Commercializing Conventional and Advanced Transport Biofuels from Biomass and Other Renewable Feedstocks

Task 39
IEA Bioenergy

Inside This Issue

From the Task

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During the last triennium (2016-2018), Task 39 continued its work to advance development and deployment of sustainable, lower carbon liquid biofuels for transport with an overall goal of facilitating the commercialization of both conventional and advanced liquid biofuels from biomass.

Through a coordinated focus on technology, commercialization, sustainability, policy, markets and implementation, Task 39's member countries and other transport biofuels stakeholders worked together to develop and deploy biofuels, with the primary goal of decarbonizing the transport sector. These included conventional biofuels (i.e. ethanol and fatty acid methyl esters (FAME) biodiesel), cellulosic ethanol, renewable diesel (also known as hydrotreated vegetable oils (HVO) or hydrotreated esters and fatty acids (HEFA)), sustainable aviation fuel, sustainable marine fuel, etc., through various processing routes involving oleochemical, biochemical, thermochemical or hybrid conversion technologies. The Task also continued to identify and facilitate opportunities for comparative techno-economic (TEA) and life cycle (LCA) assessments, and to monitor the many policies being used to try to foster increased production and use of biofuels. To a large extent, the Task continues to succeed by providing an international forum for integrated discussions of biofuels-related issues, benefiting from the active involvement of many biofules stakeholders and experts from industry, government and academia.

The primary success of Task 39 during the 2016-2018 triennium was to encourage decarbonization in the transportation sector, particularly within long-distance transport sub-sectors (i.e., aviation, marine, rail, and trucking), by producing and using more lower carbon biofuels. These transport sub-sectors have complex fuel supply chains and high fuel price sensitivities, especially aviation and marine. Task 39 reported on related technology development, commercialisation, sustainability assessment and policy implementation. This work has helped to better understand the shorter- and longer-term opportunities and challenges to reducing these sectors' carbon footprints. While

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We welcome your feedback. Please direct your comments to Mahmood Ebadian

momentum to decarbonize maritime transport, the aviation sub-sector is where industry is most actively championing development of low carbon intensity fuels.

Another accomplishment of Task 39 during the previous triennium was to enhance understanding of the commonalities and differences between four well-recognized biofuels life cycle analysis (LCA) models (i.e., EU's BIOGRACE, Canada's GHGENIUS, US's GREET and Brazil's VSB). These LCA models have been used globally by industry, policy makers and regulators to evaluate and quantify the carbon intensity of biofuels produced from specific biomass feedstocks using well defined conversion technologies. The work of Task 39's LCA expert steering committee has helped to further focus the Task's activities in this area for the 2019-2021 triennium. We anticipate ongoing joint work with the newly formed IEA Bioenergy Sustainability Task (new Task 45) as well as with other groups working in this area such as GBEP, IRENA, etc. Sustainability assessments continue to gain ever greater importance for policy makers and regulators, and Task 39 continues to explore best how to further harmonize and extend LCA modelling approaches. For example, how to more broadly consider key factors that influence LCA results, such as system boundaries and specific assumptions about soil carbon changes and how to handle coproducts (i.e., by displacement, energy content, economic allocation, etc).

During the 2016-2018 triennium, Task 39 tried to expand membership within the Task. As indicated in the IEA's World Energy Outlook, China and India are projected to become major global producers and users of transportation fuels as their economies continue to develop and grow. To build on the desire to recruit these countries, Task 39 members unanimously accepted the Chinese invitation to hold its first Task meeting of 2018 in Beijing (7-9 April, 2018). The Beijing Task 39 business meeting significantly benefited from the participation of representatives of China's National Energy Administration as well as various Chinese industry, university and government groups including several members of the IEA Bioenergy Executive Committee (ExCo). In addition to good academic, government and industry participation from China, representatives from Indonesia and Thailand also attended as well as several members of the IEA Bioenergy Executive Committee (ExCo). Task 39 also invited representatives from China and India (and Mexico) to other Task 39 business meetings. Although China has not yet joined the IEA Bioenergy TCP, contacts with China have been greatly strengthened. We remain optimistic that China will join IEA Bioenergy and Task 39 during this triennium.

Ireland recently became a member of the IEA Bioenergy TCP and Task 39 for the 2019-2021 triennium. In addition, former Task 39 members were invited to re-join, and Norway is rejoining the Task for the 2019-2021 triennium. Other countries that we also hope will become members of IEA Bioenergy and Task 39 in the 2019-2021 triennium include Chile, Indonesia, Malaysia, Mexico and Thailand. Economies in each of these countries are growing, with increased manufacturing and consumption leading to more freight transport and mounting concerns about how to decarbonize their economies, including their long-distance trucking, rail, shipping and aviation transport sub-sectors, to meet their Paris Agreement commitments.

The active participation of most country representatives/national team leaders in the Task facilitates excellent international information exchange.

With its multifaceted communication strategy, Task 39 promotes effective communications and dissemination of information relevant to biofuels stakeholders through:

1) Task 39 published reports and peer-reviewed publications: http://task39.ieabioenergy.com/publications/
2) Task 39 newsletters (approximately three per year): http://task39.ieabioenergy.com/newsletters/
3) Webinars
4) Bi-annual business meetings with active industry involvement
5) Large-scale demonstration plants database: http://demoplants.bioenergy2020.eu/

The Task's proposed program of work for the new triennium will continue to span technology, policy, sustainability and commercialization issues and benefit from Task 39's already established strong and active participating network of experts from within industry, academia and government research institutions. During 2019-2021, the Task intends to:

- Continue to contribute to informing policy by providing sound information and analysis on biofuels issues/topics that are often misinterpreted, such as sustainability assessment, especially LCA studies. A major focus will be on improving the overall sustainability assessment of transport fuels and identifying and evaluating opportunities to more quickly and cost effectively scale up production, for example the potential to coprocess biogenic and fossil feedstocks together in existing petroleum refineries, better leveraging these tremendously large existing assets.
- Continue to harmonize and extend LCA modeling approaches and to effectively communicate key results to non-technical audiences by showing and emphasizing how comparable results can be obtained using different LCA models when their assumptions and approaches are harmonized. Additional important aspects of LCA modeling for sustainability assessment to be studied include the impacts of system boundaries, assumptions about soil carbon changes, and also how coproducts are handled (i.e., by displacement, energy content, economic allocation, etc).
- Achieving greater active participation by oil refiners will be one of the Task's objective for the new triennium. While several feedstock and technology combinations can produce bio-intermediate products which could be further upgraded in petroleum refineries, there are several potential obstacles to overcome that involve a complex combination of technical, policy and sustainability issues.
- Further evaluating oleochemical, feedstocks, lignocellulosic biomass resources including agricultural and forestry residues, as well as other carbonaceous processing "waste" feedstocks (e.g., organic fraction of MSW) and their conversion technology pathways for producing advanced biofuels, especially drop-in biofuels to fuel heavy duty and long distance transport.
- Assessing the potential development of improved certification schemes across all of "waste", oleochemical and lignocellulosic feedstocks and their supply chains, i.e. from feedstock production through fuel delivery to end users.
- Continue working on TEA of prioritized feedstock-conversion technology pathways for producing advanced biofuels, in particular for drop-in biofuels, to better understand cost sensitivities and provide better direction for de-risking further investments as well as to support policy making.
- Other focus areas planned for the 2019-2021 triennium include: 1) monitoring on-going developments in algal biofuels and electrofuels (including "power-to-X" technologies); 2) expediting commercialization of 1.5 and second generation cellulosic ethanol; 3) better understanding the role of specific feedstocks in producing biofuels at lower cost and reduced carbon intensities; 4) maximizing emission reduction benefits from biofuels by co-optimizing advanced fuels for advanced engines to achieve higher transport efficiencies; 5) maintaining and updating the Task's database on advanced biofuels pilot, demonstration and commercial facilities; 6) updating the Task's periodically issued compare-and-contrast report on policies being used within member countries, their effectiveness and lessons learned to develop biofuels markets; and 7) following biofuels development in emerging markets.

In closing, we are grateful to Glaucia Mendes Souza, Brazil's lead representative to the Task, and her colleagues for authoring this newsletter's feature article on biofuels-related developments in Brazil.

As always, we appreciate your readership and value your input and feedback on this newsletter. Please email us any ideas or suggestions for increasing its value.

Thanks for reading and participating in the IEA Bioenergy Task 39 network.

Jim, Jack, and Mahmood

Biofuels Production and Consumption in Brazil: Status, Advances and Challenges

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1. Status of the Brazilian Biofuels Industry

Brazil has an energy matrix with substantial renewable content, with renewables (including hydropower) accounting for 42.9% of the total domestic energy supply (Brazilian Energy Balance 2018). As Figure 1 shows, sugarcane biomass represents 17%; hydropower 12%; charcoal and firewood 8%; and other renewables, 5.9%. In terms of electricity production, comprising domestic production plus imports, which are predominantly of renewable origin, renewables accounted for 80.4% of the electricity supply in 2017: As Figure 2 shows, hydropower represented 65.2%; natural gas 10.5%; biomass 8.2%; wind power 6.8%; charcoal 3.6%; oil derivates 3%; nuclear 2.5%; and solar 0.1%.[1] The country has a renewables share in installed capacity for electricity generation of 81.5% (Figure 3).

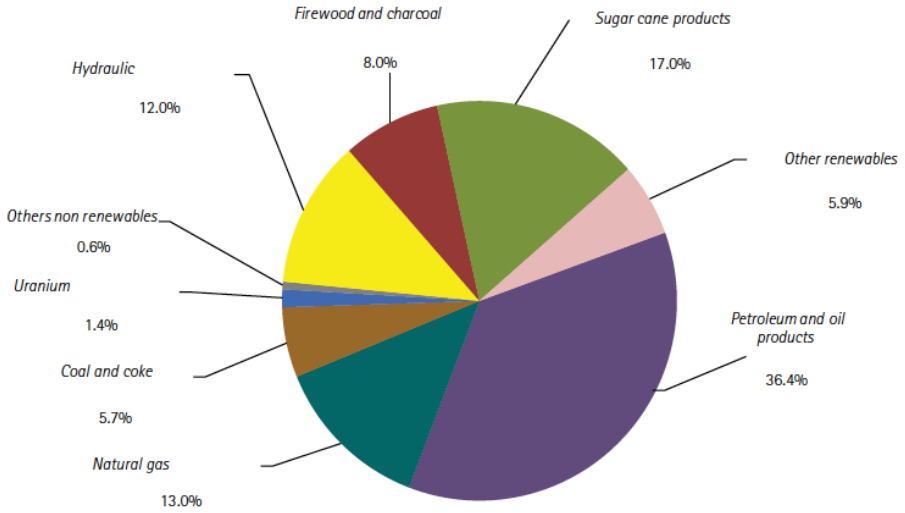

Figure 1. Domestic energy supply (Brazilian Energy Balance 2018 – Year 2017)

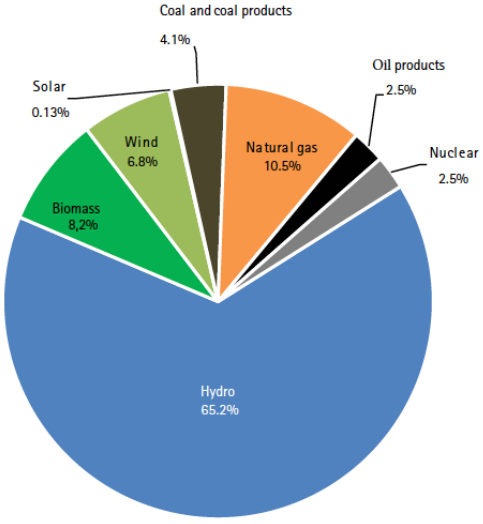

Figure 2. Domestic electricity supply by source (Brazilian Energy Balance 2018 – Year 2017)

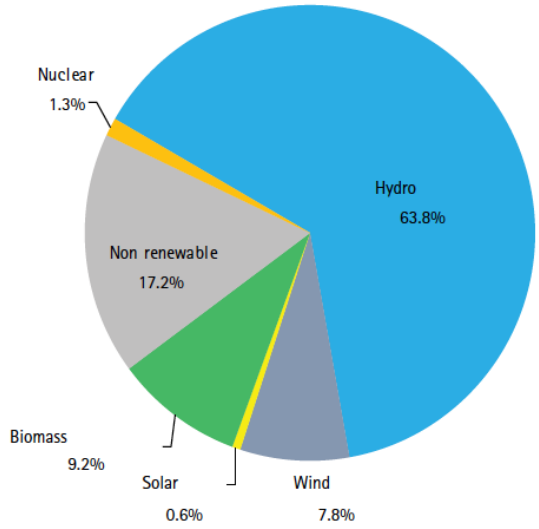

Figure 3. Participation of energy sources in the installed capacity for electricity generation (Brazilian Energy Balance 2018 – Year 2017)

Even with an energy matrix that favors renewable sources, Brazil is still dependent on fossil fuels, which account for 57.1% of the domestic supply; oil derivates alone represent 36.4% of all non-renewable sources (Figure 1). In order to promote the production of biofuels, the country has been investing in incentive policies since the 1930s. There are tax exemptions for biofuel producers, ethanol flex fuel vehicles and ethanol fuel, and also for biodiesel production, and in addition there is now a new law for biofuels, Renovabio. As a result of these policies, today Brazil has a biofuel mandatory blend level of 27% ethanol in gasoline and 10% biodiesel in diesel. Hydrous ethanol (comprising approximately 95% ethanol + 5% water) is also marketed in all gas stations in Brazil.

1.1. Ethanol

It all began with sugarcane ethanol. As a major producer of sugarcane, in 1931 the Brazilian government implemented a compulsory blend of at least 5% anhydrous ethanol in gasoline, aimed at reducing the country's dependence on imported petroleum by utilizing excess production by the sugar industry to produce ethanol.

Some decades later, in 1976, in response to the impacts on the oil supply and price shocks during the 1970s, the Brazilian government created Proalcool, a program to incentivize fuel alcohol production. This program led to increasing the ethanol blending level in gasoline up to 25% (E25) and it also introduced the use of hydrated (also known as hydrous) ethanol ("E100"; actually about E95) for use in dedicated vehicles. The Proalcool program also established: lower consumer prices for hydrated ethanol than for ethanol-blended gasoline; competitive prices for ethanol producers; and favorable financing conditions for sugar-ethanol mills to increase their production capacity. It also reduced taxes on new cars and annual registration fees for vehicles capable of running on hydrated ethanol. Under the Proalcool program, all gas stations in Brazil became able to sell hydrated ethanol and the Brazilian government created ethanol storage reserves to ensure supply throughout the year.

Brazil's policies related to fuel ethanol were revised in 1985, due to the decline in oil prices and the strengthening of international sugar prices, and this led to a temporary end to the Proálcool initiative. The sugarcane industry became focused on maximizing sugar production for export instead of ethanol.

In 2003, a new phase of expansion of sugarcane-based sugar and ethanol production took place motivated by the automotive industry launch of new flex-fuel cars (FFVs) capable of using either gasoline (with 20-25% anhydrous ethanol), hydrated ethanol or any blend of the two. These new FFVs were well accepted by consumers: as a result, the consumption of hydrated ethanol in the domestic market made a strong comeback. This also created opportunities for another expansion of the sugarcane industry in Brazil. During the period of 2003–2008, the Brazilian sugarcane industry grew rapidly, with many new and more efficient sugar-ethanol mills commissioned. An industry consolidation also

occurred during this time, as positive indicators for the industry's environmental sustainability were demonstrated alongside support for new technology development and technology transfer. It was at this time that ethanol started to become a main product in many sugar-ethanol plants and the concept of new mills only dedicated to ethanol production became an opportunity to explore.[2]

However, in 2008, the Brazilian ethanol agroindustry started to suffer due to its increasing lack of competitiveness in relation to gasoline and policies, with the use of petroleum-derived products economically favored. As the Brazilian automotive fleet was flex-fuel, gasoline demand increased and ethanol demand decreased such that by 2010 ethanol production was 30% less than in 2008.[3] However, over the intervening years, ethanol production has slowly increased. As of December 2017, 382 ethanol plants were producing anhydrous and hydrous ethanol.[4] Total anhydrous and hydrous ethanol production capacities were 128,000 m^3/day and 237,000 m^3/day, respectively.

In 2018, the share of ethanol in the fuel matrix used by light duty vehicles (Otto Cycle - in gasoline equivalent) reached 50.2%, the highest in history. This occurred despite a decrease in sugarcane production. According to the Ministry of Agriculture, Livestock and Food Supply (MAPA), 635.6 million tons of sugarcane were produced in 2017, 5.2% lower than in 2016's level of 670.6 million tons. In 2017, 38.1 million tons of sugar were produced, 2% lower than in 2016, while total ethanol production decreased by 2.1% to 27,694 thousand m^3. About 57.8% of this total, 15,998 thousand m^3, was hydrous ethanol, which decreased by 3.4% compared to 2016. There was a smaller decrease of 0.3% in the production of anhydrous ethanol, which is blended with gasoline, with 2017 production totaling 11,695 thousand m^3.[1]

In 2018, the share of ethanol used by light duty vehicles reached 50.2% of Brazil's total fuel matrix, the highest in history.

The sugarcane sugar-ethanol industry is accustomed to producing a roughly 40:60 ratio of sugar:ethanol (or vice versa) in a given year, as well as with switching between sugar or ethanol being the major intended product in any given year. Once a production plant adjusts its process to produce a targeted ratio of sugar:ethanol in a given year, there is much less flexibility to change it during that year's crushing season.

Besides sugarcane, Brazil now produces ethanol from corn grain and this is increasing. The total ethanol production from corn for 2017 is projected to be 480 million liters, or 1.8% of total projected ethanol production, more than double 2016 production (235 million liters). Currently, there are four plants producing ethanol from corn in Brazil. These plants are located in the states of Mato Grosso and Goias. Two are flex-plants, producing ethanol from both sugarcane and corn, and the remaining two are dedicated only to corn. Corn ethanol plants are feasible in corn producing areas in Brazil, especially when they are sited close to livestock operations because co-product distillers dried grain and solubles (DDGs), the major co-product from corn ethanol production, is valuable as a ruminant animal feed and can be sold to increase the profitability of the business. However, the center-west and northern areas in Brazil suitable for corn production are larger states with lower population densities and limited ethanol demand. An interesting benefit regarding corn-based ethanol production is that incorporating corn feedstock may help Brazil's seasonal sugarcane based (sugar-) ethanol production plants by extending their annual production period beyond their, on average, 200 operating days/year (due to the difficulties of harvesting sugarcane during the rainy season). Moreover, corn ethanol-based plants may be a bridge to consolidate lignocellulosic sugarcane bagasse-based ethanol since units that operate with corn can share reactors for the hydrolysis step for both feedstocks (sugarcane bagasse and corn starch both need hydrolysis reactors).

Aiming to give a new incentive to sugarcane producers, in June 2017 MAPA announced the Brazilian Agricultural Crop and Livestock Plan for 2017/2018. A total of R$190.25 billion (around US$ 50 billion) will be directed to fund agricultural and livestock improvement programs, including initiatives focused on boosting sugar and ethanol production. One example is Prorenova, a credit line to finance the renewal and/or expansion of sugarcane fields, which is intended to

prioritize the use of new sugarcane varieties and will receive a total of R$ 1.5 billion for 2017/2018. The annual interest rate is comprised of the "long term interest rate" (TJLP) plus 3.7% with payment due within 96 months after contracting the finance. In addition to conventional biofuels, these programs will promote the production of advanced biofuels for long-distance transport sectors such as aviation. Producers of biofuels can enter the market once they are authorized as a producer of biofuels by the National Agency of Petroleum, Natural Gas and Biofuels (ANP).

Besides financing, another way Brazil is promoting biofuels is through excise duty reductions. There are tax incentives for biofuel producers, blenders and users that include tax incentives for ethanol-flex fuel vehicles, which were critically important in supporting ethanol consumption since the introduction of flex-fuel cars. There are also tax incentives for ethanol fuel: currently, the federal government provides preferential tax treatment for ethanol compared to gasoline under both its Contribution for Intervention in Economic Domain (CIDE) and Contribution to the Social Integration Program/Contribution for Financing Social Security (PIS/COFINS) programs. In addition, governments from several Brazilian states provide differential treatment for ethanol by using different state taxes for circulation of goods and services (ICMS) percentages for ethanol and gasoline.

1.2. Biodiesel

Brazil has a mandatory blend of 10% biodiesel in diesel. The biodiesel program started in the 1980s, with the PRO-OLEO (Plan for the Production of Vegetable Oils for Energy Purposes) program, which established a mixture of 30% vegetable oils or derivatives in diesel and, in the long run, aimed for a total substitution. The proposed technological alternative was to produce biofuels by transesterification of vegetable oils. The main motivation was the oil crisis and sharp increase in fuel prices. After the fall in international oil prices in 1986, the PRO-OLEO program was abandoned.

In the early 2000s, the Brazilian government began another program to replace petroleum diesel with biodiesel. Several studies were carried out by inter-ministerial commissions in partnership with universities and research centers. In 2002, ethanolysis of vegetable oils was chosen as the main production route, with the fatty acid ester product named PROBIODIESEL. As Brazil is a large ethanol producer, ethanolysis was the chosen production route instead of methanolysis. The National Program of Production and Use of Biodiesel (PNPB) was created in 2005, with energy, economic and social objectives established and feedstock production by small farmers stimulated. The biodiesel industry evolved gradually, with soybean oil, castor oil and tallow becoming the most relevant feedstocks for production. In this program, a blend/substitution level of 5% (B5) was mandated by 2005, and it was suggested that in 15 years this mandated level would increase to 20% (B20). In 2018, the blending mandate for biodiesel was 10% (B10).

The federal government sets federal-level tax exemptions and incentives for biodiesel, according to the nature of the raw material, size of producer and region of production, in order to encourage the production of biodiesel and to promote social inclusion. Brazil imports almost no biodiesel. Under the country's National Biodiesel Production Program (PNPB), regulated by ANP through an auction system, only domestically produced biodiesel is eligible for auction. Businesses relying on heavy duty fleets like long haul trucks, buses, rail transportation and agricultural machinery are allowed to use higher blends than those set by the current legislation and could potentially import biodiesel, however in practice they do not as the price of imported product is not competitive with domestically produced biodiesel. As of December 2017, Brazil's 50 biodiesel production plants reached an installed biodiesel production capacity of 7.6 billion liters per year. In 2017, Brazil's production of biodiesel (B100) increased 12.9%, reaching 4,291,294 m^3, compared to 3,801,339 m^3 in 2016. The main raw materials were soybean oil (65%) followed by tallow (12%). More recently, beef and chicken industry fat have also become significant feedstocks since Brazil is among the largest producers.

2. Biofuel Policies: RenovaBio, Brazilian new biofuels legislation

Brazil's Proalcool and the Biodiesel programs were started mostly for economic and energy security reasons. More recent governmental programs consider sustainability concerns, with a focus on social and environmental aspects. One example is RenovaBio, the new legislation established for the biofuel sector in 2017. The RenovaBio program's objective is to revitalize Brazil's biodiesel sector and meet its annual decarbonization targets committed to at the 21st Conference of the Parties (COP21) (Box 1).[5]

Created by Brazil's new Law 13.576/2017, the new policy under RenovaBio recognizes the strategic role of all types of biofuels in Brazil's energy matrix, encourages energy efficiency gains in biofuels production and use, and fosters market mechanisms to reduce the carbon footprint of biofuels. Other objectives of the new law are to promote the adequate expansion of biofuels, with emphasis on ensuring regularity in fuel supply and predictability for the market. Under RenovaBio, the Brazilian government plans to increase annual ethanol production from its current level of 30 billion liters to around 50 billion liters by 2030, and over the same period to similarly boost annual biodiesel production from its current level of 4 billion liters to 13 billion liters.[6]

Box 1 - Brazilian commitments set at COP21
As a result of COP21 commitments and several voluntary goals set by Brazil, the country has committed to reduce its domestic GHG emissions to 37% by 2025 and 43% by 2030, both based on 2005 levels. When it comes to energy production and use, Brazil's Intended Nationally Determined Contributions (INDCs) commitments are:
- Achieve an estimated 45% share of renewables in the energy matrix by 2030; today this share is 42.9%;
- Increase the share of sustainable bioenergy in the Brazilian energy matrix to approximately 18% by 2030, by expanding biofuel consumption, increasing ethanol supply - including the proportion of advanced biofuels (second generation) and the share of biodiesel in the diesel mix;
- Obtain at least a 66% share of hydropower in electricity generation by 2030, not considering self-produced electricity;
- Expand the use of renewable energy sources other than hydropower in the total energy mix to between 28% and 33% by 2030; and
- Expand the domestic use of non-fossil energy sources, increasing the share of renewables (other than hydropower) in the power supply to at least 23% by 2030, by increasing the share of wind, biomass, and solar energy; and also achieve 10% efficiency gains in the electricity sector by 2030

The new RenovaBio program is not expected to include the creation of carbon taxes or any kind of subsidy for biofuels. However, one of its provisions is to provide a market-based incentive by issuing GHG emissions reduction certificates to biofuels producers that can be traded in the stock market and purchased by fuel distributers. In Portuguese, these certificates are named "CBio" (an acronym for "Crédito de Descarbonização"– Decarbonization Credit), with one CBio corresponding to a reduction of one ton of carbon dioxide equivalent (CO_2eq) in comparison to fossil fuel emissions. Biofuels production must be certified through a life cycle analysis (LCA) in order for a producer to be able to obtain CBio certificates.

The RenovoBio law will fully come into force in 2020, however throughout 2018 and 2019 some of its mechanisms began to be developed. The main policy instrument is the establishment of annual national decarbonization targets for the fuel sector. The national emission reduction targets for the fuel matrix have been defined for a period of 10 years (2018-2028) by the Resolution CNPE nº 5, released in 2018 June by the Nacional Energy Policy Council (CNPE). The national emissions reduction target starts at 1% in 2019 and gradually increases to reach 10.1% in 2028. This national target established by the NEPC will be further broken down into individual annual mandatory goals for specific fuel distributors according to their share of the fossil fuels market. These individual goals will be defined and publicized by ANP by July 1, 2019 and are expected to enter into force on December 26, 2019.

In the process of certifying biofuels production, producers and importers of biofuels will receive different grades, with CBio certificate value inversely proportional to the carbon intensity of the produced biofuel. The grades will accurately reflect the individual contribution of each biofuels producer to the mitigation of a specific amount of greenhouse gases compared to its fossil fuel reference in terms of tons of CO_2 equivalent GHG emissions. In addition, biofuels producers and importers who intend to participate in the program must hire ANP-accredited inspector firms in order to obtain their Biofuels Certification and validate their Energy Efficiency Grade; producer certification by ANP will be valid for three years, after which recertification and reassessment of energy efficiency grades will be required.

The Resolution ANP nº 758, passed November 23, 2018, regulates the certification of efficient production or imports of biofuels and the accreditation of inspector firms. Fuel distributors must prove they have fulfilled their individual compulsory goals related to emissions reduction through their purchase of CBios. Fuel distributors meet their annual mandatory individual goals by proving their ownership of a sufficient number of CBios in their portfolio. Fuel producers adherence to the program is voluntary, however once they have their production certified, they are able to generate additional revenue by selling their CBio certificates.

In January 2019, ANP approved two inspector firms to be in charge of the certification process: SGS ICS Certificadora Ltda and Green Domus Desenvolvimento Sustentável Ltda.

RenovaCalc is the tool developed for calculating the carbon intensity of biofuels following methodology established by RenovaBio. First released in May 2018, the RenovoCalc tool functions as a calculator to quantify the environmental performance of biofuel production by specific production plants. The RenovaCalc tool now can be used to calculate the production efficiency of about ten different technological routes for the the production of biofuels (comprising each of the biofuels included in RenovaBio, i.e., ethanol, biodiesel, biokerosene and biomethane). Each producer must provide detailed LCA information about their agricultural land use and manufacturing processes, such as the planting and conversion systems used as well as the amount of fuel consumption, agrochemical consumption, etc. Total estimated emissions are compared to those of the fossil fuel equivalent (ethanol should be compared to gasoline and biodiesel to diesel). Ultimately, the calculator generates a final grade representing the level of emissions mitigation. This grade becomes a multiplying factor when the CBios are valued.

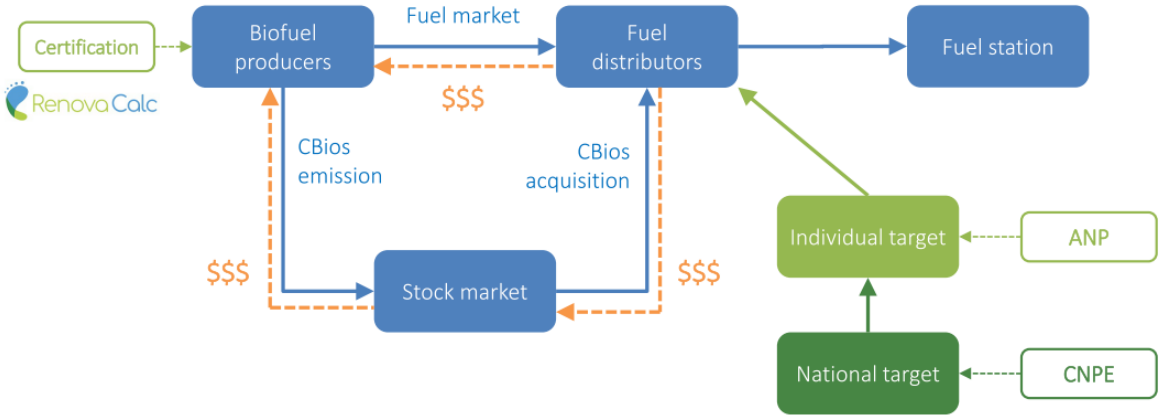

Figure 4. RenovaBio governance

3. Advances in biofuels production technologies

The recent international climate agreement and the enactment of laws such as RenovaBio promise an even greater future for biofuels in Brazil's energy sector. In addition to encouraging increased production and use of conventional biofuels, greatly increased production of advanced (lignocellulosic) biofuels will also be critical to achieving future emission reduction goals. Accordingly, Brazil is investing in substantial research and development to tackle the techno-economic challenges of producing lower carbon intensity advanced biofuels cost competitively.

When it comes to production of advanced biofuels, Brazil has two commercial cellulosic ethanol plants. These are GranBio's Bioflex-I plant in São Miguel dos Campos (Alagoas), with a nominal annual production capacity of 82 million liters, and Raízen's plant in Piracicaba (São Paulo), with an annual capacity of 42 million liters. In addition, there is an experimental plant within the Cane Technology Center (CTC) in Piracicaba, with an annual capacity of 3 million liters. The first two commercial plants are still in start up phase operating below their nominal capacities as they work to debug technical problems mainly in the pre-treatment and lignin filtration processing stages.

GranBio pioneered the first commercial-scale cellulosic ethanol plant in the Southern Hemisphere and is applying the biorefinery concept, i.e, targeting to produce a combination of biofuels, biochemicals and bioenergy products.[7] The

company resumed operations at the end of January 2019 based on 100% proprietary technology and has so far demonstrated annualized production of 36 million liters of cellulosic ethanol. GranBio expects to increase production to 45 million liters by 2020 and 60 million liters by 2021, and to achieve a production cost similar to conventional sugarcane ethanol. GranBio's main early challenge was improving the biomass (sugarcane residues) pre-treatment and enzymatic hydrolysis yields for producing lignocellulosic ("or "2G") ethanol. Its entire production of cellulosic ethanol is exported, especially to the United States and Europe where there are more mature carbon pricing markets in which lower carbon fuels command a premium. Surprisingly, the Brazilian market still does not recognize (value) the low carbon footprint of Brazil's cellulosic (and sugarcane) ethanol. It is expected that the RenovaBio program will lead to Brazil establishing carbon pricing mechanisms in the coming years.

GranBio is also developing partnerships for licensing its technology and constructing new cellulosic ethanol plants based on its design outside of Brazil. Its cellulosic ethanol technology allows countries from Africa and Asia, as well as Europe and elsewhere, to produce ethanol from wood or agricultural residues, without competing with food production or depending on corn or sugarcane suppliers. GranBio expects to announce its next joint-venture plan in 2020, to be focused on demonstrating the replicability and economic return potential of their technology to produce ethanol and other chemicals from the cellulosic portion of residue feedstocks. The company has already made three partnerships to produce biochemicals such as n-butanol by fermentation of cellulosic sugars, however this technology is still at demonstration scale.

Raízen is a joint-venture between Shell and Cosan, an established major Brazilian sugar-ethanol producer that annually produces 2.1 billion liters of ethanol and 4.3 million tons of sugar.[8] Raízen started operations at its first commercial cellulosic ethanol plant in November 2014. Its enzymatic hydrolysis technology allows the annual production of ethanol to be increased without increasing the area under cultivation. Located in Piracicaba, São Paulo, it has the annual capability to produce 42 million liters of cellulosic ethanol from sugarcane straw and bagasse derived from conventional (1G) ethanol/sugar production. In the 2017/2018 harvest, 12 million liters of cellulosic ethanol was produced. By 2024, Raízen plans to build seven more cellulosic ethanol plants located next to conventional sugar-ethanol plants which once operating at full capacity will be able to produce one billion liters of cellulosic ethanol per year.

In the field of bioproducts, Braskem is one of Brazil's leading companies continuously investing in R&D.[9] In 2010, the company launched its new Green Polyethylene (PE), which was the world's first PE resin produced on an industrial scale using sugarcane feedstock. Currently, Braskem's green PE is used by more than 150 brands in a variety of food, cosmetics, toys and bags products being marketed in the USA, Europe, Asia, Africa and South America. Braskem's production plant in Triunfo, Rio Grande do Sul, has a green PE production capacity of 200 thousand tons per year. An LCA of Braskem's green PE showed that when this products is made from sugarcane-based ethanol, 3.09 kilograms of CO_2 are captured (i.e., not emitted relative to petroleum-based production route) for each kilo of green PE produced. This is possible primarily due to the positive carbon sequestration achieved in sugarcane plantation systems in Brazil coupled with the use of renewable bagasse to generate (bio)power.

Besides PE, Braskem continues to develop new renewable products to build its product portfolio. In February 2019, Braskem and the Danish catalyst and technology development company Haldor Topsoe, which produces catalysts and technologies for the chemical and refining industries, announced they were starting to commission a pioneer demonstration plant to validate new conversion technology for cost-competitive production of mono ethylene glycol (MEG) from sugar. Located in Lyngby, Denmark, this demonstration plant represents a major step forward in confirming the technical and economic viability of producing renewable MEG on an industrial scale. MEG is predominantly used in the production of polyester resins, films and fibers. The global market for MEG is large, about US$ 25 billion annually. In 2018, Braskem in partnership with Allbirds, a company located in San Francisco (USA), introduced a new renewable ethylene-vinyl acetate (EVA) product also made from sugarcane. Braskem will also produce renewable EVA at its Triunfo plant in São Paulo.

4. Support for innovation

Due to Brazil's competitive advantages in producing renewable energy and biofuels, and growing biofuels feedstocks, there are already several science and technology funds that support technology innovation in these areas. The National Bank for Social and Economic Development (BNDES) provides specific credit lines for the sugar, ethanol and bioenergy industries to fund investments in sugarcane production, expansion of industrial capacity for sugar and ethanol production, power cogeneration, logistics and multimodal transportation. In 2016, BNDES financed a total of R$2.02 billion in investments for the sugarcane/sugar/ethanol/energy cogeneration industry. The Raízen cellulosic ethanol plant in Piracicaba, for example, received R$ 207 million in financing from BNDES, which represents over 80% of the plant's total cost of R$ 250 million.

In addition to national institutions like BNDES, CNPq and FINEP, the state of São Paulo's funding agency, FAPESP, plays an important role in supporting innovative companies in the bioenergy sector.

FAPESP supports research in small businesses under their PIPE program (Pesquisa Inovativa em Pequenas Empresas), which is devoted to supporting and financing scientific research in small companies based within the state of São Paulo. FAPESP's PIPE program was created in 1997 and has already financially supported more than 1,300 companies and 2,000 research projects with non-refundable resources ranging from R$ 200 mil to R$ 1 million. In addition, the FAPESP program facilitates access to BNDES support. Annually there are four calls for projects to transform research projects into new businesses, to provide funding to support first steps (e.g., technical feasibility assessment) through advanced stages of industrial development and start up of commercial production. The PIPE program is Brazil's largest initiative supporting small company innovation.

There are currently 148 PIPE-supported companies developing innovative technologies and bringing improved solutions to the bioenergy sector. They include start-up companies that are developing digital agriculture, intelligent farming, biotechnology, nanotechnology, hydrogen engines using ethanol, etc.[10]

FAPESP also supports partnerships between academic and industrial laboratories through its Bioenergy Research Program, BIOEN.[11] One of the roles of the BIOEN Program is to find solutions for economically viable commercial production of lignocellulosic sugarcane (bagasse and straw) bioethanol, in parallel with increased conventional ethanol production. It also aims to develop a biorefinery approach for producing biomass derived bioproducts and aviation biofuels. Research funding support spans biomass production and pre-processing to biofuel production and its impacts. The BIOEN Program involves more than 300 researchers and 453 students and has total expenditures of over US$ 200 million. Since 2009, BIOEN has funded a total of 231 projects across 25 fields of knowledge, receiving 560 research grants and scholarships in Brazil and around the world. To date, over 40 projects have been conducted with industry partners including ETH Energia, Braskem, Vale, IBM, Microsoft, EMBRAER, Agilent Technologies, AgroBio, Equipalcool, Infibra, Mahle Metal Leve, Oxiteno, Proteca Biotecnologia Florestal and Suzano Papel e Celulose.

5. Biofuture Platform

The growing consensus around the world about the need to transition to a low carbon economy has resulted in a new wave of international collaboration, dialogue and activity around clean and sustainable energy. The lack of a fully dedicated multilateral agency entrusted with energy issues contributed to a multiplicity of initiatives and fora on this subject. The international energy transition debate so far has been mostly focused on energy efficiency, the power sector, and electrification. Few initiatives have paid sufficient attention to the need and the means to rapidly scale up sustainable bioenergy production and demand, despite most climate and energy projections from IEA, IRENA, and the IPCC pointing out that a significantly increased deployment of sustainable bioenergy is also a condition for meeting the Paris Agreement objectives.

This awareness led the government of Brazil to establish the Biofuture Platform, an intergovernmental, multi-stakeholder alliance of countries dedicated to promote collaboration, dialogue and awareness raising in the low carbon bioenergy and bioeconomy fields.[12] After a successful launch at the UNFCCC COP22 in Marrakesh, the Biofuture Platform´s twenty member countries authored a Vision Declaration setting out goals for the scaling up of the low carbon

bioeconomy; organized several events and policy conferences, notably the first Biofuture Summit, in 2017; and launched the "Creating the Biofuture" report, highlighting the main barriers to progress that need to be addressed.

The role of the Biofuture Platform is to serve as a political and policy forum, catalyzing other initiatives and leveraging knowledge and technical expertise developed by agencies and programs such as the IEA Bioenergy TCP, IRENA, IEA, and others, seeking to accelerate change at national and international levels. In its just over two years of existence so far, the Biofuture Platform has contributed to a noticeable positive change in international attention on bioenergy, bio-based products, and policies for the sector.

After a two-year period serving, per the request of the member countries, as the Biofuture Platform´s interim Facilitator (a role similar to a secretariat), Brazil was elected as the first Chair country of the Biofuture Platform. In February 2019, the International Energy Agency (IEA) assumed the role of Biofuture Platform Facilitator.

6. Conclusions

Biofuels will continue to play an important role in the Brazilian energy matrix and in reducing GHG emissions, which will assist the country in meeting the targets agreed in the Paris Agreement. The new law implemented for biofuels, RenovaBio, makes the future for biofuels in Brazil even more promising and should stimulate long-term investment in the biofuels sector. This new policy brings hope for invigorated innovation and implementation of biofuels production, especially by the ethanol sector which has been negatively affected by the low petroleum/fossil fuel prices in recent years. There are technological challenges to overcome in the production of cellulosic ethanol, but companies and agencies continue to invest in research and development in order to pave a promising path for a new generation of sustainable biofuels, in a country blessed with productive and abundant biomass resources.

The importance of research funding by federal and state agencies to stimulate startups and spin-offs to develop improved solutions to key techno-economic challenges becomes clearer, however data show government investments have declined in recent years, reflecting the economic challenges the country confronts. Though applied research will strengthen the technologies and help the country become even more competitive in renewable energy, the challenge Brazil has to face is overcoming the unfavorable current economic moment and re-investing in innovation.

7. Acknowledgements

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Announcing BBEST 2020 – The Brazilian Bioenergy Science and Technology Conference

Save the date - March 30th-April 1st, 2020 - Hotel Renaissance, São Paulo, Brazil

The focus of BBEST 2020 will be on innovation and top research scientists, government policy makers and representatives of industrial sectors from around the world will particpate.

The previous BBEST conference was held in 2017 and attracted around 400 participants from 14 countries, comprising a cross section of leading research, governmental and industrial representatives, and included presentations on more than 230 cutting-edge scientific research projects related to a variety of bioenergy themes including biomass feedstocks, biorefineries, biofuels production technologies, biofuels engines, aviation applications and sustainability.

See the BBEST website at http://bbest.org.br/ for further details.

In the News

Reports and Research

- January 2019 - IEA Bioenergy News: https://www.ieabioenergy.com/wp-content/uploads/2019/01/IEA-Bioenergy-News-Volume-302-December-2018.pdf.

- January 2019 - Researchers from the National Renewable Energy Laboratory (NREL), Pacific Northwest National Laboratory (PNNL) and Argonne National Laboratory (ANL) have identified an approach to improve the efficiency and reduce costs of biofuel production that moves beyond conventional strategies (Read more).

- January 2019 - Lloyd's Register (LR) and University Maritime Advisory Services (UMAS) have released the study 'Zero-Emission Vessels Transition Pathways' that aims to show what is needed to enable the transition, both at the ship and supply infrastructure level, to deliver zero-emission marine vessels (ZEVs) that are crucial to achieve the IMO's Greenhouse Gas (GHG) Strategy 2050 ambition. The study describes what actions need to be taken now by all stakeholders (Read more).

- March 2019 - The National Association of State Energy Officials and the Energy Futures Initiative released a report that details current employment in a variety of US energy sectors, including within the biofuels and bioenergy production industries (Read more).

- March 2019 - The US Energy Information Administration (EIA) issued a comprehensive report summarizing EIA's Short-Term Energy Outlook and Annual Energy Outlook 2019 analyses and projections on the effects of changes to marine fuel sulfur limits on energy markets from 2020 onwards. The change in sulfur limits has wide-ranging repercussions for the global refining and shipping industries as well for petroleum and future biofuels supply, demand, trade flows, and prices (Read more).

- April 2019 - IEA Bioenergy's Annual Report 2018 summarizes the progress in the Tasks, lists recently completed reports, and summarizes other selected highlight accomplishments of the the IEA Bioenegy TCP in 2018 (Read more).

- April 2019 - Nanyang Technological University and Singapore (NTU Singapore) scientists have demonstrated a new genetic modification that can increase the yield of natural oil in seeds by up to 15% in laboratory conditions (Read more).

- April 2019 - Phase I results of the joint IEA Bioenergy Task 38-Task 39 LCA model comparison study are published on-line in the journal ***Renewable and Sustainable Energy Reviews***. The paper, co-authored by Pereira et al. and entitled, "Comparison of biofuel life-cycle GHG emissions assessment tools: The case studies of ethanol produced from sugarcane, corn, and wheat," shows how leading LCA models that appear to give different results for the same feedstock-biofuels pathways can be harmonized to produce similar results. It recommends greater transparency and consistency in how the results of LCA studies are reported and communicated. (Read more).

Policy and Regulatory Developments

- January 2019 - In Spain, El Mundo reports that the government intends to include a 2% biofuel blending mandate for aviation in its new climate change law that is under development, with the mandate coming into force in 2025. The proposal is a result of work done at ICAO's Committee on Aviation Environmental Protection, and France is reported to also be working on a similar proposal so that the two countries can implement the mandate simultaneously. The proposal also includes mechanisms to promote the industry's development in order to have a better chance of achieving the mandate (Read more).

- January 2019 - In India, the transportation minister announced a national 15% methanol blending policy following a research project measuring air quality around the greater New Delhi region when M15 was used (Read more).

- February 2019 - The Parliament of Finland voted in favor of a law that aims to require transportation fuel to be comprised of 30% biofuel by 2030, with advanced biofuels accounting for 10% of transportation fuel by the same year. These requirements for biofuels blending in transportation fuels would ramp up starting in 2021 (Read more).

Industry News

- December 2018 - In Finland, Stora Enso and the Forest Stewardship Council (FSC) signed an international partnership agreement establishing a long-term strategic collaboration to develop and promote sustainable forestry. The new agreement aims to increase FSC certification, especially among small- and medium-sized private forest owners in the Nordics, Baltics, and across Europe, to increase the FSC certified wood supply (Read more).

- December 2018 - The development of a waste-to-biofuels plant in Minnesota's Twin Cities metro area is one step closer to reality with the Metropolitan Council's recent approval of a memorandum of understanding (MOU) and design deposit agreement with Enerkem Inc (Read more).

- December 2018 - Neste Corp. made its final investment decision, worth 1.4 billion euros (USD$1.6 billion), to more than double its renewable diesel production capacity in Singapore by adding an additional 1.3 million tons of annual capacity (Read more).

- December 2018 - Fulcrum BioEnergy announced that it has selected Gary, Indiana, for the location of its Centerpoint BioFuels Plant, which will convert municipal solid waste into low-carbon, renewable transportation fuel (Read more).

- January 2019 - In Germany, Sulzer's solutions for separation processes are supporting the pioneering EU-funded project 'Steelanol', which aims to turn carbon-rich industrial emissions into bioethanol fuels. By winning this contract, Sulzer is further strengthening its reputation for providing high-quality, reliable and innovative process engineering services and equipment to enable more sustainable and efficient processing plants (Read more).

- January 2019 - Japan Airlines (JAL), a recognized Eco-First company by the Ministry of the Environment of Japan (MOE), will take another step forward in its commitment to invest and realize the operation of an aircraft utilizing sustainable aviation fuel (SAF). By the end of January 2019, JAL plans to operate select flights from San Francisco to Tokyo (Haneda) with SAF supplied by Showa Shell Sekiyu K.K (Read more).

- January 2019 - ExxonMobil and Renewable Energy Group signed a joint research agreement with Clariant to evaluate the potential use of cellulosic sugars from sources such as agricultural waste and residues to produce biofuels that can aid in reducing greenhouse gas emissions (Read more).

- February 2019 - The IEA officially took over the role as the facilitator for the Biofuture Platform, a group of 20 countries seeking to accelerate development and scale up deployment of modern sustainable low carbon alternatives to fossil based solutions in transport, chemicals, plastics and other sectors (Read more).

- February 2019 - The US Renewable Fuels Association (RFA) released its 2019 Ethanol Industry Outlook and Pocket Guide summarizing information and data on America's ethanol industry (Read more).

- March 2019 - Members of the Dutch Sustainable Growth Coalition (DSGC) have partnered with A. P. Moller – Maersk on the world's largest maritime biofuel project. Dutch companies FrieslandCampina, Heineken, Philips, DSM, Shell and Unilever will work with Maersk on piloting use of up to 20% sustainable advanced biofuels to power a triple-E ocean vessel (Read more).

- March 2019 - Dutch renewable fuel company GoodFuels announced that it has extended its partnership with Varo Energy subsidiary Reinplus Fiwado Bunker to improve access to biofuels for deep sea vessels leaving from Rotterdam (Read more).

- March 2019 - IKEA Transport & Logistics Services, CMA CGM, the GoodShipping Program and the Port of Rotterdam announced they will cooperate in a first-of-its-kind partnership to test and scale the use of sustainable marine biofuel oil. The test will commence with a landmark bunkering of the marine biofuel oil on a CMA CGM container vessel and represents a major step towards the decarbonization of ocean freight (Read more).

- April 2019 - Where will all the feedstock come from? As a new wave of large-scale biomass-based diesel projects develops, experts suggest market forces are ready to deliver the necessary fats, oils and greases (Read more).

- April 2019 - Greenfield Global Inc., Canada's largest producer of alcohol and fuel ethanol, and one of the largest alcohols and solvents companies in North America, announced plans to establish a new EU manufacturing headquarters in Portlaoise, Ireland (Read more).

- April 2019 - Gevo Inc. signed a binding, definitive construction license agreement with Praj Industries Ltd. to commercialize the production of renewable isobutanol using sugary-based feedstocks. The two companies also signed an MOU on renewable hydrocarbons (Read more).

- April 2019 - Neste and Air BP entered into an agreement to deliver sustainable aviation fuel to airline and airport customers in Sweden in 2019. Neste and Air BP will embark on the joint development of a viable supply-chain solution for sustainable aviation fuel to the Swedish market, after first announcing plans to explore this in 2018 (Read more).

- April 2019 - Brightmark Energy secured financing to advance development of a $260 million plastics-to-fuel plant in Steuben County, USA, that will feature technology from its recently acquired RES Polyflow unit. The facility will gather recyclables from Indiana and Illinois and will likely begin operations in 2021 (Read more).

Upcoming Meetings & Conferences

2019

May

- 41st Symposium on Biotechnology for Fuels and Chemicals - April 28-May 1 - Seattle, USA
- International Conference on Biofuels and Bioenergy - April 29-May 1 - San Francisco, USA
- Sugar & Ethanol Brazil - May 7-9 2019 - Sao Paulo Brazil
- Argus Biofuels Asia - May 7-9, 2019 - Shanghai, China
- 9th World Congress on Biopolymers and Polymer Chemistry - May 13-14, 2019 - Perth, Austraila
- 27th EUBCE 2019- European Biomass Conference and Exhibition - May 27-30, 2019 - Lisbon, Portugal

June

- 9th International Conference on Algal Biomass, Biofuels and Bioproducts - June 17-19, 2019- Boulder, USA
- 14th World Bioenergy Conference and Expo - June 06-07, 2019 - London, UK
- 35th Annual Fuel Ethanol Workshop & Expo - June 10-12, 2019 - Indianapolis, US

July

- Biofuels, Energy, Economy 2019- July 17-18, 2019- Abu Dhabi, UAE

August

- Asia Palm Oil Conference (APOC) - August 22-23, 2019 - Pattaya, Thailand
- 14th World Congress on Biofuels and Bioenergy - August 26-27, 2019 - Vienna Austria

September

- International Conference on Biofuels and Bioenergy - September 23-25, 2019 - Barcelona, Spain
- 5th Advanced Biofuels Conference - September 17-19, 2019 - Stockholm, Sweden

October

- Advances in Biofuels and Bioenergy - October 21-22 2019 – Toronto, Canada
- Global Experts Meeting on Frontiers in Biofuels and Bioenergy - October 14-16, 2019 - Rome, Italy

November

- 10th Annual Conference on Bioenergy and Biofuels - November 18-19, 2019 - Abu Dhabi, UAE

2020

March

- Brazilian Bioenergy Science and Technology Conference – March 30-April 1 – São Paulo, Brazil

IEA Bioenergy Task 39 Meetings

In 2019, IEA Bioenergy Task 39 is holding two business meetings:

Task 39's first business meeting will be held on May 15-17 at the European Commission's Joint Research Centre (JRC) in Ispra, Italy. The second and third days will comprise a joint JRC-Task 39 workshop, "Biofuels Sustainability - Focus on Lifecycle Analysis," in which many representatives of the biofuels industry will also participate.

Task 39 plans to hold its second business meeting of 2019 in Stockholm, Sweden in mid-September in conjunction with Sweden's 2019 Advanced Biofuels Conference being held 17-19 September. Details for this meeting remain to be finalized.

Please contact us for more detailed information about the Task's future business meetings.

Bioenergy Job Opportunities in New Zealand

Our New Zealand colleagues at Scion have two job opportunities within their Bioenergy team. These are for a Research Leader and a Research Scientist to be based in Rotorua, and both are permanent positions. The full position descriptions can be found on the Science New Zealand website: https://careers.sciencenewzealand.org/scion/scion-jobs.