Technology Collaboration Programme
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Task 39

Commercialising Conventional and Advanced Liquid Biofuels from Biomass

Triennium 2016-2018

IEA Bioenergy

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IEA Bioenergy

Task 39
Commercialising Conventional and Advanced Liquid Biofuels from Biomass

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Introduction

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 commercialisation of both conventional and advanced liquid biofuels from biomass. Through a coordinated focus on technology, commercialisation, sustainability, policy, markets and implementation, Task 39 assisted member countries and other transport biofuels stakeholders in their efforts to develop and deploy biofuels, with the primary goal of decarbonising 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 technology routes such as oleochemical, biochemical, thermochemical and hybrid conversion technologies. The Task also continued to identify and facilitate opportunities for comparative technical and life cycle assessment, and to monitor the various policies that have been successfully used to increase the production and use of biofuels. To a large extent, the success of the Task has been a direct result of providing a forum for these types of integrated discussions, with the active involvement of participants from industry, government and academia.

As described in the "state-of-the-art" report produced at the beginning of the triennium, the Task continues to lead and coordinate activities in three main program areas:

- **Technology and Commercialisation** with a focus on:

- Helping develop and commercialise improved, cost-effective processes for the production of sustainable low carbon biofuels, particularly the production and use of "drop-in" biofuels from oleochemicals and lignocellulosic biomass to decarbonise the long-distance transport sector;

- Working with other Tasks to assess and help develop cost-effective oleochemical, biochemical, thermochemical and hybrid technologies as well as to co-optimise fuelengine systems to maximise transport performance efficiencies and associated greenhouse gas reduction potentials using advanced biofuels; and

- Describing advancements and challenges in emerging less developed advanced liquid biofuel technologies and processes such as biomass-to-hydrogen, algae-to-biofuels, etc.

- **Policy, Markets, Implementation and Sustainability** which encompasses issues that address policy/legislative/regulatory and infrastructure concerns and needs regarding expanding conventional and advanced transport biofuels. This Task activity also provides information and analyses on policies, markets, and implementation issues that help participants foster commercialisation of sustainable low carbon biofuels. The broad goal is to replace non-renewable fossil-based fuels by enhancing the deployment of conventional (so-called first generation) biofuels and supporting the development of advanced (so-called 2nd generation) biofuels and 'future-generation' biofuels. The Task also continues work to better clarify commonalities and the main differences in methodological structures, calculation procedures and assumptions used within four of the world's most well-recognised biofuels LCA models (EU's BIOGRACE, Canada's GHGENIUS, USA's GREET and Brazil's VSB).

- A **Multifaceted Communication Strategy** to facilitate knowledge transfer, information dissemination, outreach to stakeholders, and coordination with related groups both within

IEA Bioenergy and externally. This involves a regularly updated Task 39 website, three newsletters per year and arranging at least two Task meetings a year as well as ancillary meetings such as sessions within the annual "Symposium on Biotechnology for Fuels and Chemicals" meeting.

Background

Fourteen countries collaborate within Task 39, with a goal of facilitating the commercialisation of conventional and advanced liquid biofuels for transport. During the last triennium, Task 39 delivered several cooperative research projects which assessed policy, markets and sustainable biofuel implementation issues. These reports are available on the Task's website (http://task39.ieabioenergy.com/publications/). As mentioned earlier, publication via the peer reviewed literature has also been encouraged. In two cases, webinars (Algal biofuels and Marine biofuels) were also delivered, to highlight new published reports and to facilitate knowledge transfer and information dissemination between IEA Bioenergy members and other transport biofuels stakeholders.

In addition, Task 39 strengthened collaborations with other IEA Bioenergy Tasks (Tasks 33, 34, 36, 37, 40, 42 & 43 and the new sustainability and deployment Tasks being proposed for the 2019-2021 triennium). We continue our good rapport with other groups such as IEA HQ, IRENA, the IEA Advanced Motor Fuels TCP, UN FAO and various national programmes. Task 39 also benefited from extensive industry involvement from companies at the forefront of biofuels development such as DSM, Borregaard, Licella, Steeper, Novozymes, LanzaTech, the Renewable Energy Group, Neste, skyNRG, GoodFuels, etc.

Task 39 covered several topics on decarbonisation of long-distance transport sectors (truck, rail, aviation and marine). The aviation and marine sectors in particular have fewer alternatives to low carbon fuels for achieving carbon emission reductions compared to light duty/short distance "urban" transport sectors. Task 39 continues to identify short-term and long-term opportunities and challenges that influence the production and use of conventional, advanced and drop-in biofuels. Examples of Task 39 reports completed during the triennium include, "Biofuels for the marine shipping sector", "Drop-in Biofuels: The key role that co-processing will play in its production" and "Survey of Advanced Fuels for Advanced Engines". These reports have primarily focussed on technical aspects of biofuels and their role in decarbonising the transport sector.

In terms of policy and sustainability assessments, Task 39 completed first and second phase studies (currently posted on the Task 39 website), which compared four well-recognised biofuels life cycle analysis models (EU's BIOGRACE, Canada's GHGENIUS, USA's GREET and Brazil's VSB). Task 39 also updated its periodically issued "Implementation Agendas" report that compares and contrasts biofuels policies across countries, in this case for countries that are members of Task 39 and also China and India. The Task 39 membership expects both policy and sustainability issues to continue to play crucial roles in biofuel development. Consequently, policy and sustainability assessments will continue to be a key activity for the Task in the next 2019-2021 triennium.

As part its communication strategy, Task 39 also organised twice-per-year business meetings. Task 39 members also participated in several biofuels-related conferences and workshops. The minutes of the business meetings are documented and posted on the Task 39's website (albeit access to minutes is limited to Task 39 membership and business meeting participants). In addition to commissioned reports, conference and workshop proceedings, Task 39 disseminates

information through its periodic newsletters featuring country reports, hyperlinks to media stories and reports and updates on Task 39 activities and progress.

Task objectives and work carried out

Task 39 successfully met most of its target deliverables stated in the Task's programme of work for 2016-2018. The topics and the main findings are summarised below:

Project# T39-T1: Update the status and potential of algal biofuels production in a biorefinery context

This activity was a broad inter-Task effort with contributions from both the IEA Bioenergy Executive Committee (ExCo) and Task members from 5 Tasks (Tasks 34, 37, 38, 39 & 42) and 8 countries. It provided an international update on the status and prospects of using microalgae and macroalgae as feedstocks for producing biofuels and bioenergy products. The report covered algae-based options for producing liquid and gaseous biofuels, and also algae-based bioenergy in the more general context of integrated biorefineries. A successful and well subscribed webinar was held in late January 2017 with a subsequent posting of the webinar published in February 2017.

Key findings include:

- Although high photosynthetic efficiency might make algae a promising feedstock for biofuels production in the longer term, in the near- to mid-term prospects for primary bioenergy/biofuels production are poor due to the cost of growing and harvesting (and concentrating/dewatering) algal biomass.

- Algal processing in a multi-product biorefinery context or integrated with wastewater treatment may, eventually, enable economic bioenergy coproduction.

- To better identify and prioritise commercialisation barriers that need to be overcome, greater data sharing and consensus/harmonisation of analytical methods is urgently needed – from cultivation to product isolation. This type of harmonisation is also badly needed for related TEA and LCA modeling.

- The full report can be downloaded here. A summary of the report is also published in the journal Algal Research.

Project# T39-T2: Advanced biofuels in advanced engines (with IEA AMF)

This project was funded by Task 39 and involved collaboration between Task 39 and the IEA Advanced Motor Fuels (AMF) Technology Collaboration Programme (TCP). The 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. The report shows how results can be influenced by the specific advanced biofuel that is used. One of its conclusions is that it is likely that the area of co-optimising fuel-engine systems to maximise transport performance efficiencies and associated greenhouse gas reduction potentials using advanced biofuels will continue to be an important research topic. 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). The full report can be

downloaded here.

Project# T39-T3: Comparison of LCA models (with Task 38 & contributing to Inter-Task activities)

This work was funded by Task 39 and involved an assessment of likely GHG emissions and energy balances for advanced biofuels. A comparison of four well-recognised biofuels LCA models (EU's BIOGRACE, Canada's GHGENIUS, USA's GREET and Brazil's VSB) was carried out, focusing on how each of these models estimates GHG emissions. Although the project was originally projected to involve 3 phases carried out over three years, because of delays, it was streamlined to two phases over three years so as to be able to be completed by end of the triennium. Phase I was completed in 2017 and compared these LCA models for conventional ethanol production. Publications documenting Phase I remain pending, however, owing to an unusually slow peer-review process; publication in 2019 is anticipated. Phase II was initiated in January 2018 and focussed on biodiesel fuels (both fatty acid methyl esters (FAME) and hydrotreated vegetable oils (HVO)/hydrotreated esters and fatty acids (HEFA)). This work was completed in December 2018, and the Phase II report can be downloaded here.

This project has helped identify commonalities and main differences in the models' methodological structures, calculation procedures, assumptions, etc. It has also highlighted the most influential parameters that impact the determination of emissions associated with the production and use of diesel-type biofuels (both FAME and HVO/HEFA types (also called hydrotreated renewable diesel, HRD or HDRD, or just renewable diesel, RD). One of the results of this project is to show how a "harmonisation" procedure can be used to align the results of the different models such that they agree with one another.

Project# T39-T4: Assessment of large-scale demonstration plants (with Bioenergy 2020+)

The Task continued to update its database of advanced biofuels production facilities, led by Dina Bacovsky, Austria's national team leader in Task 39. This "demoplants" database provides up-to-date information on over 100 companies' biofuels production facilities, which encompass a wide variety of biochemical, thermochemical, and hybrid conversion approaches to producing biofuels (website: http://demoplants.bioenergy2020.eu/). However, it continues to be difficult to obtain detailed and accurate, up-to-date information from many of the companies, particularly as their various processing technologies scale up and approach commercialisation. It has also proven challenging to obtain information on facilities in countries such as China that are not (yet) part of the IEA Bioenergy network. This is one of the motivations for the Task's ongoing efforts to recruit China to join the IEA Bioenergy TCP.

Project# T39-T6 (and T39-P2): Update drop-in report, specifically focusing on aviation and maritime fuels

Task 39 first published the report, Potential and Challenges of Drop-in Biofuels, in 2014. Since then, several drop-in biofuels projects have been initiated while some of the technologies highlighted in the report have been abandoned. The update to the original 2014 report includes expanded sections on aviation and maritime biofuels. The 2019 updated report was split into four parts: 1) an update of the more technical aspects of the existing report; 2) a section on biojet and marine biofuels; 3) a section on the policies that will be required to promote production and consumption of drop-in biofuels; and 4) the LCA of the production and use of drop-in biofuels. It is

recognised that specific policies will likely have to be developed and implemented to help establish drop-in biofuels, partly because these sectors are international and each has its own unique characteristics.

The 2019 updated report is expected to form the basis for future collaborations with other Tasks such as the Gasification and Thermal Liquefaction (Pyrolysis/HTL) Tasks as well as with allied organisations 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 coprocessing and upgrading strategies within existing petroleum refineries; and b) extending LCA studies to examine the life cycle/sustainability aspects of drop-in biofuels production.

Project# T39-T7: Biofuel production and consumption in emerging economies (China)

The Task published a report in 2016 on "The potential of biofuels in China" which was coauthored by Chinese colleagues and had a Mandarin speaking graduate student as a key co-author (as much of the source material was published in Chinese). The report summarised the current and potential future biofuel supply/use situation in China as well as the historical development of biofuels production in China as part of its strategy to address energy security and climate change concerns. The preparation and publication of this report was also part of the Task's efforts to encourage China to joint the IEA Bioenergy TCP and its Task 39.

Biofuel production and use in China has mainly focussed on conventional biofuels. Ethanol production was initially established based on the use of "time-expired/long-term stored" corn grain feedstock. However, with a very large population and on-going food security concerns, further expansion on this basis was prohibited. This led to exploration of so-called generation 1.5 crops such as sorghum and cassava. However, this approach had limited success in substantially increasing ethanol production. The report indicated that there is significant potential for expansion of cellulosic ethanol production based on agricultural residues. Several national and international companies have proposed projects in China. However, as one example, biodiesel has had limited penetration in road transportation due to a lack of policy support. Production is based on used cooking oil and attempts to expand the available feedstock base to include feedstocks such as jatropha seed oil and other oil seed crops have not materialised.

Although the Chinese government has set ambitious targets to increase annual biofuels production to 12.7 billion litres of ethanol and 2.3 billion litres of biodiesel by 2020, it is highly unlikely that these targets will be met. It is noteworthy that biofuels development and use received little attention in the country's 13th five-year plan. Looking forward, biofuels will likely play only a minor role in China's decarbonisation of its transport sector. While there is a significant emphasis on expanding renewable energy in China, the focus is on stationary applications. Road transportation seems to be preferentially addressed through alternative energy vehicles such as electric and natural gas vehicles.

Project# T39-P1: Update on country policies and implementation agendas

The Task 39's periodically issued "Implementation Agendas" study compares and contrasts the biofuels policies that have been developed and used within Task 39 member countries (and other key biofuels-producer/user countries like India and China). The 2018 update report describes the extent to which biofuels policies have been implemented in these countries and the measures taken by specific countries to develop or stimulate their respective biofuels sectors, including various financial incentives and investments in research, development and commercialisation. In addition, this report provides an update on the current status of biofuel sustainability assessments and the related discussions that factor into policy development. It should be noted that the policy

environment has changed substantially since the last Implementation Agendas report. The format of the report has been revised to try to better compare and contrast the relative successes of the various policies that are being used to promote biofuels development and use around the world.

Report on "Biofuels for the marine shipping sector" (Contributes to drop-in report update

Project #T39-T1):

The Task completed the report, "Biofuels in Marine Shipping," in 2017. This study assesses the current and developing marine fuel regulations, marine fuel characteristics and the new CO_2 monitoring regime for ships. It describes biofuel production technologies and the outlook for development of marine biofuels. It also provides a SWOT analysis of the potential and challenges for marine biofuels. A webinar on it was held in May 2018. Key findings include:

- Marine biofuels are a large, nearer-term opportunity, as sector sulphur emissions must be reduced. Most biofuels have low sulphur levels and many ship engines can use lower specification fuels compared to fuels used for aviation or road transport.
  - Large market: Approximately 90% of international trade involves shipping
  - Simplified supply logistics: For international shipping, there are relatively few major marine ports to supply
  - Significant potential for drop-in biofuels to replace part of the marine fuel mix
- New multi-fuel heavy-duty marine engines can also use alcohol biofuels (e.g., MeOH, EtOH)
- Development remains challenging: Testing requires: 1) very large volumes of biofuels; and 2) coordination among fuels producers, engine builders and ship owners.

Joint Project: Mobilising Sustainable Bioenergy Supply Chains (2016) – Inter-Task report, carried out with cooperation between IEA Bioenergy Tasks 37, 38, 39, 40, 42, and 43.

Analysis of the five globally significant supply chains conducted by IEA Bioenergy inter-Task teams – boreal and temperate forests, agricultural crop residues, biogas, lignocellulosic crops, and cultivated grasslands and pastures in Brazil – has confirmed that feedstocks produced using logistically efficient production systems can be mobilised to make significant contributions to achieving global targets for bioenergy. However, the very significant challenges identified in this report indicate that changes by all key members of society in public and private institutions and along whole supply chains spanning feedstock production to energy product consumption are required to mobilise adequate feedstock resources to make a sustainable and significant contribution to climate change mitigation. Notably, this report finds that all globally significant bioenergy development has been underpinned by political backing, which is necessary for passing legislation in the form of mandates, renewable energy portfolios, carbon trading schemes, etc. The mobilisation potential identified in this report will depend on even greater policy support than achieved to date internationally. The full report can be downloaded here.

Task 39 Newsletter

In addition to commissioned reports, Task 39 disseminated information through its periodic newsletters. In addition to providing updates on Task projects and meetings, every issue includes

a feature story highlighting biofuels developments in a member country or region of interest and also provides hyperlinks to recent media stories and reports of interest to the biofuels stakeholder community. These newsletters also detail the latest developments in industry and government policies pertaining to liquid biofuels. During the 2016-2018 triennium, 9 newsletters were developed and distributed to over 2000 recipients; feature articles highlighted biofuel production, use and policy developments in Sweden, Australia, Austria, Korea, China, Africa, USA, Canada and European Union. The Task's newsletters are available for download at Task 39's website: http://task39.ieabioenergy.com/newsletters/.

The country (or regional) specific feature article in each newsletter provides a unique source of information to global biofuel stakeholders. We regularly receive requests for permission to republish these reports in other magazines, e.g., Oils and Fats, Advanced Biofuels USA, Biomass Digest, etc.

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

Non-technical barriers

Delays in the LCA model comparison project resulted in the omission of Phase III, with the final report consisting of the combined Phase I and Phase II reports. In addition, several proposed objectives in the original work programme of the 2016-2018 triennium proposal were put on hold or were taken on as ExCo "special projects" executed under IEA Bioenergy Task 41. These objectives include:

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- Roadmap for Integration of advanced biofuels (with IEA AMF)
- Assessment of advanced biofuels commercialisation success (ExCo special project)
- Co-products and biorefineries (with Task 42)
- Potential of "generation 1.5" feedstocks (with China and possibly Task 43)
- Spatial analysis of possible biofuel feedstocks (work with Task 43 in coming triennium).

Success story

The primary success of Task 39 during the 2016-2018 triennium was to encourage the decarbonising of the transportation sector, particularly the long-distance transport sector (Aviation, Marine, Rail, Trucking) by the production and use of sustainable and low carbon liquid biofuels. Due to the complex fuel supply chains of these sectors and their price sensitivity, Task 39 covered various aspects of technology, commercialisation, sustainability, policy, markets and implementation. This work was done to help better identify the short- and long-term opportunities and challenges to reduce the carbon footprints of these transport sectors. Since the publication of the 2014 drop-in biofuels report, Task 39 has been invited and engaged in several workshops, seminars and studies such as the preparation of "biofuels for aviation- technology brief". For example, Task member Dr. Claus Felby (Task 39's lead Danish representative and co-author of

Task 39's "Biofuels in Marine Shipping" report), was invited to an Organisation for Economic Co-operation and Development (OECD) meeting November 26-27, 2018 on decarbonising the maritime sector. Claus presented the results from the marine biofuels report, summarising the current state of the art for marine biofuels, including the lack of scaling of advanced biofuels needed to support their use for maritime shipping. The Task has also benefitted from active industry involvement, with the aviation industry continuing to be the sector that is most actively championing the development of low carbon intensity aviation fuels.

Another success of Task 39 during the triennium was to enhance the understanding of the differences between and commonalities of four well-recognised biofuels life cycle analysis (LCA) models (EU's BIOGRACE, Canada's GHGENIUS, USA'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. For example, the CA-GREET model, which is a California-specific version of Argonne National Laboratory's GREET LCA model, has been used to calculate GHG emissions under California's Low Carbon Fuel Standard (LCFS). The work of Task 39's LCA expert steering committee (composed of Adrian O'Connell (EU), Michael Wang (USA), Mark Staples (USA), Don O'Connor (Canada), and Antonio Bonomi (Brazil)) 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 45 as well as with groups such as GBEP, IRENA, etc., in this area. These types of assessments continue to gain ever greater importance for policy makers and regulators. The Task 39 LCA expert steering committee continues to discuss how to further harmonise and extend LCA modelling approaches. For example, how to more broadly consider key aspects 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 or economic allocation, etc).

During the 2016-2018 triennium, Task 39 tried to expand Task membership. 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 industry, university and government groups, including several members of the IEA Bioenergy Executive Committee (ExCo). With an emphasis on "sustainability," representatives from the Round Table on Sustainable Biomaterials (RSB), the World Wildlife Federation (WWF), etc., also participated. In addition to good academic, government and industry participation from China, representatives from Indonesia and Thailand also attended. Task 39 also invited representatives from China and India 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 the next triennium. India 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. Norway has confirmed rejoining 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, Chile and Thailand. Economies in each of these countries are growing, with increased manufacturing and consumption leading to more freight transport (long-distance trucking, rail, shipping and aviation) and mounting concerns about how to decarbonise their economies, including their transport sectors, to meet their Paris Agreement commitments. The active participation of most country representatives/national team leaders at most of the Task 39 meetings is evidence of the value the Task 39 network plays in facilitating excellent international information exchange.

Conclusions and recommendations

It is hoped that the list of completed projects indicates that Task 39 has contributed to enhancing biofuel production and use at a global scale. The Task has documented changes in the biofuels policy landscape and tried to increase support for the development and deployment of advanced and drop-in biofuels. During the triennium the Task has highlighted the opportunities and challenges to decarbonise long-distance transport sectors (aviation, shipping, rail and trucking). Published reports have also helped us better understand and quantify how four well-recognised biofuels life cycle analysis models (EU's BIOGRACE, Canada's GHGENIUS, USA's GREET and Brazil's VSB) give different results when they are ostensibly assessing the same scenarios and using the same model inputs.

With its multifaceted communication strategy, Task 39 was also successful in promoting effective communications and disseminating relevant information through: 1) the Task 39 website; 2) Webinars; 3) Publishing 2-3 newsletters per year; and 4) organising bi-annual business meetings with active participation from the industry.

The proposed work for the new triennium will continue in areas of technology, policy, sustainability and commercialisation and will benefit from Task 39's already established strong and active participating network of experts from industry, academia and government research institutions developed over past and current triennia.

Task 39 will continue to contribute to the policy landscape by providing sound information and analysis on areas/topics that are often misinterpreted, such as sustainability assessment, especially LCA studies. A major focus area for the 2019-2021 triennium will be on the overall sustainability of transportation fuels and opportunities to cost effectively scale up production such as the potential for coprocessing biogenic and fossil feedstocks in existing petroleum refineries. The critical role that biofuels must play to achieve climate change mitigation targets (e.g., production must increase over tenfold to stay within 2DS) warrants an increasing focus on sustainability and strategies for cost advantaged deployment, as there is a growing need for accurate, representative models that can be used to reliably estimate the carbon intensity of prospective feedstock-conversion technology pathways.

Over the coming triennium, Task 39 will use the data sets and regionally specific approaches that each LCA modeling group in Task 39 (GREET, BIOGRACE, GHGenius and VSB) have used to model feedstocks-to-biofuels conversion processes. These groups will also work to further harmonise and extend this modelling approach by considering aspects such as system boundaries and specific assumptions such as soil carbon changes and how coproducts are handled (i.e., displacement, energy or economic allocation, etc.). Task 39 will also try to ensure that we can also effectively communicate the key results of Task 39's LCA studies to non-technical audiences, particularly by showing and emphasising how comparable results can be obtained using the different LCA models when their various assumptions and approaches are harmonised. For example, by illustrating how apparent differences between models are driven by the models' different default values and allocation approaches.

The gradual maturation of drop-in biofuel technologies and their increased importance and essential role in decarbonising key transport sectors such as aviation and marine have highlighted the importance of ongoing work in this area. It has also emphasised the essential role that effective policies will play if the drop-in biofuels sector is to develop and expand as required to

stay with 2DS.

As initially described in the 2014 Task 39 report, "The potential and challenges of drop-in biofuels," and highlighted in the 2018 update report, the potential for refinery integration and coprocessing is of considerable and growing interest. Thus greater active participation of oil refineries will be one of the Task's new focus areas in the new triennium. While several feedstock and technology combinations can produce bio-intermediate products, which could be further upgraded in a petroleum refinery, there are several potential obstacles that have to be overcome which involve a complex combination of technical, policy and sustainability issues. This topic is receiving increasing international attention and Task 39 will benefit from contributions from jurisdictions such as California (USA) and British Columbia (Canada) where attempts to develop and a Low Carbon Fuels Standard (LCFS) are on-going.

Another Task goal for the next triennium is to enhance collaboration with other IEA Bioenergy Tasks. The Task is committed to maximising synergies with established Tasks, new Inter-Task projects and new Tasks such as the nascent Task 45 on Sustainability".

The overall sustainability of biofuels will require ongoing use of analytical tools such as LCA to facilitate policy decisions to help implement and accelerate the commercialisation and adoption of conventional and advanced biofuels. Overall sustainability issues will be clarified and key sustainability metrics beyond GHG reduction will be assessed. These analyses, spanning both feedstocks and conversion technologies, will form an important basis of collaborations with other IEA Bioenergy Tasks (Tasks 33, 34, 36, 37, 40, 42, 43 as well as the new deployment (44) and sustainability (45)) Tasks) as well as with organisations such as IEA HQ, IRENA, GBEP, etc.

Oleochemical, lignocellulosic biomass resources and residues, and other carbonaceous processing "waste" feedstocks and their conversion technology pathways will be evaluated for the production of advanced biofuels. This evaluation will require on-going collaboration with Task 43 (Biomass Feedstocks), Task 42 (Biorefining), Task 38 (moving into the new Task 45 (Sustainability) and conversion technology tasks (especially Tasks 33 (Gasification) and 34 (Direct Thermochemical Liquefaction) as leading technology platforms for producing advanced drop-in biofuels).

In addition to sustainability assessment, another integral tool for de-risking and expediting commercialisation of conventional and advanced liquid biofuels is techno-economic analysis (TEA). The Task will continue working in this area and TEAs will be conducted on prioritised feedstock-conversion technology pathways for advanced biofuels, in particular for drop-in biofuels, to assess the economic viability of leading pathways and to provide direction to research, development, investment, and policy making.

A TEA-related proposed focus for Task 39 over the next three years is to assess the potential to reduce the final cost of producing advanced biofuels by "piggy-backing" their production with more conventional feedstock/conversion technology routes. The costs of most advanced biofuels options are currently much higher than those of conventional biofuels and their fossil fuel competitors. There is significant potential for reducing cost through increased production allowing greater economies of scale, in combination with the significant "learning effect" that occurs developing technologies. A supply chain approach will identify all the potential areas, across the feedstock-to-biofuel supply chain, to reduce both capital and operating costs of producing advanced biofuels.

Task 39 also intends to continue to contribute to some of the "special projects" initiated by the IEA Bioenergy ExCo towards the end of the 2016-2018 triennium, especially the project to assess the cost reduction potential for low carbon fuels. From a policy perspective, it is important to understand whether and under what conditions advanced biofuels and other low-carbon fuels can

be made affordable compared to petroleum fuels and conventional biofuels. We will collect current estimated costs for production of advanced biofuels from project developers and experts in the EU, North America, Brazil, Asia and other regions. This will be based on direct contact with developers and industry specialists via the ART Fuels Forum and by direct contact with other developers especially outside Europe, along with other well-informed groups (e.g., IRENA, USDoE – including NREL and PNNL – as well as ETIP, CNPEM, and VTT) and other sources. Efforts will be made to establish connections with and leverage related initiatives underway, for example in India and China.

Other topics in scope for the Task in the 2019-2021 triennium are the on-going monitoring of algal biofuels and electrofuels (including "power-to-X" technologies) developments; the commercialisation of 1.5 and second generation cellulosic ethanol; the role of specific feedstocks in achieving biofuels with lower cost and carbon intensities; maximising emission reduction benefits by co-optimising advanced fuels for advanced engines to achieve higher transport efficiency; maintaining and updating the Task's database on biofuels pilot / demonstration / commercial facilities; compare-and-contrast of country policies being used, their effectiveness and lessons learned to develop biofuel markets; and biofuels development in emerging markets.

Attachments

TASK MEETINGS AND PARTICIPATION IN MAJOR EVENTS

Task 39 organised the Task's twice per year business meetings and participated in several conferences and workshops held in conjunction with other conferences and seminars. These business meetings and affiliated conferences were:

- IEA Task 39 Business Meeting, Delft, the Netherlands, March 10, 2016 (in conjunction with ECO-BIO 2016)
- IEA Task 39 Business Meeting, Rotorua, New Zealand, November 8, 2016 (in conjunction with New Zealand's Advanced Biofuels Research Network (ABRN) Science Symposium and Bioenergy Australia 2016 Conference)
- IEA Task 39 Business Meeting, Gothenburg, Sweden, May 15, 2017 (in conjunction with Sweden's 2017 Advanced Biofuels Conference)
- IEA Task 39 Business Meeting, Brussels, Belgium, Sept. 25-27, 2017 (in conjunction with 6th International Conference on Lignocellulosic Ethanol)
- Task meeting, Beijing, China, April 7-9, 2018 (in conjunction with Beijing University of Chemical Technology Bioenergy Symposium and China-Canada Joint Centre for Bioenergy Research and Innovation (CJCBERI) meeting)
- Task meeting, San Francisco, USA, November 5-6, 2018 (in conjunction with ABLC GLOBAL conference)

Deliverables (Task meetings, conference papers, seminar proceedings, technical notes, newsletters, Industry Days, scientific publications, books, etc.), including website address and dissemination of results

- The deliverables for the Task in 2016 included: 1) organisation of two business meetings; 2) two progress reports and audited accounts (submitted to ExCo); 3) development and maintenance of the Task 39 website; 4) three newsletters; 5) the update to the Task 39 Advanced Biofuel Demonstration Database; 5) a completed report on "The Potential of Biofuels in China"; and 6) a completed update on "Algae Bioenergy State of Technology Review."

- The deliverables for the Task in 2017 included: 1) organisation of two business meetings during the year; 2) two bi-annual progress reports and audited financial accounts (submitted to ExCo); 3) development and maintenance of the Task 39 website; 4) three newsletters; 5) the update to the Task 39 Advanced Biofuel Demonstration Database; 6) a completed report on "Biofuels in Marine and Shipping"; and 7) completion of a final draft of the "Advanced Fuels in Advanced Engines" survey report.

- The deliverables for the Task in 2018 included: 1) organisation of two business meetings during the year in Beijing, China and San Francisco, USA; 2) two bi-annual progress reports and audited financial accounts (submitted to ExCo); 3) further development and maintenance of the Task 39 website; 4) three newsletters featuring country reports (USA, Canada and the EU) on biofuels production, use and policies; 5) webinar on "biofuels for the marine shipping sector"; 6) Update of Task 39's Advanced Biofuel Demonstration Database; 7) completing the "Survey on Advanced Fuels for Advanced Engines" report; 8) completion of 'drop-in' biofuels – report update" ; 9) completion of "Implementation Agendas – report update"; and 10) completion of the comparison of LCA models Phase II report.

Task 39 newsletters : http://task39.ieabioenergy.com/newsletters/

Task 39 publications : http://task39.ieabioenergy.com/publications/

Task 39 business meetings (minutes and presentations; access limited to membership): http://task39.ieabioenergy.com/business-meetings/

Co-ordination with other Tasks within IEA Bioenergy and with other bodies outside of IEA Bioenergy, e.g. other TCPs; and other organisations such as FAO.

The Task worked with other IEA Bioenergy Tasks and related organisations such as IEA HQ, IRENA, GBEP, AMF TCP, etc., to assess and help develop cost-effective oleochemical, biochemical, thermochemical and hybrid technologies as well as to co-optimise fuel-engine systems to maximise transport performance efficiencies and associated greenhouse gas reduction potentials using advanced biofuels.

- In 2018, Task 39 strengthened collaborations with other IEA Bioenergy Tasks (Tasks 33, 34, 36, 37, 40, 42 & 43 in particular, and hopes to be as productive in working with the new sustainability and deployment Tasks being initiated in the 2019-2021 triennium) as well as with other groups such as the IEA Advanced Motor Fuels TCP and IEA HQ.

- Task 39 leadership routinely reviewed and provided feedback on draft IEA reports, most recently on the draft Renewable Energy Market Report (2017) and Tracking Clean Energy Progress (2018) report. The Task 39-led update report on the status of algal bioenergy was an inter-Task activity carried out in collaboration with IEA Bioenergy Tasks 34, 37, 38, and 42. The Survey on Advanced Fuels for Advanced Engines was a collaboration with the IEA AMF TCP, while the Comparison of LCA Models for GHG Calculations is a

collaboration with IEA Bioenergy Task 38; the outcomes of this project are also helping to inform the new inter-Task project on Sustainability. Task 39 also engaged with organisations such as IEA-RETD and IRENA in reviewing reports in the biofuels sphere.

Industry participation: How was the industry involved in the Task's activities? How did it influence the work carried out by the Task? Which industries participated and what activities did they participate in?

As part of its outreach to stakeholders, Task 39 is fortunate to have the active participation of many experts from academia, government and industry. Examples of industry and institutional participants include: DSM, Boeing, Licella, Novozymes, LanzaTech, the Renewable Energy Group, International Air Transport Association, Boeing, S&T2 Consultants, World Wildlife Federation, Roundtable on Sustainable Biomaterials, Argonne National Laboratories and many others, with active industry involvement by the aviation sector continuing to be the area where industry is most actively championing the development of lower carbon intensity fuels.

The Task's structure allows participants to work together in a comprehensive manner on prioritised issues and challenges identified across the broad area of transport biofuels production, use and policy development. The industry partners helped Task 39 to collect data on biofuel production and use, capital and operating costs of their biofuel plants, and other details of their technologies. In addition to interactions through emails, phones, conference calls and in-person meetings, representatives of the biofuels industry participated in Task's business meetings and provided updates on their companies' respective biofuel development and deployment strategies as well as shared their insights on the future of the industry and the areas and issues where further reseach and development is needed, e.g., feedstock sustainability assessment, biofuel policies establishment, and greater harmonisation of TEA and LCA methodologies for estimating biofuels production economics and emissions reduction and sustainability potentials.

IEA Bioenergy

Further Information

IEA Bioenergy Website
www.ieabioenergy.com

Contact us:
www.ieabioenergy.com/contact-us/