rajasthan. A recent change in tax regimes threatens to make biodiesel substantially more expensive than regular diesel, as it envisages an addition of a 12% Goods and Services Tax (GST) on such output. India's Biodiesel Association has claimed that as soon as biodiesel is blended with diesel, taxes can go as high as 20-30% depending on the state, with a litre biodiesel becoming ~EUR 0.01 more expensive than that of diesel (Biofuels International, 2017). As a result of the tax conundrum and other constraints, the proposed biodiesel blend of 20% with conventional diesel by 2017 was not achieved, highlighting the need for a revised policy that keeps this somewhat frail industry from perishing.

The two-way road of gasoline price-control in Brazil

Brazil's federal government controls domestic A-type gasoline prices since the early 2000s, via the state-owned Petrobras, which holds exclusive refining rights in the country. The results of such interventions can be split in two distinct phases with converse effects on the country's ethanol market. Underlining such effects is the fact that flex-fuel vehicles compose the bulk of the passenger-vehicle fleet, with end-users typically following the rule of thumb in which ethanol is only a worthwhile purchase when it costs ~30% less than gasoline - given its lower performance per litre when compared to gasoline.

Between 2006 and 2010, gasoline prices were kept above international averages, stimulating the production of hydrated ethanol as it enabled the biofuel to be sold on average 9% above what it would have been in a non-intervention scenario. Between 2011 and 2014, Petrobras protected end-users from international oil price volatility, by making a loss on gasoline sales, in a governmental effort to control inflation. As a result, ethanol producers have been forced to sell the biofuel at an average 7% less than they would have in a non-intervention scenario (Costa & Burnquist, 2016). Recently however, led by the poor financial performance of Petrobras in the latter period, subsidies have been held back, allowing gasoline prices to surpass market-based estimates, enabling the recovery of the company. The distinct periods are depicted in Figure 1.

Figure 1. Observed vs. market-based estimates of gasoline and ethanol prices in Brazil.



Source: Adapted from (Costa & Burnquist, 2016).

1/2

2/2

Despite social and economic advantages resulting from the price-control strategy, e.g. inflation control, it has evidently limited the growth of Brazil's ethanol industry by reducing the industries profit margin between 2011-2014. Conversely, the government rose the ethanol blend mandate in 2015 ensuring a stable demand for the product over the coming years, giving rise to a new cycle of investor confidence.

Limitations surrounding sustainable feedstock supply

Insufficient, expensive or unreliable feedstock supplies are noted by a few countries as significant barriers to further development of the bioeconomy. This perceived barrier is inextrincably linked to the ability of sustainably providing the feedstock, raising concerns and public questioning of feedstocks (biomass) sustainability, including concerns over indirect land use change (ILUC) impacts on ecosystems and potential competition between biofuels and food production. While there is growing consensus on what constitutes sustainable best practices for biomass feedstock production and use (IEA Bioenergy; FAO; IRENA, 2017), persisting public confusion and misperceptions about the benefits of bioenergy and bioproducts relative to other products have made policy makers reluctant to develop it. Positive synergies of biofuels and bioproducts are frequently neglected in the public debate, such as links of biofuels and the circular economy through the use of wastes and residues as feedstocks.

Biofuel production costs are driven-up by the need to gather feedstock that is often scattered (e.g. agricultural waste) at a sufficient scale to run commercial-scale plants daily - often requiring logistic networks or multiple delivery agreements - and ensuring year-round certainty of supply with quality standards that render feedstocks adequate for processing. Most frequently, guaranteeing feedstock availability is not the real issue, but rather ensuring adequate feedstock supply chain networks at required scales. Similarly, feedstock supply may be inconveniently located with respect to processing facilities, all of which affect the business case for advanced biofuels development. Adding to the challenge is the fact that agricultural residues play an important role in ensuring farming soil quality, often left on fields to provide a physical buffer from rain, wind, and sunlight. Over-harvesting residues for biofuel purposes might therefore have negative effects on agricultural sustainability. Research is progressing on optimal levels of residue removal to maintain productivity and soil quality, which can vary greatly by location.

Considering the variables above, project developers and investors need to be certain of feedstock supply costs, scale and quality before making investment decisions, given downturns may jeopardize the business case of biofuel production sites. The challenge is particularly pressing in production sites that depend on feedstock gathered from its surroundings (such as American sites processing corn-stover from neighbouring agricultural properties), as opposed to sites which receive stable supplies of feedstock via ports (such as Dutch plants processing starch or palm oil from overseas). An early assessment of the first three companies to launch corn stover cellulosic ethanol plants in the US, between 2014-2015 (Kemp, 2015) - DuPont, Abengoa Bioenergy, and POET-DSM (the first two no longer running) - provide a sense of the scale of the challenge and a glimpse into tried solutions. The three commercial sites required ~1,000 - 1,500 truck loads of corn stover per day, working with sub-contracted third parties to shred, pile, bale, and stack specified stover within a 35-45 mile radius of the facilities corresponding to ~1/3 of the cost of their ethanol output.

Feedstock costs can amount to 1/3 of cellulosic ethanol prices in the USA.

Sustainable feedstocks at scale and the "food versus fuel" debate

Although not listed as a barrier by countries, the competition of food versus fuel is a common concern among policymakers and has influenced the advanced biofuel market to some extent. In particular in Europe, the ILUC directive (EU/2015/1513) caps the volumetric contribution of biofuels from crops grown on agricultural land - motivated by concerns that these may cause an upheaval in food costs and provoke induced land use change (iLUC), offsetting their contributions to a low carbon economy. Whilst biofuels could lead to such undesired effect, it is important to note that impacts on iLUC depend on country-specific context and a number of variables such as agricultural practices and feedstock management.

In a collaboration among the IEA Bioenergy Technology Collaboration Programme, IRENA and FAO, "Bioenergy for Sustainable Development" (IEA Bioenergy; FAO; IRENA, 2017), best practices that can be adopted to minimize impacts over food security were listed, in particular:

I. the identification and limitation of suitable areas for biofuel production, through mechanisms such as agro-ecological zoning or contract farming;
II. agricultural intensification and landscape planning to increase the output per unit of land;
III. restoring degraded land and integrating production systems (e.g. crop rotation, flexible crops and intercropping), using the same area for food and fuel crops;
IV. the use of crop and processing residues not required for soil management or animal bedding or feed as feedstock to produce biofuels and;
V. the use of forest process and manufacturing residues as feedstock, considering sustainable forest management principles.

Similarly, the 2015 SCOPE report on Bioenergy and Sustainability, a collective assessment of the state of knowledge on the matter, with contributions from 137 researchers of 82 institutions in 24 countries, considered bioenergy expansion and its impacts in the energy, food, environmental and climate security, sustainable development and innovation nexus in both developed and developing regions. The report concluded that current scientific evidence supports the large-scale use of bioenergy without compromising competing demands and land services, as long as land and bioenergy practices are implemented properly.

The report projects that 50 to 200 million hectares would be needed to provide 10 to 20% of primary energy supply in 2050. However, given proper resource management, good governance, and good practices, available land that would not compromise increasing food demands, preservation of forests, protected lands, and rising urbanization was estimated to be at least 500 million hectares, and possibly 900 million hectares if pasture intensification or water-scarce, marginal and degraded land is considered. (Souza, Victoria, Joly, & Verdade, 2015).

The United Nations' Bioenergy Decision Support Tool (UNEP, 2018) can measure the effect of biofuels on food security. The tool enables countries to insert variables such as local resources, feedstock, supply chain and value added to the economy to define potential pathways for sustainable bioenergy development, whilst laying risks and opportunities and how to best monitor and evaluate them. Indonesia applied the tool to understand whether its palm oil biodiesel production was impacting food basket items (e.g. rice and cooking oil) as its biofuels targets will cause a 10-fold increase in biodiesel use by 2020. The assessment concluded the policy should have no significant impact on food price and availability.

1/2

2/2

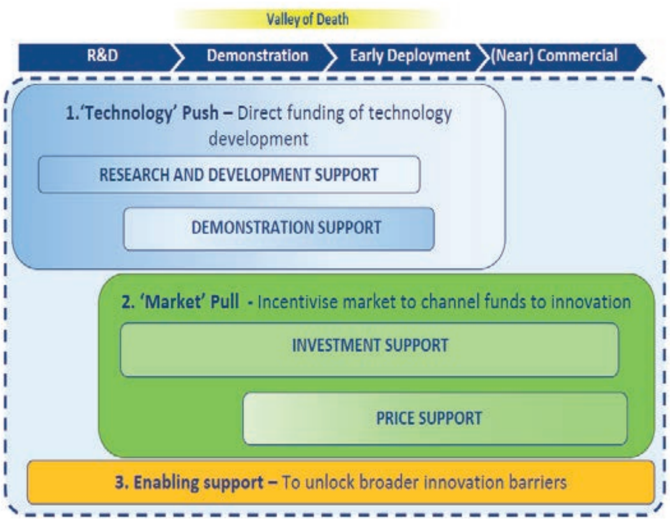
The 2017 IEA Bioenergy Technology Roadmap cites the lack of a widely accepted and deployed sustainability governance mechanism as a barrier to investments. The report advocates for the creation of an international consensus over a sustainability regime that will prevent bad practices and adopt a nuanced approach to sustainability management, avoiding a too-strict interpretation of the "precautionary principle", which could close off sustainable options and provoke investor insecurity. This regime should, on the other hand, encourage and incentivize good practice and innovation in sustainable biomass supply. (IEA, 2017b). Such a regime could be achieved by means of international dialogue and cooperation, involving scientists, experts, regulators, and the experience of international iniciatives such as the Global Bioenergy Partnership (GBEP), the IEA Bioenergy, and the Biofuture Platform.

5. STATUS OF SUPPORT INSTRUMENTS TO OVERCOME BARRIERS

Within and outside the BfP and SBIC/MI, a number of efforts have been enacted to support the advanced bioeconomy through the innovation journey, but a lot more support will be needed to achieve the goals laid out by the BfP. This section provides detail into BfP and SBIC/MI member countries' current approach to support the bioeconomy. To enable consistent comparison and discussion of support instruments across different countries[19], this section classifies these into three broad families listed below and illustrated in Figure 17, commonly seen to work together to drive technologies towards commercialization. This section focuses on the first two families, in which most BfP and SBIC/MI member countries' responses were classified, whilst the value of enabling support policies is herein acknowledged.

- **Technology-push** - where policies help reduce the cost of research and development to drive new ideas and reduce the cost of technology, taking early stage technologies through the valley of death that exists between early development and demonstration.
- **Market-pull** - where the policy helps create or increase market demand for the technology.
- **Enabling support** - where the policy addresses the barriers existent in the institutional environment to enable further innovation and deployment.

Figure 17. Three key innovation policy families: push, pull and enabling support



Source: (Carbon Trust & Element Energy, 2014)

19 The comparison of support instruments across countries cannot be done faultlessly, as each country has a unique innovation policy support framework as a result of historic factors and national policy preferences. Furthermore, it is found that the definitions of different policy types are not used consistently, limiting the ability to compare policy success across different countries. Nonetheless, the classification presented in this report should prove useful to guide the reader through the thought of developing balanced support packages.

The reader is invited to critically assess the information presented in this section, noting that a successful innovation support strategy will usually include a balanced portfolio of interventions across these three categories and that mechanisms must be aligned with the maturity levels of specific technologies (if these are directed towards specific technologies) or to technology groups (if these are technology agnostic). Choosing the right balance is essential and requires policymakers to allocate efforts to systematically address barriers limiting different technologies, technology groups, or sub-components whilst balancing needs of relevant stakeholders.

An overview of countries' existing support instruments for the bioeconomy reveals that: (i) a lot more support is available for biofuels than bioproducts; and (ii) Support is mostly concentrated in market pull instruments, which might be insufficient to take advanced biofuel technologies into the market.

Table 6 summarizes countries´ responses for the biofuels sector and reveals that: (i) a lot more support is available for biofuels (especially 1G) than for bioproducts; and (ii) support instruments are mostly concentrated in market-pull instruments, which might be insufficient to take early-stage advanced bioeconomy technologies into the market. Namely, mandates, tax incentives and investment support are among the most popular support instruments currently utilized.

Responses referring to bioproducts are not shown in a table format, as these are significantly limited. In summary, there is limited knowledge around technology-push support available for bioproducts, with most known R&D resources coming from the private sector. Market-pull instruments are also relatively scarce for bioproducts, with Mozambique, Italy and the Netherlands deploying a mix of subsidies, labelling and quotas that, although not dedicated to bioproducts directly, can be said to boost the bioproducts market - as detailed further below. Investment support mechanisms, although not always exclusive for bioproducts, were identified in the EU, France, Italy, the Netherlands, Brazil, Paraguay and Uruguay, most of which venture funds, investment grants and preferential finance.

Table 6. Support instruments enabling biofuel development

Region/ Country	Technology Push				Market Pull								
	R&D grants	Demonstration support	R&D subsidies	Other	Auctions	Labelling	Mandates	Public Procurement	Quotas	Subsidies	Tax Incentives	Others	Investment support
Africa													
Egypt	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered
Morocco	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered
Mozambique	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Yes	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Yes	Unknown or unanswered	Unknown or unanswered
Asia													
China	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Yes	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	No	Unknown or unanswered	Unknown or unanswered
India	Yes	Yes	Yes	No	No	No	No	No	Unknown or unanswered	Yes	Yes	Unknown or unanswered	Yes
Indonesia	Yes	No	No	No	Unknown or unanswered	Unknown or unanswered	Yes	No	No	Yes	Yes	No	No
Philippines	No	No	No	Yes	No	No	Yes	Unknown or unanswered	No	No	Yes	No	No
Europe													
Denmark	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Yes	Unknown or unanswered	Yes	Unknown or unanswered	Yes	Unknown or unanswered	Unknown or unanswered
EU	Yes	Yes	Yes	Yes	Unknown or unanswered	Unknown or unanswered	Yes	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Yes	Yes	Yes
Finland	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	No	No	No	Unknown or unanswered	No	No	Yes	Yes	Yes
France	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	No	No	Yes	No	Yes	No	Yes	No	Yes
Italy	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Yes	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Yes
Netherlands	Yes	Yes	Yes	Yes	No	No	Yes	Unknown or unanswered	No	No	No	No	Yes
Norway	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	No	No	Yes	Unknown or unanswered	Yes	No	No	No	Yes
Sweden	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered
UK	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Yes	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Yes
South and Central America													
Argentina	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Yes	Unknown or unanswered	Yes	Unknown or unanswered	Yes	Unknown or unanswered	Yes
Brazil	No	No	No	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Paraguay	No	No	No	No	No	No	Yes	No	Yes	Yes	Yes	No	Yes
Uruguay	No	No	Yes	No	No	No	No	No	No	No	Yes	No	No
North America													
Canada	Yes	Yes	No	No	No	No	Yes	Unknown or unanswered	No	No	No	No	Yes
Mexico	No	No	No	Yes	No	No	Yes	No	No	No	No	No	No
USA	Yes	Yes	No	No	Unknown or unanswered	Unknown or unanswered	Yes	Yes	Yes	Unknown or unanswered	Yes	Unknown or unanswered	Unknown or unanswered

KEY:	
Unknown or unanswered	(grey)
No	(red)
Yes	(green)

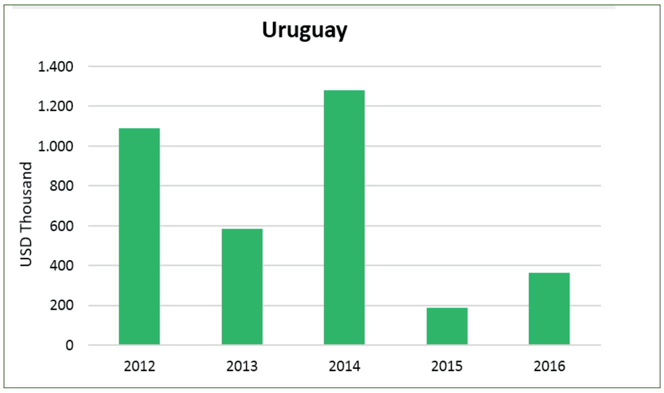
Source: Countries responses to the questionnaire; (Biofuels Digest, 2015); (GAIN, 2017a). Notes: Brazil uses bimonthly auctions since 2005 to guarantee there is an output of biodiesel for blending with fossil diesel, according to law n° 11.097/2005.

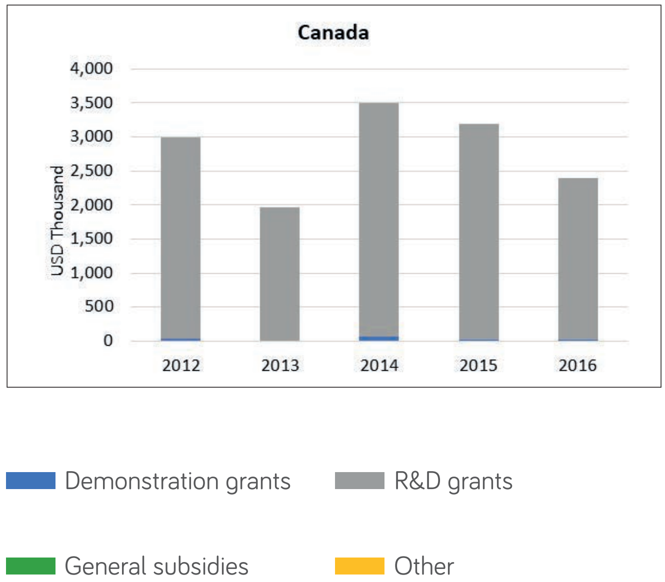
Technology-push instruments

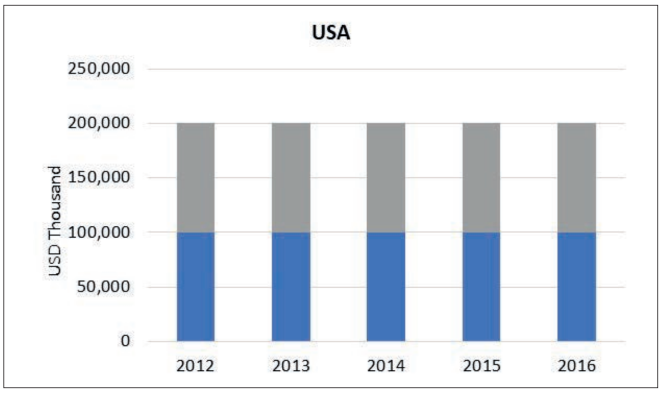
Despite the dominance of market-pull instruments revealed in Table 6, significant amounts of resources have been dedicated to support technology research, development and demonstration (RD&D), in particular through grant instruments dedicated to advanced biofuels. Very limited public resources seem to be dedicated to bioproducts' RD&D, where efforts are still led by the private sector.

Technology-push instruments are typically effective to drive early stage technologies (such as second and third generation biofuels) towards demonstration and commercialization and are hence essential if the BfP and SBIC/MI countries are to achieve the deployment targets indicated in Figure 1. Figure 18 shows the split between resources allocated to R&D grants, demonstration grants, general subsidies and other R&D resources - as reported by BfP and SBIC/MI members. Overleaf, further detail is provided into R&D and demonstration grants globally and in selected countries/regions.

Figure 18. R&D support available for advanced biofuels and bioproducts by country (2012-2016)







Source: Countries responses to the questionnaire. Note: the following countries did not provide figures: Egypt, Morocco, Mozambique, China, Denmark, Finland, France, Italy, Norway, Sweden, UK, Argentina, Brazil and Paraguay. EU only provided figures for R&D support.

R&D grants

R&D grants are an effective instrument to accelerate different phases of innovation, from early technology development to later stages of technology validation. It has also proven to be successful in de-risking technology and catalyzing private investment for subsequent stages, somewhat sparing public budgets as technologies advance into commercial stages. As shown in Figure 18, the overall amount of R&D grants for advanced biofuels has varied from an average USD 55 million in 2012 to USD 59 million in 2016, led by the USA and the EU, which dedicated an average USD 200 million/year and USD 70 million/year respectively in the five-year timeframe.

In the United States, R&D grants originate primarily from DOE and USDA, to develop biorefinery technology, scale up advanced biofuel production and biobased chemicals and co-products. Government support has also been provided by other agencies such as the Department of Defense, which has directed its efforts in biorefineries to produce drop-in aviation and marine biofuels. In 2016, for instance, USD 90 million in grants were offered by the DOE, through its Office of Energy Efficiency and Renewable Energy (EERE), to develop pilot and demonstration biofuel production facilities from cellulosic, algae or biogas feedstock, with bioproduct allowed as co-products (EERE, 2017). Table 7 presents a non-exhaustive list of some of the main R&D grants provided by several partners to support the development of advanced biofuels and bioproducts.

Table 7. Summary of R&D grants supporting advanced biofuels

Program	Project Status	Budget
USA		
Bioenergy Technologies Office	On-going projects	USD 99-232.5 million
The Advanced Research Projects Agency (ARPA-E)	On-going projects	USD 306 million/ 2017
Biomass Research and Development	On-going projects	USD 118 million/ 2009-2012
UK		
The Energy Entrepreneurs Fund Scheme	On-going projects	GBP 60 million (~USD 84 million)/ 2013-2017
SUPERGEN	On-going projects	GBP 3.5 million overall (~USD 4.9 million)
The Carbon Trust: The Pyrolysis Challenge	Finalized	GBP 12 million (~USD 16 million)/ 2009-2016
Technology Strategy Board (TSB): various calls	On-going projects	Grant size GBP 5-400k (~USD 7k-563k)
Energy Technologies Institute (ETI): various competitions	On-going projects	Grant size GBP 5-25 million (~USD 7-35 million)
EU[20]		
ERA-NET Plus: Bioenergy Sustaining the Future (BESTF)	On-going projects	EUR 52 million (~USD 64 million)/ 2013-2016
European Investment Bank (EIB)	On-going projects	EUR 315 mi (~USD 388 million)/ 2013-2018
NER 300	On-going projects	EUR 2.1 billion (~USD 2.5 billion)/ 2010-2016
Horizon 2020	On-going projects	EUR 80 billion (~USD 98 billion)/ 2012-2020
Biobased Industries PPP	On-going projects	EUR 81 million (~USD 100 million)/ 2017
EU CORDIS FP7	Closed superseded by Horizon 2020	EUR 50 billion (~USD 61 billion) / 2007-2013
EU CORDIS FP6	Closed superseded by FP7	EUR 17.5 billion (~USD 21 billion)/ 2002-2006
European Regional Development Fund (ERDF)	On-going projects	EUR 279 billion (~USD 344 billion)/ 2012-2020
INTERREG IVA Program	On-going projects	EUR 283 million (~USD 349 million)/ 2014-2020
Brazil		
Joint Plan for Supporting Industrial Technological Innovation in the Sugar-based Energy and Chemical Sectors (PAISS)	Closed	USD 2.5720 million
Canada		
Agricultural Bioproducts Innovation Program (ABIP)	Closed	CAD 145 million (~USD 112 million)

Source: adapted from (Arup URS Consortium, 2014), (CRS, 2012), (DOE, 2018a).

20 Listed funding projects are not exclusive to advanced biofuels and bioproduts and may be applicable to other areas.

In the EU, the European Strategic Energy Technology Plan (SET-Plan) aims at establishing an integrated European energy research and innovation strategy (European Commission, 2015). Financing of RD&I activities relevant to the SET Plan at European level mainly originate from the EIB, the European Bank for Reconstruction and Development (EBRD), and the European Commission's (EC) funds (Structural and Cohesion Funds – CF – and the ERDF) and framework programs for innovation and technological development (CIP and FPs) (Lepsa, 2015). The EIB regularly finances research, development and innovation projects, having provided loans for some major RD&D projects on advanced biofuels, financing part of Novozymes corporate RD&I program, as well as Biochemtex/Mossi and Ghisolfi second generation biorefinery. Following successive framework funding programs ("FPs"), in 2014 the EC launched Horizon 2020, bringing together previous RD&I funding under what is now the EU's biggest research and innovation program. Horizon 2020 Program has directed investments for the bioeconomy sector, mainly through its grant component. In 2016, more than USD 80 million were invested in advanced biofuel projects. Currently, there are 19 projects on advanced biofuels and another 20 on bio-based products (European Commission, 2018). Distant followers regarding the allocation of R&D grants are the Netherlands, India and Canada - averaging USD 17 million/year, USD 5 million/year and USD 2.7 million/year, respectively, to develop new feedstock and test new technologies.

Canada is one of the few countries identified as having had a dedicated R&D grant program for bioproducts - the Agricultural Bioproducts Innovation Program, which dedicated USD 44.5 million from 2006-2011 for bioproducts' technology transfer and pre-commercialization activities (AAFC, 2011). The country has developed different funding sources for advanced biofuels and bioproducts, such as the Natural Sciences and Engineering Research Council Canada – NERSC Strategic Partnership Grants and Natural Resources Canada's (NRC) Investments in Forest Industry Transformation Program. Other countries, such as the Netherlands, have combined R&D grants with other mechanisms. In the Netherlands, the MKB Innovatieregeling Regio en Topsectoren (MIT) and the Stichting Topconsortium voor Kennis-en Innovatie Biobased Economy (TKI-BBE) Biobased programs provide funding for biobased materials and biorefineries projects, respectively. In addition, the Dutch Ministry of Economic Affairs provided a R&D grant for the BE-Basic Program, a public-private initiative focusing on the development of biochemicals and biomaterials.

Similar to the Netherlands, India has also combined R&D grants with demonstrative grants and subsidies to support advanced biofuel projects. The Department for Biotechnology and the Department of Science and Technology have funded a significant number of advanced biofuel projects in the country. While figures for grants in Brazil are not widely available, BNDES and FINEP, through the PAISS program, each gave BRL 100 million (~USD 30 million) in grants towards the development of advanced biofuel and bioproduct technology, divided evenly between both sectors. These grants, combined with loan and other forms of investment instruments, discussed later on, unlocked opportunities at different TRL levels, particularly lab-scale pilots.

Demonstration grants

Public-funded grants have been successfully deployed by few BfP member countries to support the private sector in demonstrating innovative technologies at larger scale - pushing these towards commercial feasibility. Such grants are often the crucial support required to get technologies over the 'valley of death' depicted in Figure 17, so it is in governments' interest to spare a portion of resources into such instruments and to ensure these are used as efficiently and effectively as possible, catalyzing private sector investments. Selected examples of demonstration grant programs in the UK, EU, USA and Canada are summarized below to illustrate how such instruments have been deployed, along with their challenges and expected outcomes.

Public-funded demonstration grants can be allocated through competitions with specific criteria around minimum technical requirements, value-generation, business prospects, and emission mitigation. Match-funding criteria can also be required to further ensure best value for money on public spend.

The UK's Department for Transport Advanced Biofuel Demonstration Competition was launched in 2014 and encouraged companies or consortia to apply for grants to enable the demonstration of lab-proven 2G biofuel technologies from non-food feedstocks. A total of GBP 25 million (~USD 35 million) was made available as match-funding - meaning grants could cover from 45%-65% of each project's value (depending on project characteristics) and applicants were compelled to use other sources of private capital. By 2017, three projects were selected: (i) Celtic Renewables Limited (GBP 10,925,000/ ~USD 15 million), to fund a new plant to make biofuels from Scotch whisky by-products[21]; (ii) Advanced Plasma Power Limited (GBP 10,958,194/ ~USD 15 million), developing biofuels from ordinary household waste; and (iii) Nova Pangaea Limited (GBP 3,000,000/~USD 4 million), developing biofuels from forestry waste. Altogether, such projects are seen as milestones to reduce the UK's reliance on imported energy, to generate over 5,000 new jobs by 2030, to open up international markets, and add value to the UK economy - waste-fed biofuels are expected to generate GBP 130 million (~USD 183 million) gross value-added to the UK economy by 2030 (UK GOV, 2015). More recently, on 2017, a second competition was launched, "Fuels for Flights and Freight" (F4C), which will see £20m in matched funding for companies producing advanced biofuel for aviation and heavy goods vehicles. This competition compliments the amendment to the RTFO, where an additional obligation for development fuels was introduced[22].

EU demonstration grants have been allocated for the most promising projects as well. Through the 7th Framework Program of the European Commission, the Netherlands, Germany and Denmark developed a EUR 9.2 million (~USD 11 million) project to test polygeneration pyrolysis for the production of fuel oil, process steam, electricity and organic acids using woody biomass (European Commission, 2016b). The EU grant covered 50% of projects costs and the other 50% were funded by the Dutch government via the Topsector Energie (TKI-BBE and Overijssel Energy Fund). The project consortium was composed by Bruins & Kwast Recycling BV - BKR (feedstock supplier), Biomass Technology Group -BTG, Stork Thermeq, HoST Bioenergy Installation and Amandus Kahl GmbH & Co. KG - AK (technology suppliers), R&R Consult -RRC (modelling and optimization of liquid fuel combustion), Biomass to Liquid - BTL (pyrolysis plant design) and AkzoNobel (industrial end-user). Under this framework, projects aim develop new technologies and strengthen EU industry and competitiveness. The project was concluded in 2015 and the Empyro pyrolysis plant is operational. In 2012, the Netherlands received EUR 199 million (~USD 245 million) award from the EU New Entrants' Reserve 300 (NER300) scheme to build a large-scale biomass refinery as part of the EUR 500 million (~USD 617 million) Woodspirit Project led by BioMCN, a leading bio-methanol producer (BioMCN, 2012). The NER300 set no fixed percentage and funding covered a proportion of relevant costs, estimated through the cumulative operating costs over the first five years of operation. The project is currently on hold waiting for further investments. Investments in advanced biofuels are

21 The project would also include a further three commercial plants across Scotland. However, Celtic Renewables recently decided to withdraw it, as they were unable to source the matched funding from the private sector.

22 https://ee.ricardo.com/transport/case-studies/f4c

perceived as a way to reduce dependence on fossil fuels, support the decarbonization of the transport sector and create jobs – estimates point to 300,000 new jobs by 2030 (Harrison, et al., 2014)

The US DOE's offices and support programs regularly provides funding and grants to support the private sector in piloting and demonstrating advanced biofuel technologies, bioproducts and biorefineries. Amongst its key successes, Project Liberty, in Iowa, illustrates how DOE's support was essential to catalyze private sector investments and take a promising technology onto a commercial production site with vast potential for scale-up. In 2006, a private company (POET) requested DOE's support to demonstrate a biorefinery concept including a state-of-the-art biological process to convert post-harvest corn stover (cobs, leaves, husks, and upper stalks) into cellulosic ethanol. Selected by the DOE's process, the company received an USD 100 million grant, equivalent to ~40% of the total project value, to support the design and construction of this pioneer facility. In the following years, as the company advanced in its design plan, however, it became clear that further R&D was required, inducing it to utilize a share of the DOE grant (capped at USD 5 million) for such purposes, before effective construction could begin. In 2008, POET started up a pilot plant (Project BELL), to research and test the technology. Having successfully navigated through R&D difficulties and secured enough private capital to match with the DOE grant, POET-DSM (now a joint venture with Royal DSM) hosted a grand opening of the facility in September 2014, with the capacity to produce up to 94 million liters/year. Significant learnings are reported to have been gained from this pioneer commercial plant, including improvements in the construction design and in the day-to-day feedstock collection logistics and conversion route - all of which lead to substantial cost reductions to POET's subsequent developments. Furthermore, the facility is expected increase Iowa's economic output by USD 24.4 billion and create more than 13,500 jobs in the state over the next 20 years (DOE, 2018b).

Canada has also developed different initiatives to support 1G and 2G biofuels, particularly via NRC, Agriculture and Agri-Food Canada (AAFC) and Sustainable Development Technology Canada (SDTC). A few programs include the ecoAgriculture Biofuels Capital Initiative, EcoEnergy for Biofuels, and NextGen Biofuels Funds, which supported the country's renewable fuel strategy, launched in 2007 – all programs expired between 2011 and 2017. One initiative supporting advanced biofuels was the NextGen Biofuel Fund (NGBF), established by the SDTC in 2007, to develop first-of-their-kind commercial scale demonstration facilities to produce advanced biofuels and co-products. The fund covered 40% of project costs (capped at USD 200 million) and is repayable over ten years after the project's completion. The fund had a low uptake, receiving seventeen applications, with two cancelled projects and two fully funded ones (Sears & Vodden, 2017). The successful projects under the NGBF include the Enerkem Alberta Biofuels Project, which converts municipal solid waste to cellulosic ethanol, and the AE Cote-Nord RTP project, which coverts wood residues and forestry waste to renewable fuel oil. Overall, the Canadian renewable fuel industry generates CAD 4 billion (~USD 3 billion) to the country's economy and over 1,000 direct and indirect jobs per year (Renewable Industries Canada , 2018).

The examples above show that demonstration grants can pay off and generate a lot more value than what they cost to governments. However, all such grants face the key challenge of demonstration projects being generally capital intensive, requiring relatively high sums, even when programs cap their support at a percentage of project costs (as shown in the UK and USA examples), meaning grant programs are often incapable of supporting too many projects. This in turn increases the emphasis on scrutinizing projects to ensure that those that are selected are the best placed to generate the results intended (in terms of commercial biofuel output, job generation, value add generation, GHG mitigation, etc.), despite there being significant uncertainty in such outcomes, due to the innovative nature of such technologies.

Market-pull instruments

As shown in Table 6, market-pull instruments are popular across the BfP member countries, and particularly focus on biofuels rather than on bioproducts. Furthermore, there is a clear preference for volumetric-based mandates, quotas, tax incentives and investment support mechanisms. Notably, all such instruments are broadly effective to support technologies that are relatively mature, as they create a demand for biofuels, which is typically met with commercial conversion technologies such as 1G ethanol or biodiesel. However, such instruments can be limited in their capacity to pull early-stage technologies into the market, since these are often not commercially viable, or are typically more expensive to be produced commercially - struggling to compete against first generation biofuels. Regulatory schemes such as California's Low carbon Fuel Standard (LCFS); Brazil's RenovaBio; and Canada's Clean Fuel Standard (CFS) are examples of policies that aim to pull 2nd generation biofuels into the market by providing a fuel-agnostic incentive to products with lowest carbon intensity. This section delves into the most popular market-pull instruments, providing an overview of their status and perspectives in selected countries/regions.

Mandates & quotas

Mandates establish biofuel markets on the basis of volumetric requirements or carbon-intensity standards, offsetting some of the externalities brought by fossil fuels by creating demand for low carbon alternatives rather than establishing a direct carbon tax. They are the most popular form of market-pull instruments for biofuels across BfP member countries and beyond[23]. Currently, fourteen countries in the Americas have mandates or targets in place or under consideration, twelve in Asia-Pacific, eleven in Africa, and two in the Indian Ocean (Biofuels Digest, 2018). Globally, major blending mandates set by the USA, Brazil, the EU and China (all major markets with targets in the 15-27% range by 2020-2022) have been the key drivers of the demand for first generation biofuels in particular.

Mandates offset some of the externalities brought by fossil fuels by creating demand for low carbon alternatives rather than establishing a direct carbon tax.

Table 8. Biofuel mandates in the transport sector per country and per fuel

Region / Country	Aviation biokerosene	Biodiesel	Cellulosic ethanol	Ethanol	Hydrogenated vegetable oil
Africa					
Egypt					
Morocco					
Mozambique		7%		15%	
Asia					
China				10% in 9 provinces	
India		5% (indicative, not yet mandated)	10% (indicative, not yet mandated)	5% (indicative, not yet mandated)	
Indonesia	less than 5 %	10%		3%	
Philippines		5%		10%	

Source: Country responses to the questionnaire; (IEA, 2017d); (GAIN, 2017e); (GRFA, 2017b); and (MME, 2017).

1/2

23 Mandates also exist in Australian states, Vietnam, South Korea, Thailand, Fiji, Malaysia, Nigeria, Sudan, Angola, Zambia, Malawi, Kenya, Colombia, Panama, Peru, Costa Rica, and Jamaica. (GRFA, 2017b).

2/2

Region / Country	Aviation biokerosene	Biodiesel	Cellulosic ethanol	Ethanol	Hydrogenated vegetable oil
Africa					
Egypt					
Morocco					
Mozambique		7%		15%	
Asia					
China				10% in 9 provinces	
India		5% (indicative, not yet mandated)	10% (indicative, not yet mandated)	5% (indicative, not yet mandated)	
Indonesia	less than 5 %	10%		3%	
Philippines		5%		10%	
Europe					
Denmark		5.75% energy content (agnostic to fuel type but capping the contribution of fuels produced from edible-feedstock)			
EU	less than 5 %	10% energy content (agnostic to fuel type but capping the contribution of fuels produced from edible-feedstock)			
Finland					
France		7.7%	less than 5 %	7.5%	less than 5 %
Italy		7% energy content (agnostic to fuel type but capping the contribution of fuels produced from edible-feedstock)			
Netherlands	less than 5 %	7.75% energy content (agnostic to fuel type but capping the contribution of fuels produced from edible-feedstock)			less than 5 %
Norway			4% 1G ethanol and 1.5% additional blending with advanced biofuels of any sort (eligible for double counting)		
Sweden					
UK		4.75% energy content (agnostic to fuel type but capping the contribution of fuels produced from edible-feedstock)			
South and Central America					
Argentina		10%		12%	
Brazil		10%	between 11% and 30%	27%	less than 5 %
Paraguay		1% Minimum		between 24% and 27%	
Uruguay		5%		5%	
North America					
Canada[24]		2%	5% (agnostic to fuel type)		2%
Mexico		less than 5 %	less than 5 %	between 5% and 10%	less than 5 %
USA		between 11% and 30%	between 5% and 10% (agnostic to fuel type)		between 11% and 30%

KEY:	
No mandate	(red)

Source: Country responses to the questionnaire; (IEA, 2017d); (GAIN, 2017e); (GRFA, 2017b); and (MME, 2017).[24]

24 Canada's existing federal mandate requires a 5% renewable content in the national gasoline pool and 2% renewable content in fossil diesel and heating oil since 2010, with no specific mandate requirements per fuel.

In Europe, the wide use of mandates currently derives from: (i) the EU's Energy and Climate Change Package, which includes a 10% minimum target for renewable energy consumed by the transport sector across member states by 2020; and (ii) the 2009 Fuel Quality Directive, which defined a 6% GHG reduction target by 2020 in road transport and mobile machinery. In 2015, the iLUC Directive (EU/2015/1513) was approved, limiting the way the 10% renewable fuels target can be met in the transport sector, capping biofuels produced from food crops and providing a greater focus on advanced biofuels (IEA, 2017c).

Mandates in South and Central America have been historically focused on volumetric blends of first generation biofuels, although Brazil's recent enactment of RenovaBio is bound to shift much of the region's demand to a carbon intensity approach that favors biofuels with the highest GHG mitigation potential (as further discussed below). Brazil's ethanol blending mandate into gasoline dates back to 1993, and currently requires gasoline to include a 27% blend with sugarcane ethanol - this percentage has varied over the years and is currently set at the highest level (MAPA , 2017). In tandem, Brazil's blending mandate for biodiesel is in force since 2005, gradually increasing to 5% by 2014 and, being currently at 8% the intention is to rise it to 10% by 2019 (ANP , 2017). Similarly, since the mid-2000s, Argentina mandated a product agnostic mandate of 10-12% mix of renewables into transport fuels – ethanol (12%) or biodiesel (10%); whereas Paraguay mandates a mix of 24%, ethanol and 1% for biodiesel in transport fuels (IEA, 2017d).

Asian mandates also focus on 1G fuels, albeit challenged by supply chain gaps. India announced plans to set a 22.5% mandate on ethanol mix to gasoline (The Economic Times, 2016), although a range of limitations have impeded the realization of the 5% blend mandate for ethanol enforced in the past years. Indonesia's more realistic 1% blend for ethanol and 10% for biodiesel (IEA, 2017d); and the Philippines' 10% ethanol and 5% biodiesel blend mandates have been generally met (GAIN, 2017d). Finally, China enforced a 10% blend mandate for ethanol (van Dyk, et al., 2016) although the extent to which it has been met is still unclear.

Mandates played a key role in building demand for biofuels in North America over the past two decades, especially driven by state and provincial level specificities. Whilst volumetric requirements have underlined North American mandates, California has led a fuel-agnostic carbon intensity approach, which is also expected to be adopted by Canada and specific American states. Canada's existing federal mandate requires a 5% renewable content in the national gasoline pool and 2% renewable content in fossil diesel and heating oil since 2010, with a few provinces enforcing higher local mandates, including ethanol blends of 7.5% in Saskatchewan, and 8.5% in Manitoba. Driven by such policies, Canada's ethanol consumption doubled between 2010 (1.8 million m^3) and 2014 (3.2 million m^3) (Moorhouse & Wolinetz, 2016). Canada's new framework - the Clean Fuel Standard[25]- was announced in December 2017 and is currently undergoing public consultation; a draft regulation is expected to be published in spring 2019. The new approach will set lifecycle carbon intensity requirements for liquid, gaseous and solid fuels used in transportation, industry and buildings that become more stringent over time. Fuel producers, importers and distributors will be required to meet these requirements. This will induce the blending of biofuels with lower carbon intensity into fossil fuels to generate compliance credits. By 2030, Canada will look to phase out its volumetric biofuel mandates once the CFS has been in place and the market has adjusted.

Mandates and state regulations have also played a key role in driving the demand for biofuels in the USA. The

25 https://www.canada.ca/en/environment-climate-change/services/canadian-environmental-protection-act-registry/publications/clean-fuel-standard-regulatory-framework.html.

federal Renewable Fuels Standard (RFS), created by the Energy Independence and Security Act (EISA) in 2007, requires a volumetric blend of biofuels into the country's fuel supply – growing from 49 billion liters in 2011 to 136 billion liters by 2022 (EPA, 2018b). Additional state-level incentives have however been crucial to boost the demand for biofuels in America. In particular, California's low carbon fuel standard[26], enacted in 2007 - the world's first carbon-intensity-focused regulation to induce the market towards blending biofuels based on carbon mitigation goals to generate compliance credits -, which attracts a significant share of the USA's biofuel output into the state.

Somewhat similar to mandates are quota instruments[27], utilized for biofuels in Denmark, France, Norway, Argentina, Brazil and Paraguay. In Brazil for instance, quotas are used to limit the volume of imported biofuels, enabling a 1.2 billion liter tax-free biofuel import in 2017, valid for two years (MDIC, 2017).

Advantages and disadvantages of mandate approaches

As shown above, most existing mandates are based on specific biofuel blending volumes, creating market certainty for specific outputs and conversion technologies. Conversely, technology-agnostic carbon intensity approaches, pioneered by California's low carbon fuel standard, are on the rise and should soon be rolled out in Brazil and Canada (through the RenovaBio and Clean Fuel Standard programmes, currently in final regulatory stages). An assessment of BfP and SMIC/MI country responses to the questionnaire and insights gathered through selected interviews with most prominent countries reveals that there are advantages and disadvantages to both approaches, much uncertainty regarding outcomes and ideas to join both approaches.

A volumetric-based mandate provides certainty of demand in time and hence confidence to investors. It allows countries to focus support on technologies with highest potential to achieve national goals beyond GHG emission mitigation (such as value-add generation), based on assessments of how can specific technologies support the achievement of such goals. Conversely, selected mandated technologies may not provide the most cost-effective alternative to mitigate GHG emissions and decarbonize mandated sectors. The approach might therefore drive the sector development towards a pathway that is not necessarily favourable to specific country goals in the long-run - reinforcing the importance of fully assessing technology support scenario costs and benefits prior to unrolling such mandates and of matching mandates with focused technology push policies.

A carbon-intensity based approach (LCFS, RenovaBio) can provide certainty of biofuel demand in time and to some extent confidence to investors - limited by the uncertainty of whether a conversion route will be able to produce a biofuel output that outcompetes others in terms of price and emission mitigation. That is, the mandate creates an economic advantage for the biofuel outputs with the highest GHG mitigation potential, but this advantage must be weighed against the cost of producing such a fuel, and against how other fuels perform in terms of their carbon intensity and production costs. The carbon-intensity approach opens up markets beyond a country's biophysical constraints, and enables the most cost-effective decarbonization of mandated sectors, as biofuel blending certificates are valued and traded on the basis of their GHG mitigation potential. It should be noted that carbon-intensity approaches can be combined with base volumetric mandates and technology push instruments for maximum impact.

1/2

26 https://www.arb.ca.gov/fuels/lcfs/lcfs.htm.

27 Determines the volume blended into biofuels, which will receive tax exemption.

2/2

Further into the pros and cons of specific mandates, the EU's Renewable Energy Directive allows 2G biofuels (waste, residues, non-food cellulosic material and lignocellulosic material) to receive double-counted credits towards the 10% renewable transport target and 20% renewable energy target. The double counting mechanism is aimed at encouraging the use of diverse feedstocks and novel technologies to meet blending mandates, but limits the demand for 1G biofuels, with countries like Norway specifically capping the contribution of 1G biofuels to avoid ILUC risks attributed to these. In 2017, ten EU member countries adopted double counting (UDSA, 2017a), with variations about definitions on eligible feedstocks. When not properly compensated for, double counting mechanisms can jeopardize the integrity of the general target, by effectively reducing the total share of renewable energy ultimately reached under the mandate. Other criticisms to the double counting mechanism include that it can negatively affect investment decisions on 1G biofuels, often by the same players who can bring in 2G biofuels into the market; and that it can produce a bias towards more established 2G technologies, such as waste and residues, over early-stage 2G biofuel technologies. In fact, more than 90% of double counted biofuels in 2014 came from cooking oil and animal fats (Pelkmans, et al., 2014). Nevertheless, the EU's 2017 Renewable Energy Progress Report (European Commission, 2017b) highlights that the overall share of 2G biofuels increased from 1% to 23% in 2015, particularly due to the use of cooking oil.

Technology and feedstock agnostic, carbon-intensity based approaches in California, and soon in Brazil, face other challenges. California has successfully attracted a great deal of biofuel supply from other American states, particularly due to the addition premium it offers to biofuels when compared to other states, resulting in a cost-effective GHG mitigation mechanism and a powerful incentive to pull technologies with lowest carbon intensity into the market. A key challenge for such schemes, however, lays on the extent to which their support manages to effectively bring 2G technologies into the market, i.e. how much more competitive will they render advanced biofuels, and whether or not that will be sufficient to offset their typically higher production costs. The challenge reinforces the importance of joining such mandates with technology push support policies and underscores Brazil's intention to embed flexibility to its scheme, allowing the level of support to be tailored to needs of the biofuel markets as these evolve.

Tax incentives

Tax incentives have been utilized as a market-pull mechanism by a number of countries in Asia, South and Central America and Europe to achieve biofuel market participation targets - whether or not associated to mandates. Hardly any country reports utilizing tax incentives to support non-energetic bioproducts, with exceptions from Italy, Netherlands, Paraguay and Uruguay, which claim to have incentives that indirectly support these. Tax incentives can be crafted as a market-pull instrument to level the playing field of specific technologies, sub-components, biofuel output types, or even biofuels per origin, minimizing or eliminating taxation upon these. These can also be crafted as a technology push-instrument when tax breaks are offered to facilitate early-stage technology advances, e.g. for R&D efforts or innovative start-ups.

In China, biodiesel produced from UCO can obtain 0.8 RMB/L tax exemption, introduced in 2013 to stimulate production (IEA Bioenergy, 2016). Since 2007, India's biodiesel industry benefitted from zero excise duty and zero Value Added Tax (VAT) on the states of West Bengal, Uttar Pradesh, Uttarakhand, Chhattisgarh and Rajasthan. The exemptions were recently replaced by implementation of a new tax regime, which includes an 12% Goods and Services Tax upon biodiesel. In the Philippines, local or imported biofuels used to meet blending mandates are not taxed. The country also provides value added tax exemption for raw materials (e.g. coconut, jatropha, sugarcane and cassava) used for biofuel production.

Brazilian tax incentives have most heavily impacted the biofuel industry in South and Central America, playing an important role in sustaining ethanol demands in the gasoline-fuelled share of the transport sector. The country's key tax-related measures backing up the sector are: (i) a significant discount on the Tax on Industrialized Products (IPI) for flex-fuel vehicles, notably from 2009 onwards - when the incentive was utilized to protect the automobile industry from the global recession; and (ii) a lower taxes applied on ethanol as compared to gasoline under its Contribution for Intervention in Economic Domain (CIDE) and Contribution to the Social Integration /Contribution for Financing Social Security (PIS/COFINS) federal programs, as well as under state-level taxes for circulation of goods and services (ICMS), as demonstrated for selected states in Table 9.

Table 9. ICMS taxes for selected Brazilian states per fuel

State	Gasoline	Hydrated Ethanol	Diesel
Alagoas	29%	25%	18%
Bahia	28%	20%	18%
Goiás	30%	22%	15%
Minas Gerais	29%	14%	15%
Rio de Janeiro	34%	25%	16%
Sao Paulo	25%	12%	12%

Source: Adapted from (USDA, 2017b)

In Argentina, biofuels are exempt from main taxes applied to fossil fuels, whilst local producers enjoy anticipated reimbursement of VAT and accelerated depreciation on capital investment. Since 2014, Argentina's law 23996 suspended 19% tax on local biodiesel sold at the pump - a measure originally foreseen as temporary, which has been held up until the publication of this report. Argentina set the export tax on biodiesel to 15%, since mid 2018.

Up until late 2016, the USA provided income tax credit for fuels containing biodiesel, splitting credits to blenders (USD 0.27 per liter mixed with fossil diesel), producers (USD 0.27 per liter produced), and small producers (an additional USD 0.1 for up to 56 million liters). The law also provided a biodiesel excise tax credit that could be taken against the taxpayer's fuel tax liability. With the extinction of the tax credit, the American Renewable Fuel and Job Creation Act was introduced into the US congress in April 2017 seeking to reinstate the credits exclusively for U.S. producers instead of blenders, and extend it through December 31, 2020. This measure can prevent the subsidization of foreign manufacturers exporting biodiesel to be blended in the USA, thus favoring exclusively American-made biodiesel.

Tax incentives for Research and Development of bioproducts in the Netherlands

Tax incentives can also serve to push technologies along the innovating journey. Designed by the Dutch Ministry of Economic Affairs and Climate Policy and implemented by the Dutch Enterprise Agency (RVO.nl), the scheme allows companies of any size and sector to deduct R&D costs from their tax obligations. Though it is not specific for bioproducts, it can benefit companies with a total tax break of EUR 1.2 billion (~USD 1.4 billion) in 2018, including breaks for R&D wage costs and other eligible expenditures carried out in the Netherlands and in other EU member countries (RVO, 2018). Expenses must be directly related to R&D production, meaning costs with administrative staff, outsourced work, land purchase improvements and financing are not qualified for WBSO support.

Two types of projects are eligible under the scheme: development projects creating tangible products, production processes or software and technical scientific research generating new knowledge. Claims can be made on a cost and expenditure basis or fixed sum approach. Deduction amounts are set at 32% for the first EUR 350,000 (~USD 432,098) of total underlying R&D costs

1/2

2/2

(composed by total R&D wages, costs and expenditures) and at 14% for remaining costs; start-ups receive a 40% deduction for the first EUR 350,000 (~USD 432,098) of total underlying R&D costs. Latest available figures on the scheme contribution to R&D investments in bio-based companies indicate EUR 115 million (~USD 141 million) in 2012 and EUR 104 million (~USD 128 million) in 2013 (Biomass Research, 2016).

Carbon Pricing

Carbon taxes can be relevant measures to offset the negative externalities of fossil-based resources, bridging the price gap of sustainable, low carbon biobased sources

Carbon taxes place a price on CO_2 emitted by fossil fuels with the purpose of reducing GHG emission. This increase in tax obligations provides a financial incentive to switch to cleaner alternatives like 1G and 2G biofuels. Carbon taxes have been implemented in the EU since the 1990s, with Finland as the first country to adopt a carbon tax as a surcharge on fossil fuels, based on its carbon content (current levy is 62 €/ton CO2). Afterwards, other countries, such as Denmark, France, Norway and Sweden also set fees for the purchase and sale of fossil fuels. In 2015, prices by ton of CO_2 equivalent (tCO_2e) in these countries spanned from USD 4 to USD 132 (Partnership for Market Readiness, 2017). Results have varied from country to country, with Denmark, for instance, achieving high abatement costs due to biofuel content in gasoline and diesel.

In the late 2000s, other places beyond Europe also established carbon taxes. In 2008, British Columbia, in Canada, set a USD 10/tCO_2e price over the purchase and use of fossil fuels, which is now worth USD 35/tCO_2e. Price will increase in USD 5/tCO_2e per year until it reaches USD 50/tCO_2e by 2021 (British Colombia, 2018). A nation-wide carbon tax is expected to be introduced January 1, 2019, at USD 20/ tCO_2e, raising USD 10/ tCO_2e per year until it reaches USD 50/ tCO_2e by 2022. Revenues from the provincial and national taxes can be recycled to reduce other taxes or finance low carbon growth.

Sector specific carbon pricing or targets are a promising option when economy-wide instruments are politically difficult to implement. While based on carbon-intensity reduction targets (see "Advantages and disadvantages of mandate approaches" box), Brazil´s RenovaBio effectively puts a price on carbon in the transportation sector, by creating a free market for a tradeable emissions reduction certificate (the CBIO) that fuel distributors are mandated to acquire in proportion to their fossil fuel marketshare.

There are also global initiatives that are using different carbon pricing instruments to reduce carbon emissions. The International Civil Aviation Organization (ICAO) designed a Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) to neutralize CO_2 emissions from the sector post 2020. The voluntary carbon offset scheme will become operational in four years and allow for the use of biofuels as credits to meet reduction obligations, although further details on biofuel accounting are still being defined. It is evident that both carbon taxes and offsetting can provide incentives to stimulate biofuel production.

Labelling

While there are ~500 eco-labels worldwide they are less common for bio-based products (European Commission, 2017c). Labels, standards, norms and certification have been used to verify product related claims and to build business and consumer confidence, hence facilitating the development, procurement, and purchase of advanced biofuels and bioproducts. Key existing labelling schemes for biofuels and bioproducts, include the Roundtable for Sustainable Biomass Standard (RSB), International Sustainability and Carbon Certification (ISCC+), Better Biomass and BioPreferred Label.

Introduced in 2011 by the USDA as a voluntary label for biobased products, the BioPreferred Label indicates third-partying testing and verification of biobased content. In order to be labelled, products must meet or exceed a minimum 25% biobased content, often set at higher thresholds for different product categories. The label is a mandatory purchase requirement in a number of American federal agencies and their contractors, having certified over 2,500 products in 100 different categories by December 2015 (USDA, 2016), hence catalyzing bioproducts uptake.

The Dutch Better Biomass label was also introduced in 2011, to ensure resources used for fuel, heat, power and chemical production met sustainability criteria throughout its supply chain. The certification is issued after independent bodies carry out audits to ensure requirements are met and is valid for 5 years. The Better Biomass certification is one of the voluntary schemes to meet sustainability compliance requirements under the Renewable Energy Directive. Other countries - such as Italy - have used labelling and certification criteria within the Circular Economy Package to support bioproducts. Other efforts as the incorporation of bio-based criteria into the EU Ecolabel scheme are also underway.

Investment support instruments

Other than tax incentives, a number of instruments exist to attract investments into biofuel and bioproduct sectors. Across the BfP and SBIC/MI, investment grants and loan guarantees are preferred means to direct investments into the biofuels sector, as depicted in Table 10. Limited investment support is available for bioproducts, in particular venture funds in the EU, tax incentives and preferential finance in Italy, the Netherlands and Paraguay, and a marginal amount of investment grants in France, Italy and Paraguay.

Table 10. Investment grants and loan guarantees are preferred means to direct investments to biofuels

Region / Country	Investment grants	Loan guarantees	Preferential finance	Venture funds	Others
Africa					
Egypt					
Morocco					
Mozambique					
Asia					
China					
India					
Indonesia					
Philippines					
Europe					
Denmark					
EU					
Finland					
France					
Italy					
Netherlands					
Norway					

1/2

2/2

Region / Country	Investment grants	Loan guarantees	Preferential finance	Venture funds	Others
Sweden	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered
UK	Yes	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered
Latin America					
Argentina	No	Yes	Yes	Unknown or unanswered	Unknown or unanswered
Brazil	Yes	Yes	Yes	No	No
Mexico	No	No	No	No	No
Paraguay	No	No	Yes	No	Unknown or unanswered
Uruguay	No	No	No	No	Unknown or unanswered
North America					
Canada	Yes	Yes	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered
USA	Yes	Yes	Unknown or unanswered	Unknown or unanswered	Unknown or unanswered

KEY:	
Unknown or unanswered	(grey)
No	(red)
Yes	(green)

Source: Countries responses to the questionnaire.

Loan guarantees have been used to finance large-scale ethanol plant projects. It is particularly popular in the USA, where the DOE and USDA have funded development, construction and retrofitting projects through a hybrid equity model backed by grants and loans. In 2015, the DOE created the Energy Loans Program Office (LPO) to address financing barriers to bring innovative new technologies to commercial stages. The LPO manages over USD 30 billion of loans, loan guarantees and conditional commitments (DOE, 2018c). Loans for bioenergy & biofuels are issued through the Title XVII Program. The cellulosic ethanol project in Hugoton, Kansas, with Abengoa Bioenergy (recently closed due to the restructuring of the company), received a loan guarantee worth USD 134.4 million (DOE , 2017). Other investment support included a USD 42 million contract award from the Defence Production Act (DPA) Title III Program for an Advanced Drop-in Biofuels Production Project, in 2013 (DPA, 2018). Red Rock Biofuels, Fulcrum Bioenergy and Emerald Biofuels were commissioned to build biorefineries that collectively produce 37 million liters/year to meet military and transportation needs (DPA, 2018) – for an average price of USD 0.91/ liter.

In the EU, loan guarantees have not been as popular as in the USA and have been provided mainly through the InnovFin- EU Finance for Innovators. It was established by the EC and EIB as a Risk Sharing Finance Facility to facilitate access to finance for innovative firms under the Horizon 2020. Up to 2014, it had allocated more than EUR 1.4 billion (~USD 1.7 billion) in loan guarantees, which mobilized an additional EUR 37.2 billion (~USD 45.9 billion) in private investment (EIB, 2017). This program has different loan instruments (e.g. SMEs, Midcap and Large Projects) that vary from EUR 25 thousand (~USD 30 thousand) to EUR 25 million (~USD 30 million) (Horizon 2020, 2018). Although there is no breakdown on how much has been directed to advanced biofuels or bioproducts, these types of projects are considered eligible for funding. Another guarantee mechanism developed by the EU is the European Fund for Strategic Investments (EFSI). It was created by the EIB Group and the EC to address investment gaps in priority areas and strategic projects, including energy and transport infrastructure and renewables, which could benefit 1G and 2G projects (although the extent to which is has done so is unclear). The EFSI is a EUR 21 billion (~USD 25 billion) fund – with EUR 16 billion (~USD 19 billion) provided by the EU and

EUR 5 billion (~USD 6 billion) by the EIB. The guarantee scheme is expected to unlock another EUR 315 billion (~USD 388 billion) in 2018 (EIB, 2018).

In Brazil, BNDES has been the main vehicle of investment support for the advanced bioeconomy, deploying two key financial instruments: (i) the Joint Plan for Supporting Industrial Technological Innovation in the Sugarcane-based Energy and Chemical Sectors (PAISS); and (ii) the Program for Renewable Energies (PRORENOVA). Delivered in two editions, 2011 and 2014, PAISS provided a total BRL 2.5 billion (~USD 720 million) in concessional loans to 4 major projects implementing commercial-scale 2G biofuel and bioproduct facilities (BNDES, 2018a) (BNDES, 2018b), leveraging another ~USD 300 million in private investments from Granbio, Raizen, Solorzyme and Amyris. PRORENOVA directed BRL 4 billion (~USD 1.2 billion) in loans to finance the renewal and expansion of sugarcane agriculture and harvest capacity, increasing 1G biofuel production and leading to a greater availability of feedstock for 2G fuels. The program holds a further BRL 5 billion (~USD 1.5 billion) for the development of new sugarcane varieties in 2017/2018.

Argentina has established two main policy instruments to promote the bioeconomy: the Ministry of Agroindustry's Bioeconomy Policy and an Interministerial Cooperation Agreement. Within the framework of this a coordinated policy environment, several vehicles for promoting investment are underway. PROBIOMASA (Program for the Promotion of Energy from Biomass), in place since 2012, involves institutional strengthening, capacity building, technical assistance, dissemination of information and awareness raising. The NAMA for the Promotion of Bioenergy aims to leverage investment in 400MW of thermal and electrical installed capacity at an estimated cost of USD 990 million, focusing on the creation of bioenergy-suitable financial instruments and capacity building of financial institutions. The GEF project "Reducing Argentina's greenhouse gas emissions from the energy sector through the utilization of organic waste for energy generation in agriculture and agroindustries" (USD6 million GEF grant and total project costs of USD38, 460,000) includes proposals for institutional and legislative improvements, investment in demonstrative projects and the creation of an applied R&D network. The GEF MSW *PRO-Biogás* involves a USD2.8 million GEF grant and a total cost of USD15, 6 million. The objective of the Bioeconomy Policy and the interministerial Cooperation Agreement is to further advance the bioeconomy including and beyond the bioenergy sector.

Another potential source of investment support for the bioeconomy may come from the use of green bond issuance proceeds to finance the commercialization of demonstrated technologies across 1G & 2G. Some experts among BfP and SBIC/MI member countries noted the need to enable such utilization of green bonds, including through working towards that purpose with financial institutions and ensuring clear, adequate standards for bioenergy investments.

Enabling environment

A combination of market-pull and technology push mechanisms is necessary to push the bioeconomy forward. However, the unlocking of investments at a necessary scale also requires an enabling environment. This includes, among others, well defined, practical and effective quality and sustainability regulations (see box: "Sustainable feedstocks at scale", page 74); a favorable public environment and communications; and predictable, stable national and global strategies and targets. An open, commoditized market, and unimpeded market for national, regional and international trade in bioeconomy products, although not essential to start a comprehensive policy, can also be key in the medium term to achieve greater production and resource efficiencies at global level, compensate for local, temporary supply chain shortcomings, and enhance energy security.

6. CONCLUSIONS

This assessment enables us to draw conclusions about the status and perspectives of the bioeconomy in selected countries/regions, as well as to list recommendations for policymakers moving forward. To fulfill its role in cost-effectiveness-based scenarios designed by the IEA (2DS) and IRENA (ReMap), however, the advanced bioeconomy will require an unprecedented effort in technology innovation and diversification to be set forth worldwide. Beyond the bioeconomy, long-term decarbonization objectives will require a range of complementary mitigation efforts to be deployed in parallel across all economic sectors, such as vehicle electrification and other renewable energy technologies.

Output implications of achieving BfP targets are well known and challenging for sustainable biofuels and remain unquantified for the bioproduct markets. With regards to biofuels, 1G outputs are on course to meet the BfP aspirational target of significantly increasing the share of sustainable, low carbon biofuels as a percentage of transport fuels, but a significant boost is required to get 2G and 3G outputs on track. Approximately 131 billion liters of biofuels are produced annually around the world, of which >99% can be classified as 1G. The realization of the IEA's 2DS scenario would require a 69% increase in the global sustainable biofuel output, to reach 222 billion liters by 2025, of which ~26% in 2G or 3G routes - which translates into scaling up the global output of 2G and 3G biofuels from ~1 billion liters/year to 57 billion liters/year by 2025. By 2030, global sustainable biofuel output should reach 500 billion liters to be in line with IRENA's ReMap scenario.

An uneven playing field holds back the development of the advanced bioeconomy against fossil-based fuels and products, requiring targeted policies to level competition. Unevenness spurs from the generally higher cost of advanced biofuels and bioproducts against fossil alternatives - linked to the bioeconomy's earlier stage of technology development - from a range of subsidies, which directly or indirectly support fossil-fuel industries, and from the general lack of recognition of the positive externalities in carbon emissions inherent to the bioeconomy. The bioeconomy can also be a driver of environmental improvements, positive social impacts and local development. The global economic recession early in this decade and low oil prices witnessed in the past few years add additional obstacles to the challenge. As a result, global investments in the advanced bioeconomy declined steeply in recent years, with biorefineries struggling to make financial sense against alternatives. Further innovation and development of integrated biorefineries yielding bioproducts, sustainable biofuels and other goods can be part of the solution to enhance business profitability and improve the case for investments - requiring governments to take a holistic approach when supporting the bioeconomy.

Most countries within the BfP and SBIC/MI have underlying targets to reduce GHG emissions through to 2030 or beyond, justifying efforts to level this playing field in support of the advanced bioeconomy. The extent to which countries are individually moving towards delivering their respective targets is mostly unclear, although declining investments and modest advances in 2G biofuel outputs indicate the bioeconomy is not contributing to such targets to the extent it could. Countries, however, report their intentions to establish national bio-based industries and acknowledge the value of doing so - urging policymakers to put together bioeconomy support plans based on evidence-based assessments of cost and benefits.

BfP and SBIC/MI member countries show diverse realities of biofuel and bioproduct production and consumption, primarily due to variables such as historic drivers and incentives to develop such industries, climate, availability of land and current incentives to induce consumption. The market for biofuels is largely concentrated in the USA, Brazil and EU - responsible for ~85% of the global output - although Chinese production - ~ 3% of global output - also sets it apart from the rest of the world. Among advanced biofuels, 18 commercial facilities are reported to be in operation across the BfP and SBIC/MI countries, most of which are in North America and Europe. Thirteen demonstration facilities and 19 pilot facilities are also reported to be in operation, albeit still largely geographically concentrated. Biofuel consumption patterns are largely aligned with production, with the exception of countries such as Canada, UK and France - responsible for major imports. Few countries reported shares of bioproducts in their markets, noting significant uncertainties in terms of volume and market value.

Key barriers reported to limit the development of the advanced bioeconomy are: limited availability of financial resources; lack of competitiveness with fossil-based alternatives; unfavorable policy frameworks; limitations around feedstock supplies; and persisting misconceptions regarding the true benefits of biofuels and bioproducts. Countries are implementing mechanisms to overcome such barriers to some extent, but a lot more support will be needed to drive the advanced bioeconomy towards the goals laid out by the BfP. Policymakers can benefit from lessons learnt from low carbon innovation policies more broadly.

A number of efforts have been enacted to support the advanced bioeconomy through the innovation journey, but a lot more support will be needed to drive the advanced bioeconomy towards the goals laid out by the BfP. An overview of countries' responses around instruments currently deployed to support the bioeconomy reveals that: (i) a lot more support is available for biofuels (particularly 1G) than for bioproducts; and (ii) support is mostly concentrated in market-pull instruments, which might be insufficient to take early-stage advanced biofuel technologies into the market, hence requiring a broader bioeconomy policy portfolio.

Seven key recommendations are set out below to support policymakers in overcoming the barriers and boosting the support needed to achieve the growth in the advanced bioeconomy. These are put forward by the technical drafters of the present report as an input for country-to-country and multistakeholder debate and exchange.

7. RECOMMENDATIONS - OVERCOMING BARRIERS TO HARNESS OPPORTUNITIES

Acknowledging the global and regional status of the advanced bioeconomy; the challenge posed by BfP's aspirational collective goals; barriers reported by countries; and drawing from the existing experience of policy support to the bioeconomy and to low carbon innovation more broadly, a set of recommendations[28] for policymakers is listed below. Inasmuch as this report does not constitute a consensus document, these recommendations and conclusions were not necessarily endorsed by all Biofuture Platform members, representing identified potential measures to be considered by stakeholders from member countries, according to their own national circumstances, policies, targets, and points of departure.

Whilst recommendations are often relatively self-evident, they are not found to be consistently implemented, to the detriment of national bioeconomy potentials. These recommendations, therefore, form an important foundation from which policymakers can design appropriate policy support packages that have maximum chances of long-term government support and effective results.

I. **Establish clear goals and identify technologies (or technology groups in case of technology-agnostic approaches) with potential to deliver such goals.**

A successful innovation strategy starts with clear goals established at the highest level of government. These goals need to align with a country's national priorities e.g. economic growth, job generation, emission mitigation, value-add generation, and/or poverty reduction. Defining national goals requires considerable efforts to ensure there is crosscutting buy-in among government levels, relevant agencies, the private sector and civil society representatives - noting that these can be synergistic or complementary to any other objectives the country might have already set itself. Once established, goals should cascade through the selection of policy mechanisms to use, and eventually the choice of programs to establish in support of the advanced bioeconomy. Policy support packages (and resource allocation) are justified to the extent that they map onto such goals and generate benefits to the country that outweigh their costs.

II. **Map the local market of sustainable biofuel and bioproduct production technologies and their potential for development to best understand how technologies (or technology groups in the case of technology agnostic approaches) can**

28 The items presented in this sub-section are an adaptation of existing best practice guidance for low carbon innovation policy, bringing in specific insights from the analysis presented in this report, and inputs from BfP and SMIC/MI countries responses to the questionnaire and interviews, to make recommendations more focused on matters relevant to the advanced bioeconomy. The original best practice guidance frameworks are presented in (Carbon Trust & Element Energy, 2014) and (Carbon Trust, 2017) and were elaborated collaboratively with leading international policymakers and industry experts assembled by the IEA's Renewable Energy Technology Deployment (IEA-RETD) and the Clean Energy Solutions Center (CESC), respectively, and synthesize proven innovation policy methods from around the world.

generate results that are aligned with national goals.

A deep understanding of the landscape of sustainable biofuels and bioproducts production technologies available (see Figure 1- noting it may differ from country to country) and their potential for further development is essential for policymakers to quantify the extent to which technologies (or technology groups) can help deliver national goals. In essence, this means developing scenarios of technology development to simulate the extent to which technologies (or technology groups) can contribute to the achievement of national goals within realistic parameters, e.g. if 2G biofuel technologies were to be widely deployed to take advantage of a realistic share of agricultural waste available in a country, how much GHG could they mitigate by offsetting transport fuels? How could such practices be carried out sustainably in terms of other environmental impacts, incluing local ones? How many jobs could this industry generate? How much value-add could it create locally and from exports? How will it affect the SDGs associated with the activity? To answer these questions, policymakers should identify supply chain gaps (e.g. logistic challenges, lack of adequate feedstock supply, unsuitable location of processing activities or inadequate planning for the industrial configuration of the bioeconomy) and make realistic assumptions to estimate the extent to which these can be overcome in time.

Ultimately, this recommendation will enable policymakers to get an initial sense of how technologies or technology groups can deliver against national goals if they are to be realistically scaled-up. With such answers, countries can objectively identify technologies (or technology groups in case of fuel-agnostic approaches), feedstocks, and even regions within a country, based on their likelihood to deliver.

III. Understand the support needs for priority technologies (or technology groups in case of technology-agnostic approaches) and available policies to enable these to achieve their potential.

Having set goals and developed a good understanding of the potential for different technologies to deliver against these goals, governments can assess what policy instruments can be deployed to allow technologies (or technology groups) to realize their full commercialization potential. The following questions need to be answered: What barriers are holding back technologies or technology groups? What policy instruments can be implemented to overcome existing barriers for the large-scale commercialization of the advanced bioeconomy? What changes in market structure, supply chains, infrastructure and territorial planning need to take place for the bioeconomy to prosper?

Barriers are often distinct across technologies and their readiness levels, requiring policymakers to carefully identify them, as well as how these barriers interact with each other and which are the most relevant to level the playing field for sustainable biofuels and bioproducts against their fossil alternatives. Policy support should be addressed to resolving key barriers, and will most likely need to involve a mix of technology-push, market-pull, and enabling support policies. A policy support package must not leave a barrier unaddressed if it can hold back the market.

IV. Simulate the cost and benefit of multiple policy support package options, by running scenarios of alternative policies to address barriers identified, assigning costs and benefits (aligned with national goals) to each intervention.

Once barriers and support needs are well mapped, policymakers can develop scenarios of policy support package options that are aligned with the needs of specific technologies or technology groups (in case of technology-agnostic approaches). To best inform policy

A multi-criteria assessment of support package costs and benefits provides tangible evidence upon which to base policy decisions

decisions, it is recommended that policymakers estimate the costs of each intervention in such scenarios, along with the benefits resulting from such support, e.g. delivering a tax break for advanced biofuel R&D can cost USD 10 million/year for a government, but can result in benefits in the form of value add generation, jobs created, lowering the costs of advanced biofuels to consumers, and GHG mitigation.

Drawing lessons from the experience reported by countries in the BfP and SMIC/MI in support of the advanced bioeconomy, it is recommended that policymakers design policy support scenarios that:

- **Are built in consultation with relevant stakeholders to make use of realistic assumptions** around the feasibility of different interventions. Whilst it is often impossible to reach consensus across a broad range of stakeholders concerning variables and assumptions forming the proposed cost and benefits assessment, policymakers must navigate through uncertainties and interests to come up with a robust analysis that is credible.
- **Match market-pull instruments to sufficient resources allocated to technology-push**, since advanced biofuel and bioproduct technologies are mostly at early stages of readiness, and are hence largely unable to out-compete fossil alternatives. The assessment above demonstrates that existing mandates for sustainable biofuels (even technology-agnostic carbon-intensity-based ones) are most likely to be supplied by commercially established biofuel technologies.
- **Consider that limited public budgets can be complemented with co-funding from private actors and international climate funding**. Policy frameworks and programs can attract additional funding from the private sector and international climate funds early along the innovation chain by addressing the high risks of failure from capital-intensive activities. This can be done in several ways, e.g.:
    - Innovation grant competitions that select the best projects based on robust criteria such as value-add generation potential, lowest USD/tCO2 avoided, and private co-funding;
    - Tax breaks for companies investing in bioeconomy R&D resulting in measurable benefits;
    - Providing attractive finance for the riskiest tranche of investments in the form of loans, guarantee mechanisms or exchange rate risk coverage;
    - Raising public or green bonds to boost the availability of resources for low carbon innovation, making sure green bond standards are developed to include a broad range of sustainable low carbon bioeconomy projects.

- Consider the introduction of adequate carbon tax instruments, assessing its potential to internalize positive externalities of sustainable, low carbon biofuels, e.g. a (higher) carbon tax on CO2 emissions from fossil fuels or a cap on permitted emissions in the transport sector.
- **Include instruments that effectively help companies and technologies overcome the 'valley-of-death' towards commercialization**. Market pull policies that ensure market demand (such as mandates) are often not enough to get advanced bioeconomy technologies to move towards commercialization. Complementary market pull instruments (such as investment support) are often needed to take technologies from demonstration to commercialization. When

estimating costs of such support, note that biorefineries are costly and require significant sums. Examples shown above reveal that major sums allocated by governments are unable to support a large number of facilities into commercial operation (e.g. ~USD 720 million provided in co-finance by Brazil's Development Bank was sufficient to get 4 commercial advanced biofuels and bioproduct plants in operation - despite leveraging another ~USD 300 million in private investments).

- **Promote indigenous feedstocks production and sustainable biomass supply chains**, based on objective, transparent and practical criteria, such as to expand adoption of the best agricultural and industrial practices is of great importance to enable production and domestic and international trade, contributing to the expansion of feedstock supply chains and to the scale up of the production and use of bioenergy and biobased products.
- **Include support to bioproducts in technology-push and market-pull policy support packages**, acknowledging their value to the achievement of national goals, and capacity to enhance the business case for the bioeconomy as a whole, in particular through integrated biorefineries. Bioproduct technologies require push policies, since they are mostly at early stages of development and could largely benefit from innovation and cost reductions e.g. through tax break schemes for R&D; and pull policies, where governments could provide the support required to take demonstration facilities into commercial stages, and to secure demand for bioproducts, e.g. through public procurement policies.
- In parallel to bioeconomy policy support scenarios, consider the impact of **removing direct and indirect subsidies or other forms of support to fossil fuels and fossil-based industries**. Although subsidies to fossil fuels involve a complex web of social and economic goals, policymakers are urged to assess the impact that removing subsidies (even if partially) can have on socio-economic indicators, along with the extent to which the support for the advanced bioeconomy can positively impact such indicators. Examples of fossil-related interventions to be considered include reduced tax incentives to fossil-fuel industries or incorporating the externalities of carbon emissions to fossil-based-outputs through a carbon tax - even if only to products or sectors which mostly limit the advance of the bioeconomy.
- **Support a suite of emerging technologies to maximise the chances of creating successful industries**. A broad portfolio of support helps countries mitigate the inherent risk of technology failures and company losses, which are bound to happen.
- Recognize that a transition to the bioeconomy will involve significant changes in business practices, market configuration, geopolitical and territorial relations, power structures, modes of production and lifestyles.

V. Decide on a pathway forward involving the right stakeholders and assigning ownership of activities

The multi-criteria assessment framework proposed above is likely to produce results that are not easily comparable, given the subjectivity of benefits (e.g. what is a most valuable benefit among value add-generation, jobs or GHG mitigation?) and the large number of scenarios that can be built. Following the recommendations above, policymakers should be able to come up with few preferred scenarios and produce results that are broadly comparable, enabling the selection of a preferred set of policy support interventions to move forward.

At this stage, it is recommended that policymakers lay out implementation roadmaps and assign ownership of activities to specific players, as appropriate. A policy success will largely depend on the engagement and quality of the actors it manages to involve from the start, noting stakeholders have different drivers and barriers to action, depending on which role they are playing: setting policy, funding innovation, developing technology, or using technology. Policymakers should also take into account that some stakeholders may incur losses (of markets, for example) or perceive themselves to be harmed by the changes. Thus, they should consider the necessary measures to deal with such situations, including the deliberate creation of win-win environments and opportunities. Furthermore, stakeholders move along different innovation journeys, such as the technology journey - described in Figure 3 -, from early stage R&D to commercialization; the company journey, from start-up to large corporation; the market journey, from no market to technology-market; and the regulatory journey, from hostile regulation to positive regulation. The interventions proposed in the selected policy package should consider the journeys and interests undertaken by players involved and fully ensure they can effectively play their roles as required.

VI. Deploy a package of interventions

Backed-up by a solid evidence base, constructed by implementing the steps outlined above, policymakers can justify the allocation of public budgets to interventions that address barriers holding back the advanced bioeconomy and demonstrate how these interventions will achieve national goals. At this point, the innovation strategy needs to meet the reality of implementing programs, which can have a real impact on the ground. At this stage, it is recommended that policymakers:

Simulate investment decisions in specific bioeconomy technologies or niches to better understand what variables define a 'go' vs. 'no go' decision, such as exchange rate risk, policy risk, certainty of feedstock supply, availability of local finance, human resource limitations, and expected return on investments. Specific instruments, e.g. a risk sharing mechanisms for investors bringing in foreign currency, or a tax incentive, can have a bigger impact in attracting investors than a financing mechanism per se.

Embed flexibility into policy instruments. The support needs of technologies or technology groups can change along the way, owing to a number of market variables. Policies should be designed to allow governments to adjust support according to periodic impact assessments. This is particularly relevant for carbon-intensity-based mandates for sustainable biofuels, which must ensure the competitive advantage they provide is sufficient to outweigh the fact that advanced biofuels tend to be costlier than conventional biofuels.

Couple innovation expenditure with industrial policies to forge national capacities, create industries that can actually compete for international market share, e.g. through tax incentives, and upskilling programs. Smaller countries will typically face difficulties to become competitive across multiple value chain segments and should act strategically to ensure that they do not waste national resources trying to outcompete other countries in manufacturing areas where they lack this advantage. Such countries should pay particular attention to areas with national competitive advantage for technologies that are highly tradable.

Evaluate market and territorial planning changes needed for bioeconomy development and design policies that take into account and manage the social, political and territorial impacts in such a way as to achieve objectives. Create win-win environments and opportunitives as far as possible or desireable.

Periodically assess the impact of interventions to demonstrate value-for-money to taxpayers. For the sake of ensuring policies are effective and can be adjusted (or terminated) if they are not delivering as expected, policymakers can embed periodic assessments of impact in their inception. In this respect, it is crucial to find the right balance between a detailed impact assessment, which is excessively onerous and robust, and a superficial assessment, which is simple to deliver but possibly misleading. A periodic impact assessment should be able to continuously demonstrate the value of policies to achieve national goals, and its results should feed into the regular improvement of the policy, through levers built-in from policy inception, e.g. a tax incentive for advanced biofuel plant construction can be phased out, as investors perceive less risk in building such plants.

Assess and periodically monitor the impact of interventions on GHG emissions, adaptation and on social criteria and the environment, including the pertinent SDGs.

VII. Collaborate with existing international initiatives using the means provided by BfP and SBIC/MI, among other initiatives.

In coordination amongst themselves and with multilateral agencies, countries can identify common interests, advance specific agendas in co-funded programs and via joint research and scientific interchange, share knowledge of policy best practice, strategically engage public and private stakeholders, and disseminate results amongst themselves, contributing to raise awareness regarding the true benefits of sustainable biofuels and bioproducts. In doing so, they decrease overall policy development/deployment costs, avoid duplication of efforts, enhance communication and ultimately accelerate technology deployment. The BfP can also enhance collaboration with existing initiatives such as GBEP, IEA Bioenergy, inter alia, where co-funded R&D projects of multilateral interest are underway with information exchange and a task-sharing component.

Having recognized the need for a significantly scaled up deployment of bioenergy and bioproducts, and established ambitious goals to that effect, the Biofuture Platform Vision Declaration, from 2017, calls for the development of more specific bioeconomy targets, an action plan, and a monitoring mechanism. The conclusions and recommendations presented above – with due care to avoid overprescriptiveness – could be developed into a basic "low carbon bioeconomy preflight checklist", to be agreed on by the Biofuture Platform countries and then progressively implemented domestically, with full recognition of every country and region´s particularities, needs, and circumstances. Future editions of the present report could then follow up on progress in the implementation of this minimum agenda, with attention to lessons learned and actual results on the ground, including evolution of production, investments, competitiveness, and technology.

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LIST OF ABBREVIATIONS

Abbreviation	Meaning
~	Approximately
10^3 hec	One thousand hectares
1G	First-Generation
2DS	IEA's 2°C scenario - aligned with the goal set-out in the Paris Agreement to limit the increase in global average temperature[29]
2G	Second-Generation
3G	Third-Generation
AAFC	Agriculture and Agri-Food Canada
ABRABA	Brazilian Association for Biofuels in Aviation
AFDC	Alternative Fuels Data Center
AK	Amandus Kahl GmbH & Co. KG
ANAC	Brazilian Civil Aviation Agency
ANFAVEA	Brazilian Association of Automotive Vehicle Manufacturers
ANP	Brazilian Agency of Petroleum, Natural Gas and Biofuels
APEX-Brasil	Brazilian Trade and Investment Promotion Agency
BAU	Business as Usual
BEN	Brazilian Energy Balance
BfP	Biofuture Platform
BKR	Bruins &Kwast Recycling BV
BNDES	Brazilian Development Bank
BTG	Biomass Technology Group
BTL	Biomass to Liquid
CCS	Carbon Capture and Storage
CEBDS	Brazil's Business Council for Sustainable Development
CEM	Clean Energy Ministerial
CFS	Canada's Clean Fuel Standard
CH4	Methane
CIDE	Brazilian Contribution for Intervention in Economic Domain

29 The 2DS is the main focus of the International Energy Agency's annual publication: Energy Technology Perspectives (IEA, 2018). The scenario lays out an energy system pathway and a CO2 emissions trajectory consistent with at least a 50% chance of limiting the average global temperature increase to 2°C by 2100 (IEA, 2017a). Annual energy sector emissions are reduced by 70% from today's levels by 2060 with cumulative emissions of around 1,170 gigatons of CO2 (GtCO2) between 2015 and 2100 (including additional industrial process emissions). To stay within this range, CO2 emissions from fuel combustion and industrial processes must continue to decline after 2060 and carbon neutrality in the energy system must be reached by 2100.

CIDEB	Uruguay's Research Center for Second Generation Biofuel Development
CO2	Carbon Dioxide
COFINS	Brazilian Contribution for Financing Social Security
COP	Conference of the Parties
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
CRS	United States' Congressional Research Service
CTC	Sugarcane Technology Center
DBT-ICT	India's Center for Energy Biosciences and Institute of Chemical Technology
DME	Dimethyl ether
DOE	United States Department for Energy
DPA	Defence Production Act
EBP	Ethanol Blending Program
EC	European Commission
EERE	United States Office of Energy Efficiency and Renewable Energy
EFSI	European Fund for Strategic Investments
EIA	U.S. Energy Information Administration
EIB	European Investment Bank
EISA	Energy Independence and Security Act
EJ	Exajoules
EMBRAPA	Brazilian Agricultural Research Corporation
ENI	Ente Nazionale Idrocarburi
EPA	United States Environment Protection Agency
EPE	Brazilian Energy Research Office
ESALQ/USP	Luiz Queiroz College of Agriculture – University of Sao Paulo - Brazil
ETIP	European Technology and Innovation Platform
EU	European Union
EUR	Euros
FAO	Food and Agriculture Organization of the United Nations
FAPESP	São Paulo's Research Foundation
FINEP	Brazil's Funding Authority for Studies and Projects
FOG	Fats, Oil and Grease
FT diesel	Fischer-Tropsch
G20	Group of 20 nations that represent 85% of the global gross domestic product
GAIN	Global Agricultural Information Network
GBEP	Global Bioenergy Partnership
GBP	Great Britain Pounds
GDP	Gross Domestic Product
GHG	Greenhouse gases
GRFA	Global Renewable Fuels Alliance
GSI	Global Subsidies Initiative
GST	Goods and Services Tax
GtCO2	Gigatons of Carbon Dioxide
HVO	Hydrotreated Vegetable Oil
ICAO	The Intentional Civil Aviation Organization
ICCT	The International Council on Clean Transportation
ICMS	Brazilian state tax for circulation of goods and services
IEA	International Energy Agency

IISD	International Institute for Sustainable Development
iLUC	Indirect Land Use Change
IPI	Brazilian Tax on Industrialized Products
IRENA	International Renewable Energy Agency
ISCC+	International Sustainability and Carbon Certification
LCFS	California's Low carbon Fuel Standard
LCICG	Low carbon Innovation Co-ordination Group
LPO	Energy Loans Program Office
m^3	Cubic meter
MAPA	Brazil's Ministry of Agriculture, Livestock, and Supply
MDA	Brazil's Ministry of Agrarian Development
MDIC	Brazil's Ministry of Industry, Foreign Trade and Services
MI	Mission Innovation
MIT	MKB Innovatieregeling Regio en Topsectoren – Netherlands
MJ	Megajoule
MME	Brazil's Ministry of Mines and Energy
MOPNG	India's Ministry of Petroleum and Natural Gas
MRE	Brazilian Ministry of External Relations
MtCO2e	Metric tons of carbon dioxide equivalent
N2O	Nitrous Oxide
NDC	Nationally Determined Contribution
NER300	New Entrants' Reserve 300
NERSC	Natural Sciences and Engineering Research Council Canada
NGBF	NextGen Biofuel Fund – Canada
NRC	Natural Resources Canada
PAISS	Brazil's Joint Plan for Supporting Industrial Technological Innovation in the Sugarcane-based Energy and Chemical Sectors
PIS	Brazilian Contribution to the Social Integration
R&D	Research and Development
RD&D	Research, Development and Demonstration
RDA	R&D Allowances
RE	Renewable Electricity
REDII	Renewable Energy Directive
ReMap	Renewable Energy Roadmaps
REN 21	Renewable Energy Policy Network for the 21st Century
RFA	Renewables Fuels Association
RFS	United States Renewable Fuel Standard
RRC	R&R Consult
RSB	Roundtable for Sustainable Biomass Standard
RVO.nl	Netherlands Enterprise Agency
SBIC/ MI	Sustainable Biofuels Innovation Challenge, a Mission Innovation initiative to accelerated advanced biofuels research & development
SDTC	Sustainable Development Technology Canada
SE4All	Sustainable Energy for All
SENER	Mexican Ministry of Energy
SET	Research Framework and Strategic Energy Technologies Program
SNG	Substitute Natural Gas

tCO2e	Ton of carbon dioxide equivalent
TINA	Technology Innovation Needs Assessments
TKI-BBE	Stichting Topconsortium voor Kennis-en Innovatie Biobased Economy – Netherlands
TRL	Technology Readiness Level
UCO	Used Cooking Oil
UK	United Kingdom
UN	United Nations
UNCTAD	The United Nations Conference on Trade and Development
UNFCCC	United Nations Framework Convention on Climate Change
UNICA	Brazilian Sugarcane Industry Association
UNIDO	United Nations Industrial Development Organization
UPM	The Biofore Company
USA	United States of America
USD	United States Dollars
USD/L	Dollars per liters
USDA	United States Department for Agriculture
VAT	Value Added Tax

NOTE ON EXCHANGE RATES

For the sake of comparability, international currency figures presented in this report are also shown in their current approximate United States Dollar (USD) values. When utilized, conversion rates throughout the report are:

USD/GBP	0.71
USD/EUR	0.81
USD/CAD	1.29
USD/BRL	3.3
USD/IDR	65.15
USD/INR	71.8

Source: (Bloomberg, 2018)

About the Biofuture Platform

The Biofuture Platform is an international, 20-country effort launched in November 2016 to promote an advanced low carbon bioeconomy that is sustainable, innovative and scalable. It facilitates policy dialogue, collaboration and awareness raising among policy-makers, private sector, and academia. Its members are Argentina, Brazil, Canada, China, Denmark, Egypt, Finland, France, India, Indonesia, Italy, Morocco, Mozambique, Netherlands, Paraguay, Philippines, Sweden, United Kingdom, the United States and Uruguay, and among its partner institutions are IRENA, the IEA, FAO, UNCTAD, UNIDO, and UNSE4ALL. It is currently being coordinated by the government of Brazil, as the Platform´s interim Facilitator.

For more information visit **www.biofutureplatform.org**
Contact: **facilitator@biofutureplatform.org**

About the report consultants and partner institutions

WayCarbon is a technology-based company that works to solve sustainability challenges. With eleven years in the market, WayCarbon is a reference in advisory on climate change, environmental asset management and in the development of strategies and business models based on eco-efficiency and the low carbon economy. The company employs knowledge and technology to support its customers to overcome the challenges of a fast-changing world.

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The Carbon Trust's mission is to accelerate the move to a sustainable, low carbon economy. We act as a catalyst for governments, multilateral organisations, businesses, and the public sector in this transition. We are independent, world leading experts on carbon reduction action, resource efficiency strategies, and commercialising clean technologies. As a not-for-dividend group, we reinvest any profits into our mission.

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Questionnaire design and implementation

Established in 1974, the International Energy Agency (IEA) is an intergovernmental organizational that works to ensure reliable, affordable and clean energy for its 30 member countries and beyond. Its four main areas of focus are energy security, economic development, environmental awareness and engagement worldwide.

For more information visit **https://www.iea.org/**

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