Newsletter Issue #50 December 2018

Commercializing Conventional and Advanced Liquid Biofuels from Biomass

Task 39 IEA Bioenergy

Inside This Issue

From the Task

By Mahmood Ebadian, Jack Saddler and Jim McMillan

Since publishing our last Newsletter, IEA Bioenergy Task 39 has continued its work to advance the commercialization of sustainable, lower carbon liquid biofuels for transport.

IEA Bioenergy Task 39 held its most recent meeting in San Francisco, USA on 5-6 November, in conjunction with the IEA Bioenergy end of triennium/ExCo82 meeting and the Advanced Bioeconomy Leadership Conference GLOBAL ("ABLC GLOBAL") held on 7-9 November, 2018.

Day one of the Task 39 meeting (Monday, 5 November 2018), was devoted to internal Task 39 business and primarily attended by Task 39 representatives from member countries (including newly rejoining member Norway) and a few other IEA Bioenergy Task and ExCo members. The focus was reviewing the Task's ongoing and recently completed work and the proposed activities for the 2019-2021 triennium.

Task work that has recently been completed and will soon be posted on the "publically available" sections of the Task 39 website (http://task39.ieabioenergy.com/) includes the final report entitled, "Survey of Advanced Fuels for Advanced Engines" which Task 39 carried out jointly with the IEA Advanced Motor Fuels (AMF) Technology Collaboration Programme (TCP). This report contains up-to-date information on current and prospective advanced biofuels – especially biomass-based liquid fuels – for road vehicles. Performance attributes, such as fuel properties and exhaust emission characteristics in compression or spark ignition type engines, are discussed in detail and show how results are influenced by the specific advanced biofuel that is used. It is likely that the area of co-optimizing fuel-engine systems to maximize transport performance efficiencies and associated greenhouse gas reduction potentials using advanced biofuels will continue to be an important research topic of joint interest. In addition to providing a useful reference for Task 39 stakeholders, this report also serves as an updated and complementary resource to AMF's online fuel information portal (http://www.iea-amf.org).

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Other work that is currently being discussed and progressed is an update on assessing GHG emissions and energy balances for advanced biofuels. The current project involves a comparison of four well-recognized biofuels LCA models (GREET, BIOGRACE, GHGenius and VSB), focusing on how each of these models estimates GHG emissions. This project has helped identify the commonalities and main differences in the models' methodological structures, calculation procedures, assumptions, etc. It has also highlighted the most influential parameters impacting the determination of emissions associated with the production and use of diesel-type biofuels (both fatty acid methyl esters (FAME) and renewable diesel (also known as hydrotreated vegetable oils (HVO) or hydrotreated esters and fatty acids (HEFA). Through a "harmonization" procedure, it is possible to successfully align the results of the models to agree with one another. After the report is assessed internally in early 2019, it will made publicly available.

We anticipate continuing joint work with the IEA Bioenergy Sustainability Task in this area in the next triennium as these types of assessments continue to gain importance to policy makers and regulation. The group also discussed how to further harmonize and extend LCA modeling approaches going forward, e.g., how to more broadly consider other key aspects influencing LCA such as system boundaries and specific assumptions about soil carbon changes and how coproducts are handled (i.e., by displacement, energy or economic allocation, etc).

Another report that was discussed and will soon become publicly available is the update of Task 39's periodically issued "Implementation Agendas" study that compares and contrasts biofuels policies being developed and used within Task 39 member countries (and other key biofuels-producer/user countries). We discussed ways to further improve data collection and aggregation processes used to by the member countries to provide input for this report. Although a questionnaire template has been developed and used to collect the data for the report, the group agreed that it should continue to be refined to enable better comparisons of the existing biofuel policies used within the Task's member countries.

Newsletter readers are also asked to review the most recent updates of the Task's Demonstration plant database (https://demoplants.bioenergy2020.eu/). This is an ongoing Task activity and we depend upon our readership, as well as input from other sources, to ensure it remains accurate and up-to-date.

As well as continuing the projects that have been summarized above, Task 39 continues to tackle other key topics such as the ongoing development of drop-in biofuels, which will be essential to decarbonize long-distance transport sectors (i.e., Marine, Aviation, Rail and Truck). A draft of the updated report, "The potential and challenges of 'drop-in' biofuels" is nearing completion and will soon be circulated within the Task and is expected to form the basis for ongoing/increased collaboration with other Tasks (such as the Gasification and Thermal Liquefaction (Pyrolysis/HTL) Tasks as well as with allied organizations such as IEA HQ, IRENA, GBEP, etc). Future work in this area will include: a) assessing the various methods used to measure/follow the "green" molecules when adopting co-processing and upgrading strategies within existing petroleum refineries; and b) extending LCA studies to examine the life cycle/sustainability aspects of drop-in biofuels production. A more detailed description of Task 39's focus for the coming triennium will be provided in the first newsletter of 2019.

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

On Tuesday, 6 November 2018, most of the Task 39 members were able to participate in a study tour to the Joint BioEnergy Institute (JBEI) and the Advanced Biofuels and Bioproducts (ABPDU) pilot plant facility. JBEI is a U.S. Department of Energy (DOE) Bioenergy Research Center dedicated to developing advanced biofuels and bioproducts. It is a research partnership combining the scientific talent, expertise, resources and support of four national laboratories, six academic institutions and one industry partner. JBEI is located in the Bay Area biotech hub city of Emeryville. As part of the tour, JBEI's Dr. Steven Singer gave an overview of JBEI's missions and goals. This was followed by a guided tour of JBEI's plant biology, pretreatment and conversion labs. (Jim McMillan and ExCo members attended the IEA Bioenergy ExCo meeting occurring at the same time so weren't able to participate and are missing from the photo below.)

Left to right: Ning Sun (ABPDU research scientist), Glaucia Mendes Souza, Antonio Maria Bonomi, Mahmood Ebadian, Eric Sundstrom (ABPDU research scientist), Tomas Ekbom, Satoshi Aramaki, Timo Gerlagh, Duncan Eyewumi Akporiaye, Jin-Suk Lee, Steve Rogers, Henning Jørgensen, Rubens Maciel Filho, and Jack Saddler (Task 39 business meeting attendees who were not able to attend the JBEI/ABPDU site visit: Alex MacLeod, Paul Bennett, Birger Kerckow, Helena Chum, Jim McMillan, Adrian O'Connell, Dina Bacovsky, Nicolaus Dahmen and Don O'Connor)

Task 39 members also participated in the joint IEA Bioenergy/ABLC GLOBAL conference held 7-9 November, 2018. This "ABLC Global 2018" conference was a collaboration involving IEA Bioenergy, USDOE BETO and The Biofuels Digest. The IEA Bioenergy Conference 2018 represented the first day of the conference (Wednesday, 7 November) and profiled the various IEA Bioenergy Tasks. In an "Advanced Biofuels Summit" session moderated by Alex Macleod (NRCan and Operating Agent for Task 39), presentations on current developments and the global and USA situations were given by Philip Stratmann, (VP, Biofuels, Velocys), Jim McMillan, Jack Saddler and Adam Brown (IEA HQ).

The overall conference included 180+ speakers and 17 distinct workshops, forums, and summits spanning Clean Fuels & Energy, Renewable Chemicals and Biomaterials, Feedstocks & Supply Chain Development, New Nutrition, Advanced

Agriculture, International Partnerships, Policy & Finance and many more. The conference was well-attended, with almost 600 participants from industry, academia, and governments.

In other news, Task member, Dr. Claus Felby (Task 39's lead Danish representative and co-author of the Task 39 report, "Biofuels for marine shipping sector"), attended an Organisation for Economic Co-operation and Development (OECD) meeting on decarbonisation of the maritime sector November 26-27, 2018. As discussed at this meeting, the maritime sector is soon facing substantial reductions in the allowable sulphur content of its fuels and has aspirations to reduce its carbon emissions by 50%. Claus presented the results from IEA Bioenergy's Task 39 marine biofuel report which covers the current state of the art for marine biofuels, including the lack of scaling of advanced biofuels need to support their use for maritime shipping. Although E-fuels were also discussed in some detail, they are expected to continue to be quite expensive and the infrastructure for supplying synthesis gases is not yet in place.

In closing, we are grateful to our colleagues Adrian O'Connell and Laura Lonza (Task 39's European Commission (EC) members) of the EC's Joint Research Centre (JRC) for authoring this newsletter's feature article on biofuels-related developments in the European Union (EU). This article is especially timely as the EU's Council of Ministers has recently approved an updated Renewable Energy Directive, RED II, which sets a headline target of achieving 32% energy from renewable sources at EU level by 2030, including a sub-target of at least 14% of energy from renewable sources in transport by 2030.

As always, we appreciate your readership and would value any input or feedback you have on the newsletter. Please send us by email any ideas or suggestions for increasing its value.

Best wishes for the Christmas/New Year holiday season and thanks for participating in the IEA Bioenergy Task 39 network.

Jim, Jack, and Mahmood

Biofuels Production and Consumption in the European Union (EU): Status, Advances and Challenges

Laura Lonza and Adrian O'Connell, Joint Research Centre, European Commission

1. Status of the biofuels industry in the EU

The EU is the third largest producer of biofuels in the world. In 2017, North America, South & Central America and Europe had world shares of 45.5%, 26.9% and 16.8%, respectively. The EU's biofuels production in 2018 is estimated to be about 18.8 million tonnes. The main biofuels being produced are biodiesel (fatty acid methyl ester or FAME), renewable diesel produced by hydrogenating (hydrotreating) animal and vegetable oils and fats (also known as hydrotreated vegetable oil (HVO) or hydrotreated esters and fatty acids (HEFA)), as well ethanol and a small but growing amount of biomethane in some countries (e.g., Germany and the Netherlands). As shown in Figure 1, the production of FAME biodiesel, HVO/HEFA renewable diesel and conventional (first generation) and cellulosic (second generation) ethanol were estimated to be 12.2, 2.2, 4.3 and 0.008 million tonnes, respectively. FAME biodiesel has the highest share of biofuels production in the EU (65%) due to the strong demand in EU Member States to meet blending mandates. Figure 2 shows the estimated shares of different feedstocks in the production of FAME biodiesel in 2018.

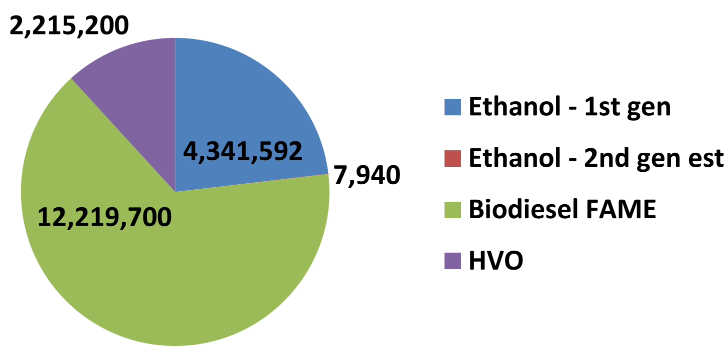

Figure 1. Estimated production of biofuels in the EU (tonnes), 2018 (USDA, 2018)

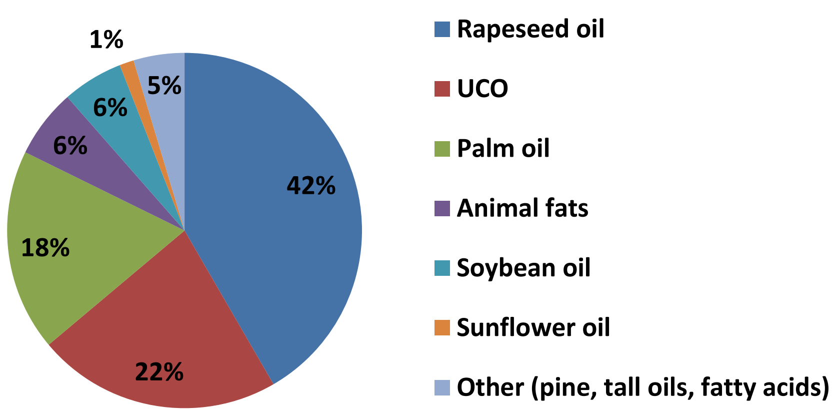

Figure 2. Estimated 2018 FAME biodiesel feedstock shares in the EU (USDA, 2018)[1]

A considerable percentage of FAME biodiesel production can be considered advanced, at least not coming from food or feed sources, due to the significant availability of used cooking oil (UCO) and waste animal fats (tallow) in the EU. The absolute figure for usage of non-food or feed feedstocks used to make biodiesel is difficult to estimate, however,

[1] The data in Figures 1 and 2 are taken from the 2018 USDA Gain Report on biofuel production (USDA, 2018). While giving a good indication of the production status of the EU biofuels industry, it includes information - most notably for biodiesel feedstocks - not often publicised by industry.

as the translation of EU legislation into national law allows for margins of flexibility resulting in different consideration being given to certain feedstocks, with palm fatty acids produced during the refining of palm oil being the most notable example. Ethanol production, in contrast, remains almost entirely conventional, i.e., from food crops, mainly sugar beet, corn and wheat. The small portion of cellulosic ethanol being produced is also from non-food feedstocks such as crop residues, however actual production figures for advanced (or second generation) ethanol remain difficult to find.

2. Policies driving the production and consumption of biofuels

The policy mechanisms stimulating increased production and use of biofuels within EU Member States are the EU's Energy Directive (RED, 2009/28/EC) and Fuel Quality Directive (2009/30/EC), as amended in 2015 by establishing – among others – a 7% cap for food/feed-competing feedstocks to comply with the mandatory 10% renewables transport sub-target in the RED (so-called ILUC Directive ((EU) 2015/1513). These EU directives are binding for all EU Member States and need to be implemented in their respective national laws. In November 2016, the European Commission published its 'Clean Energy for all Europeans' initiative. As part of this package, the Commission proposed a recast of the Renewable Energy Directive. The RED II was adopted by the Council on 4 December and will be published on 21 December 2018.

2.1. Overall target

In RED II, the overall EU target for Renewable Energy Sources consumption has been raised to 32% by 2030, up from 20% by 2020 previously. A transport sub-target wasn't included originally, but has been introduced in the final agreement. This requires Member States' fuel suppliers to supply a minimum of 14% renewable energy in the energy consumed in road and rail transport by 2030. Each Member State will define and design its detailed trajectory to reach these targets in their respective Integrated National Energy and Climate Plans following the guidelines set out in the Energy Union Governance Regulation.

2.2. Sustainability criteria in RED II

The RED II defines a series of sustainability and greenhouse gas (GHG) emission criteria that transport biofuels must comply with to count towards the 14% target and to be eligible for financial support by public authorities. Some of these criteria are the same as in the original RED, while others are new or reformulated. In particular, the RED II introduces sustainability for forestry feedstocks as well as GHG criteria for solid and gaseous biomass fuels.

The RED II provides default GHG emission values and calculation rules in Annex V (for liquid biofuels) and Annex VI (for solid and gaseous biomass for power and heat production). The Commission can revise and update the default values when technological developments make it necessary. Producers have the option to either use default GHG intensity values provided in RED II or to calculate actual values for their respective production pathways.

Table 1. Greenhouse gas emissions savings thresholds in RED II

Plant operation start date	Transport biofuels	Transport renewable fuels of non-biological origin	Electricity, heating and cooling
Before October 2015	50%	-	-
After October 2015	60%	-	-
After January 2021	65%	70%	70%
After January 2026	65%	70%	80%

Biofuels, bioliquids and biomass fuels from agricultural biomass must not be produced from raw materials originating from specific land categories, as summarized in Table 2.

Table 2. Non-eligible land categories for the production of biofuel feedstocks in RED II

High biodiversity land (as of January 2008), including: primary forests; areas designated for nature protection or for the protection of rare and endangered ecosystems or species; and highly biodiverse grasslands
High carbon stock land that changed use after 2008 from wetlands, continuously forested land or other forested areas with trees higher than five meters and canopy cover between 10% and 30%
Land that was peatland in January 2008

The RED II sustainability criteria apply to production plants above a minimum size, either a total rated thermal input above 20MW for installations producing power, heating, cooling or fuels from solid biomass fuels, or a total rated thermal input capacity equal to or exceeding 2MW for installations using gaseous biomass fuels.

The RED II also introduces new sustainability criteria for forestry feedstocks. Harvesting must be legally permitted, the harvesting level must not exceed the growth rate of the forest, and forest regeneration must take place. In addition, biofuels and bioenergy from forest materials must comply with requirements which mirror the principles contained in the EU Land Use, Land Use Change and Forestry (LULUCF) Regulation. These "forestry" criteria apply either at the country level or the forest sourcing area level; the Commission will define implementation guidelines by 31 January 2021.

2.3. Advanced biofuels

Within the 14% transport sub-target, there is a dedicated target for advanced biofuels produced from feedstocks listed in Part A of Annex IX (see Table 3). These advanced biofuels must supply a minimum of 0.2% of transport energy by 2022, 1% by 2025, and at least 3.5% by 2030.

2.4. Caps and multipliers

The maximum contribution of biofuels produced from food and feed crops will be capped at 2020 consumption levels plus an additional 1%, with a maximum cap of 7% for road and rail transport fuels in each Member State. For comparison, the EU average is just above 5% today, with the 2018 EU Biofuels Barometer indicating that the current share of biofuels from food and feed crops is just over 4%. If the total share of conventional biofuels in any Member State is less than 1% by 2020, the cap for that country will still be 2% in 2030. Furthermore, if the cap on food and feed crops in a Member State is less than 7%, that country may reduce its transport target by the same amount (for example, a country with a food and feed crop cap of 5% could set its transport target as low as 12%). Notably, "intermediate crops" such as catch and cover crops are exempt from this cap.

Biofuels and bioenergy produced from wastes and residues listed in Annex IX only need to comply with the GHG minimum emission threshold sustainability criterion (Table 1). Advanced biofuels listed in Part A of Annex IX will be double-counted towards both the 3.5% target and the 14% target. Biofuels produced from feedstocks listed in Part B of Annex IX will be capped at 1.7% in 2030 and will also be double counted towards the 14% target.

Fuels produced from feedstocks with "high indirect land-use change-risk" will be limited by a more restrictive cap at the 2019 consumption level, and will then be phased out to 0% by 2030 unless specific batches are certified as "low indirect land-use change-risk." Feedstocks with "low indirect land-use change-risk" include those that are produced on land not previously used for crop production.

Renewable electricity will count 4 times its energy content towards the 14% renewable energy in transport target when used in road vehicles, and 1.5 times when used in rail transport. The renewable electricity used in road vehicles and rail can be calculated on the basis of either the average share of renewable electricity in the EU or in the Member State where the electricity is supplied. The Commission will also develop a framework to guarantee that the renewable electricity used in transport is in addition to the baseline of renewable electricity generation in each Member State.

Fuels used in aviation and maritime sectors can opt in to contribute to the RED II's 14% transport target but are not obligated. The contribution of non-food feedstock-based renewable fuels to these sectors will count 1.2 times their energy content.

Table 3. Advanced feedstocks for biofuels in RED II

Part A (i.e. "advanced biofuels")	Part B
Algae, if cultivated on land, either in ponds or photobioreactors Biomass fraction of MSW from unsorted household waste Bio-wastes separately collected from households Biomass fraction of agro-industrial waste not fit for food or feed Straw Animal manure Sewage sludge Palm oil mill effluent and empty palm fruit bunches Tall oil pitch Crude glycerine Bagasse Grape marcs and wine lees Nut shells Husks Corn cobs (cleared of corn kernels) Waste and residues from forestry and forest products industries: bark, branches, pre-commercial thinnings, leaves, needles, tree tops, saw dust, cutter shavings, black liquor, brown liquor, fibre sludge, lignin, and tall oil Other non-food cellulosic material, including for instance perennial grasses, but also non-starchy cover crops before and after main crops as well as ley crops. This category also includes industrial residues after the extraction of vegetable oils, sugars, starches and proteins. Other ligno-cellulosic materials, including for instance woody short rotation crops, pulp logs and other forest-based biomass, but excluding veneer logs and saw logs.	Used cooking oil Animal fats with high risk for human health (Category 1) and animal fats suitable for soil enhancement and chemical industry (Category 2)

2.5. Flexibility

RED II grants individual EU Member States (MS) broader margins of flexibility compared to the original RED when translating this EU Directive into their national legislation, as summarized in Table 4.

Table 4. Flexibility clauses foreseen in RED II with respect to the implementation of the Directive by EU Member States

EU MS can exempt or distinguish between different fuel suppliers and energy carriers when defining their trajectory to achieve the 14% minimum sub-target for the transport sector.
EU MS are free to choose the most suitable form of support for renewables in transport, for example volume mandates, energy mandates or GHG emission savings targets.
EU MS can distinguish between different types of conventional biofuels and set different limits for each category (for example, setting a lower cap on oil seed crops than other types of food and feed crops).
EU MS can set lower limits on food and feed-based biofuels than prescribed in the RED II and may also reduce the 14% renewable energy in transport target by the same.
EU MS can set a different cap for biofuels produced by feedstocks in Part B of Annex IX if justified by the local availability of such feedstocks, and can define additional sustainability criteria for bioenergy but not for biofuels.

2.6. Translation and implementation

EU Member States must translate RED II provisions into their respective national legislation by 30 June, 2021, with several technicalities and revision clauses being defined via delegated and implementing acts.

Table 5. Implementation of RED II provisions towards 2030

The Commission will review the overall 32% target by 2023, as well as the 14% sub-target for transport, and could propose to increase, but not decrease, the targets.
The Commission must review the feedstocks included in Annex IX every two years and may add feedstocks to the list, but cannot remove any.
The Commission must set out criteria by February 2019 to define both "high indirect land-use change-risk" and 'low indirect land-use change-risk' feedstocks. These findings will be reviewed by 2023.
The Commission must set a GHG reduction threshold for recycled carbon fuels by January 2021, and by December 2021 must specify the methodology for GHG accounting for these fuels and for renewable fuels of non-biological origin.
By January 2021, the Commission must define the operational guidance required to demonstrate compliance with the sustainable forest management criteria and the LULUCF requirements.
In 2026, the Commission must propose a regulatory framework for the promotion of renewable energy for the post-2030 period.

3. Advances and challenges in biofuels technologies

Consistent with EU's regulatory framework, technological and market research in Europe are largely focussed on 'advanced' biofuels from non-food or feed feedstocks (Table 3), a situation which is expected to continue – or even consolidate – upon the formal adoption of RED II.

Technological advances are therefore sought in process technologies for converting feedstocks having no or only low indirect land-use change (ILUC) impacts. The RED II is also quite demanding on biofuel producers to achieve high minimum GHG emission reduction thresholds towards 2030 (Table 1) compared to the baseline.

Industry in the EU is focussed on three broad categories of feedstocks: ligno-cellulosic residues from agriculture and forestry; animal manures and the biogenic fraction of wastes and residues like municipal solid wastes; and biomass types not competing with production of food and feed, such as grass feedstocks, perennial and cover crops, and algae.

Two imperatives for the EU's biofuels industry are access to sustainable feedstocks in sufficient volumes and conversion processes able to perform well and at scale on such feedstocks. Three categories of conversion technologies are relevant to achieving the RED II's mandatory targets: biochemical, thermochemical, and oleochemical production routes. Oleochemical is the most proven and the use of waste and residues as feedstocks is expanding, and is expected to continue to do so as a result of regulation. Each one of these broad conversion categories includes a number of sub-technologies. The remainder of this section highlights the main identified challenges for each.

3.1. Biochemical conversion routes

A lot of research continues in this area (see Figure 3) , however more and clearer public information on performance would be beneficial, particularly regarding cellulosic ethanol production systems. For anaerobic digestion, work continues to make production more profitable, in particular while using more challenging feedstocks.

A large part of EU research in this area aims to show or improve the robustness and efficiency of cellulosic ethanol production routes, with butanol production also attracting increasing attention. The increasing scale (and number) of production plants worldwide indicates some progress and a high degree of continued interest in this technological area exists both in the EU and in other world regions. However, the environmental and economic performance of the processes remain critical areas for improvement. While detailed information on production costs is limited, the low level of deployment and market success of these technologies at commercial scale suggests that production costs remain higher than previously forecast, likely because of high feedstock and enzyme costs among other factors.

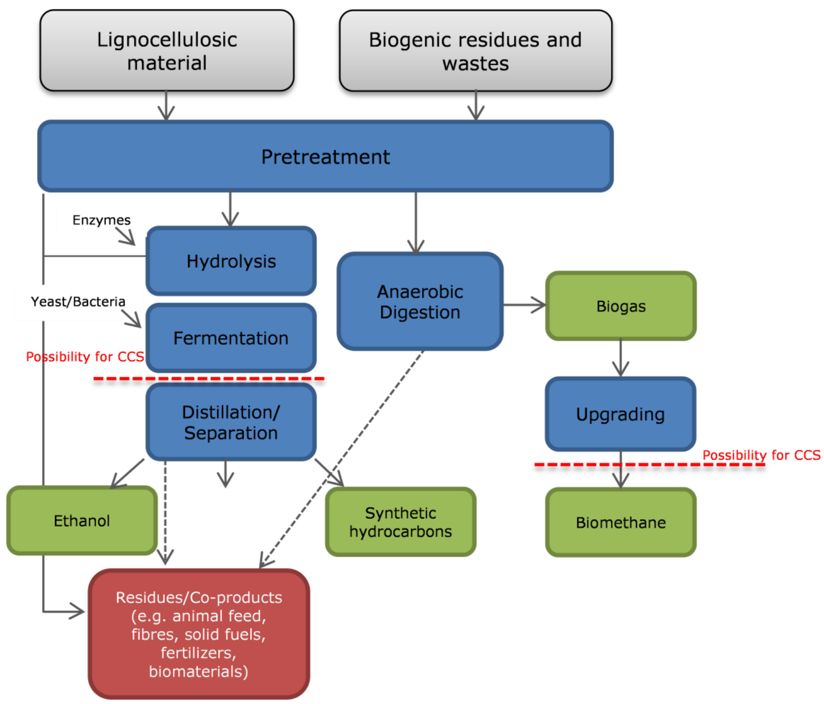

Figure 3. Biochemical conversion routes

For the anaerobic digestion (AD) sector, availability of sustainable feedstocks in sufficient volumes is among the key priorities for the EU-based biofuel industry, with specific attention being given to agricultural residues and other complex waste streams (e.g., wastewater sludges). AD processes are currently not economically viable and improvements in technology are paramount to demonstrate economic feasibility. Current research priorities include work to valorise AD digestate by recovering nutrients to co-produce market-ready products, or to embed the AD step as one of the processes in a biorefinery. Biogas upgrading to biomethane is another large goal of much new investment in AD. Public awareness about the potentials of AD is still limiting technical efforts in scaling down the technologies, so interesting possibilities to enlarge feedstock choices, for example by improving the recovery of waste streams at urban and peri-urban levels, remain under exploited.

3.2. Thermochemical conversion routes

This area comprises several sub-technology areas (see Figure 4). Overall, research on thermochemically-based biomass to liquid (BtL) technologies is attempting to achieve lower operating and capital costs to improve economic feasiblity. Again, it would be beneficial to have more and clearer information on performance and costs in the public domain.

Processes making various types of bio-crude oils are attempting to take advantage of possible opportunities to co-process their bio-crudes in existing petroleum refineries, and some of large oil refiners are engaged in this work.

There are no large-scale gasification plants in the EU producing BtL biofuels today. Improving gasification, syngas cleaning, and Fisher-Tropsch (FT) synthesis are all research areas with potential to enhance process efficiencies and in turn decrease production costs.

Smaller scales of operation requiring lower capital and operational costs to establish and run conversion plants have been identified as a promising way forward for process optimization. The energy balance of thermochemical production plants would especially benefit from enhanced integration of sub-processes to reduce external energy import requirements. Improving biomass handling to enable more flexibility towards a broader variety of feedstocks is another important research area. Others include novel clean-up systems for produced raw syngas that reduce the energy required to purify syngas, and also new catalysts that are more tolerant to impurities in syngas. Generally speaking, however, and with the exception of the AMBIGO initiative (Ambigo, 2018), this sector is not showing high confidence in the near-term possibility to profitably produce synthetic natural gas (SNG) via biomass gasification.

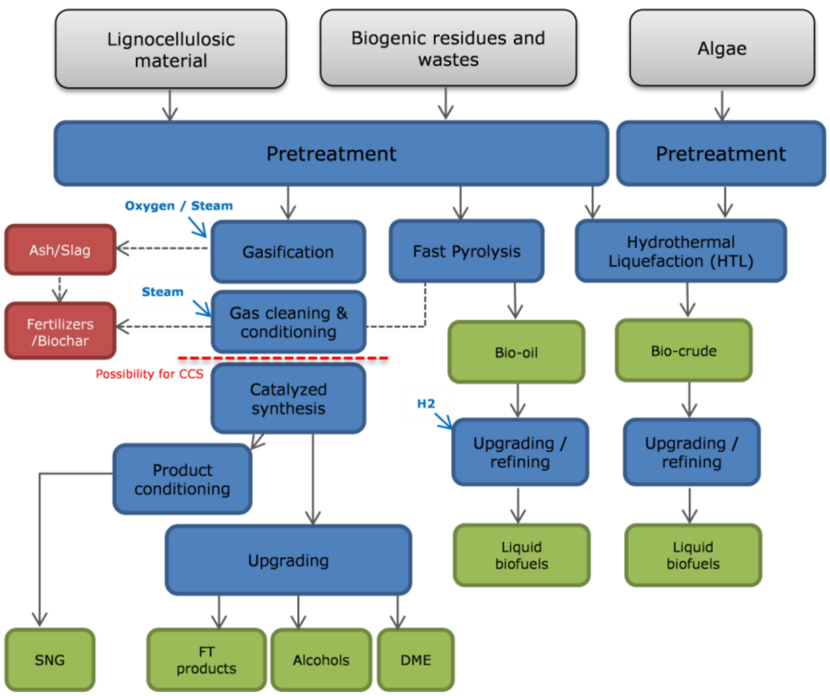

Figure 4. Thermochemical conversion routes

Considerable interest exists in the EU – and other world regions – to co-process FT products at existing crude oil refineries in order to achieve greater economies of scale and efficiencies than stand-alone production would permit. This approach would also provide a better opportunity to tailor fuels/products portfolios according to market needs.

For fast pyrolysis, there are opportunities to improve processes to maximise bio-oil yields and to use catalysts to promote higher selectivity and yield of desirable products. Catalyst improvements also provide opportunities for the subsequent upgrading step. Several technical developments are being researched in the EU to improve catalytic fast pyrolysis and up-grading via refining processes but these are not yet at commercial scale. Reducing hydrogen consumption during hydro-treatment is another important technical challenge being researched.

Co-feeding pyrolysis oils in petroleum refinery units using existing infrastructure and commercial technologies is another promising opportunity being investigated. Obtaining pyrolysis liquids from cheaper residual resource feedstocks while maintaining product quality that meets bio-liquid specifications is another important area of investigation.

Hydrothermal liquefaction (HTL) approaches for wet feedstocks are technologically proven at laboratory and/or pilot scales and appear promising with additional development for producing bio-crude oils that can – as for the previous technologies - be blended with traditional fossil crude for upgrading at existing petroleum refineries.

Scaling up production to close-to-market maturity remains a challenge but is critical for ongoing projects, such as the one led by Steeper Energy Aps (SEA) in Denmark, to validate process performance at large-scale and over realistic year-round operation. The potential for more cost-optimised routes that integrate HTL processing into other existing production facilities, such as with a paper mill in the case of Licella Pty Ltd in Australia, have not yet been explored in the EU.

Interesting developments brought forward by EU operators to progress upgrading of bio-oils are the initiatives of NesteOil (Neste Oil-2, 2018) and Repsol (REPSOL, 2016) which are testing at the scale of their production sites co-processing HTL with crude oil, albeit so far at very low blend levels.

3.3. Oleochemical conversion routes

For oleochemical routes (see Figure 5), the main issue for the EU (and worldwide) biofuel industry is the need to find increasing volumes – and variety – of sustainable feedstocks, and this is exacerbated by the move away from food-based feedstocks for biofuels. Unlike other routes discussed in this section, FAME and HVO pathways have proven reliable at industrial scale for many years.

In the EU, the need for FAME and HVO routes to be more flexible in terms of input feedstocks is currently driving the sector's technological development. At an individual production plant level, this translates into the need to include more complex pre-treatment units for the process. In parallel to input flexibility, HVO plants in particular are required to be increasingly flexible with respect to outputs. With a more diversified demand for final products to fuel road and other transport modes, namely aviation and marine, the product slate including diesel, kerosene and naphtha from HVO production needs to be able to swiftly adapt to match dynamic market demand.

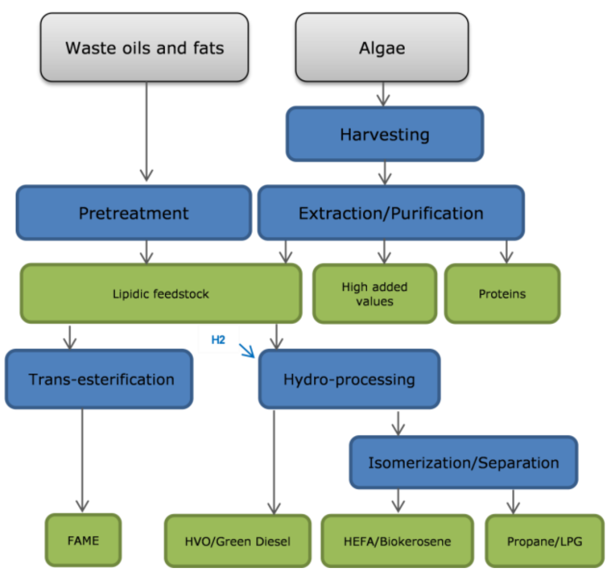

Figure 5. Oleochemical conversion routes

3.4. Broad indicator of funding by technology routes

Figure 6 shows an overview of the number of EU-funded advanced biofuels and biorefineries projects and how this funding is distributed across the different technical approaches for projects above 250k EUR in value and that are starting at greater than lab-scale Technology Readiness Levels (TRLs). It should be noted that some of the biorefinery projects incorporate biofuels within their product slate. Nonetheless, as this figure shows, the majority of fuel focussed projects are in the anaerobic digestion area, followed by fermentation, while the latter has received the largest proportion of funding compared to the other approaches.

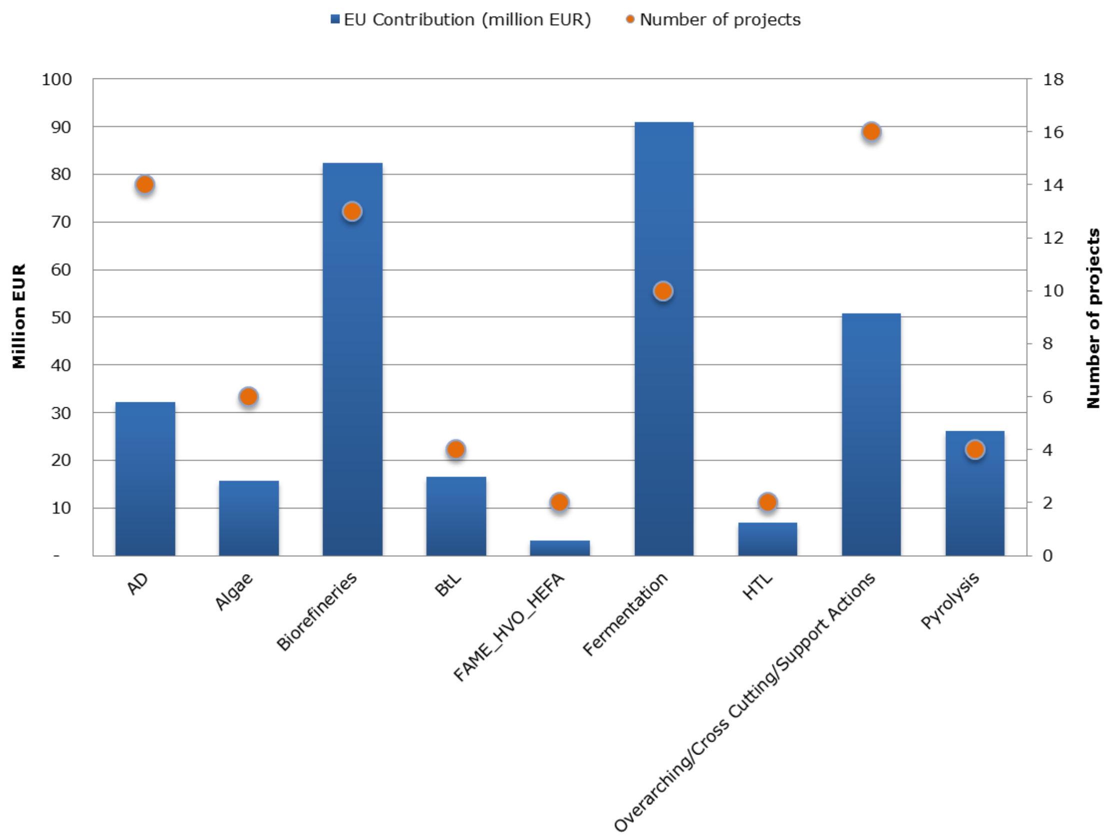

Figure 6. Distribution of EU funded advanced biofuel technologies projects above 250k EUR

4. Conclusions

The existing and forthcoming regulatory framework in the EU requires certain areas or aspects within each biofuel technology pathway to be further developed. Improvements in these areas will yield the greatest benefits towards making these biofuel pathways commercially successful in pursuit of the EU's established mandatory biofuels targets. For lignocellulosic pathways, a robust operation demonstrating steady and reliable production will be key to derisk further commercialization of the technology. Detailed and verifiable results from an operating facility will be highly beneficial to all parties; it is understood that results can be commercially sensitive, but without such clarity it is unlikely that future R&D investments will be targeted as efficiently as possible. For anaerobic digestion, further developments in the successful use of lignocellulosic feedstocks and other complex waste streams will help resolve the currently constraining issues of feedstock availability and sustainability; improving digestate valorisation and biogas upgrading to biomethane are other key elements that will enable this technology to be more widely implemented. For BtL, smaller scale operations and enhanced process integration may help to make these approaches more financially appealing. In general, co-processing of bio-crudes and bio-oils in existing refining infrastructure is an area of increasing focus, with obvious economic benefits to be realized by taking advantage of existing facilities and technologies. The fine tuning of the systems that produce such bio-crudes is also likely to reap considerable rewards, especially if this can produce materials that can be more easily upgraded. For FAME and HVO pathways, a on-going search for sustainable feedstocks remains the key issue, although there are some benefits to be gained by further improving the basic processes themselves.

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In the News

Reports and Research

Recent IEA Bioenergy publications:

- IEA Bioenergy published its 2018 Update Countries' Report summarizing bioenergy policies and their status of implementation. Prepared from IEA statistical data, combined with data and information provided by the IEA Bioenergy Executive Committee and its Tasks, this report is available to read and download here.
- A report, prepared by Task 32, entitled, "Status of PM emission measurement methods and new developments". It can be read here.
- A report, commissioned by Task 33, entitled, "Gas analysis in gasification of biomass and waste", compiles a representative part of the extensive work in recent years in the field of gas analysis applied to (biomass and waste) gasification. The two documents making up the full report can be downloaded here.
- A Task 33 report entitled, "Implementation of bio-CCS in biofuels production – IEA Bioenergy Task 33 special report". Available for download here.
- A Task 37 report entitled, "The role of anaerobic digestion and biogas in the circular economy", highlighting the diversity of benefits from anaerobic digestion and biogas systems Available for download here.

October 2 - Carbon-rich pollution converted to a jet fuel will power a commercial flight for the first time. A Virgin Atlantic Airlines' flight from Orlando to London using a Boeing 747 ushers in a new era for low-carbon aviation that has been years in the making. Through a combination of chemistry, biotechnology, engineering and catalysis, the Pacific Northwest National Laboratory and its industrial partner, LanzaTech have shown the world that carbon can be recycled and used for commercial flight (Read more).

October 15 - In the UK, a report by Lloyd's Register and UMAS, 'Zero Emission Vessels 2030', aims to assess the viability of low/zero-emission fuels and technologies for shipping through an economic lens (i.e., profitability). The report looks at five ship types and several ship sizes, in three different scenarios. It shows that costs at the 'ship level' would vary widely between the different fuel and machinery options when compared to a conventional ship of today, for which the study uses the example of a 9,000-TEU containership. Biofuels appear to be the clear winner (noting the availability and sustainability issues surrounding biofuel supply), with the next best options being hydrogen with an internal combustion engine and ammonia with a similar configuration, with the trade-off being around cost of CAPEX (for hydrogen) and OPEX (for ammonia) (Read more).

October 22 - TU Wien (TUW), an Austrian university of technology, announced it has developed a diesel engine that utilises over 70% bioethanol. TUW details the technology used in the development of this engine capable of using both diesel and bioethanol in a 'special' dual-fuel combustion process which allegedly enables the use of a large portion of bioethanol in diesel engines (Read more).

Policy and Regulatory Developments

October 1 - In California, the California Air Resources Board (CARB) approved changes to the Low Carbon Fuel Standard (LCFS) designed to make the program a more versatile, comprehensive tool in the fight against climate change. The amendments approved by the Board require a 20 percent reduction in carbon intensity by 2030, the most stringent requirement in the nation. This new requirement aligns with California's overall 2030 target of reducing climate changing emissions 40 percent below 1990 levels by 2030, which was set by Senate Bill 32 and signed by Governor Brown in 2016 (Read more).

October 22 - In Washington, the first carbon fee anywhere in the U.S. could become reality in Washington State where voters will decide on election day if they want companies to pay a carbon emissions fee of $15 per metric ton of carbon. Washington-based companies like REI, Expedia, Microsoft and Northwest Energy are supporting the measure in order to meet the state's greenhouse gas reduction goals (Read more).

November 13 - The European Parliament approved new targets for renewables, energy efficiency and second-generation biofuels when it voted to confirm a provisional agreement reached with the European Council in June on a revised Renewable Energy Directive (REDII). As part of the package, second generation biofuels must provide at least 14 percent of transportation fuel by 2030. First generation biofuels that are considered to have a high risk for indirect land use change (ILUC), however, will no longer be able to count toward the EU's renewable energy goals starting in 2030. From 2019 until 2030, the contribution of first generation biofuels to the EU's energy goals will be gradually phased out (Read more).

December 10 - China is set to more than triple its ethanol production capacity by 2020, a government researcher said, with demand for the commodity expected to surge as the country shifts toward cleaner fuels. (Read more).

Industry News

October 4 - Norway is taking action to require the use of renewable aviation fuel. The country's Ministry of Climate and Environment announced it will require aviation fuel to contain at least 0.5 percent advanced biofuel starting in 2020. According to information released by the ministry, the mandate will require those who sell aviation fuel in Norway to ensure 0.5 percent of their fuel comes from advanced biofuels, defined as those made from waste and residues. Biofuels made from "problematic raw materials," such as palm oil, will not qualify to meet the mandate (Read more).

October 11 - Neste, the world's leading renewable products producer and Air BP, the international aviation fuel products and services supplier, have entered into an agreement to explore opportunities to increase the supply and availability of sustainable aviation fuel for airline customers. Through this innovative collaboration, Neste's knowledge and manufacturing solutions for producing and blending renewable jet fuel will be brought together with Air BP's customer relationships, expertise in developing efficient and effective supply chains, as well as their certification and product quality assurance capabilities. One goal of the cooperation will be complementary efforts to bring a co-branded sustainable aviation fuel to market at airports across Air BP's global network (Read more).

October 17 - In the Netherlands, GoodShipping bunkered the first batch of biofuels into a container vessel that otherwise would have entirely run on fossil fuels. The first pioneering cargo owners that made this possible along with GoodShipping and their biofuel program are Tony's Chocolonely, Dopper, Blygold, Magic Marine and Mystic. Together they avoided over 40 tons of CO_2 emissions and, because their biofuels replaced Heavy Fuel Oil, they also significantly reduced other local emissions like sulphur, soot and black carbon (Read more).

October 18 - D3MAX and Ace Ethanol announced they have started construction of the first D3MAX facility at Ace Ethanol's facility in Stanley, Wisconsin. Ace Ethanol will be the first ethanol plant to integrate the patented D3MAX technology with its existing corn dry mill (Read more).

October 23 - Emerging Fuels Technology Inc. executed a license agreement with Red Rock Biofuels LLC under which EFT will provide its TL8a Fischer-Tropsch technology to provide additional FT capacity for RRB's biorefinery in Lakeview, Oregon (Read more).

October 28 - In Indiana, POET is moving forward with full construction of a new biofuel facility in Shelbyville, Indiana. Final permit approval came this week for the planned 80 million-gallon-per-year facility. With full construction started, the expected completion date for the nearly $160 million facility is spring of 2020. POET Biorefining – Shelbyville will be the 28th starch biofuel plant in POET's network, and the fifth in Indiana (Read more).

October 29 - In Finland, Reuters reports that Neste is sticking to an internal deadline of December to make its investment decision regarding a potential new aviation biofuel production facility in Singapore. The company already produces biofuel in Singapore but increased demand for renewables spurred by the most recent IPCC report and Norway's 0.5% aviation biofuel mandate has given further impetus to the project that the company has already spent "tens of millions" developing. On the renewables front, the company has a 70% market share globally thanks to global sales of biofuels from 13 feedstocks (Read more).

October 29 - In California, World Energy announced a $350 million investment over the next two years to complete the conversion of its Paramount, California facility into one of the cleanest fuel refineries in the world. The project will enable World Energy Paramount to process 306 million gallons annually. The conversion to renewable jet, diesel, gasoline and propane will reduce both refinery and fuel emissions while supporting more than 100 advanced, green economy jobs (Read more).

November 5 - Valero Energy Corp. announced that its board of directors approved a project to expand the Diamond Green Diesel plant in Norco, Louisiana, to 675 million gallons per year renewable diesel production capacity. This expansion adds a second, independent parallel plant adjacent to the existing facility and a renewable naphtha finishing facility, which provides incremental low carbon fuel standard credit generation capability. Valero expects its 50 percent share, or approximately $550 million, to be funded from cash generated by DGD's operations and for the project to be completed in late 2021 (Read more).

November 9 - In Iowa, DuPont Industrial Biosciences and VERBIO North America Corporation (VNA), the U.S. subsidiary of leading German bioenergy producer, VERBIO Vereinigte BioEnergie AG (VERBIO), have reached terms for VNA to acquire DuPont's Nevada, Iowa-based cellulosic ethanol plant and a portion of its corn stover inventory. Completion of the transaction is subject to customary closing conditions and is expected to occur in November. VNA intends to install facilities to produce renewable natural gas (RNG) made from corn stover and other cellulosic crop residues at the site. This would be VERBIO's third production facility devoted to this cellulosic technology – in 2014, the company commissioned its first facility in Schwedt, Germany, and its second facility in Pinnow, Germany is currently being commissioned (Read more).

December 3 - From the Netherlands comes news of a world first: GoodFuels Marine and the shipping company NORDEN have completed successful trials of what they bill as "the world's first zero emission, 'drop in' Heavy Fuel Oil equivalent marine biofuel" that almost entirely reduces carbon and sulphur emissions (Read more).

December 4 - Maersk, the world's biggest container shipper, aims to be carbon neutral by 2050, in a challenge to the rest of the world's fossil fuel-dependent fleet. Denmark's Maersk said it aimed to have carbon neutral vessels commercially viable by 2030 by using energy sources such as biofuels and would cut its net carbon emissions to zero by 2050. The shipping industry, which carries around 80 percent of global trade, accounts for 2.2 percent of CO2 emissions, the UN's International Maritime Organization (IMO) says (Read more).

December 6 - Gevo and Renmatix inked a joint development agreement to evaluate the commercial feasibility of creating renewable jet fuel by integrating Renmatix's Plantrose Process with Gevo's GIFT technology and alcohol-to-jet process. The key word here is cellulosic, but not limited to "trees to fuels," though Renmatix has been most visible along those lines (Read more).

Upcoming Meetings & Conferences

2019

January

- ICBBBB 2019: 21st International Conference on Biomass, Bioenergy, Biofuels and Bioproducts — January 10-11, 2019 — Singapore, Singapore
- Biomass Trade Summit Europe 2019 — 16-17 January, 2019 — Rotterdam, The Nethelands
- Fuels of the Future 2019 and 16th International Conference on Renewable Mobility — 21-22 January, 2019 — Berlin, Germany
- Industrial Biotechnology for a Sustainable Future — January 30-31, 2019 — Glasgow, Scotland

February

- 13th International Conference on Biofuels and Bioenergy — February 18-19, 2019 — Amsterdam, Netherlands
- 14th International Conference on Biofuels, Energy and Economy — February 22-23, 2019 — Dallas, USA
- 22nd Global Congress on Biotechnology — February 28-March 2, 2019 — Berlin, Germany

March

- 10th Edition of International Conference on Biofuels and Bioenergy — March 4-5, 2019 — Barcelona, Spain
- U.S. Department of Energy's Bioenergy Technologies Office (BETO) 2019 Project Peer Review — March 4–8, 2019 — Denver, USA
- 2nd International Conference on Biofuel and Bioenergy — March 27-28 — Paris, France
- ICABB 2019: 21st International Conference on Algae Biotechnology and Biofuels- March 28-29, 2019- Sydney, Australia

April

- The Advanced Bioeconomy Leadership Conference — April 3-5, 2019 — Washington, USA
- 10th Annual Conference on Bioenergy and Biofuels — April 25-26, 2019 — Helsinki, Finland
- International Conference on Biofuels and Bioenergy — April 29-May 01, 2019 — San Francisco, USA
- 41st Symposium on Biotechnology for Fuels and Chemicals — April 28-May 1, 2019 — Seattle, USA

May

- 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

IEA Bioenergy Task 39 Meetings

In 2019, IEA Bioenergy Task 39 plans to hold two business meetings. In the first half of 2019, Task 39 is considering having a meeting in Italy in May, possibly tying-in with the 2019 EUBCE meeting being held in Lisbon 27-30 May. In the second half of 2019, Task 39 is planning to meet in Stockholm, Sweden in September in conjunction with Sweden's 2019 Advanced Biofuels Conference, 17-19 September 2019. Please contact us for more detailed information about the Task's business meeting plans for 2019.