IEA Bioenergy
Technology Collaboration Programme

Task 39
Commercializing Conventional and Advanced Transport Biofuels from Biomass and Other Renewable Feedstocks

Final Task Report
Triennium 2019-2021

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INTRODUCTION

During the last triennium (2019-2021), Task 39 continued its work to advance development and deployment of sustainable, lower carbon intensity biofuels used to decarbonise the transport sector (particularly long-distance transport segments where electrification is more challenging, i.e., aviation, marine, trucking and rail). Through a coordinated focus on technology, commercialization, sustainability, policy, markets and implementation, Task 39 assisted member countries and other transport biofuels stakeholders in their efforts to develop and deploy sustainable, lower carbon intensive biofuels. These included conventional biofuels (i.e. ethanol and fatty acid methyl esters (FAME) biodiesel), drop-in biofuels produced by treating lipid feedstocks with hydrogen (known as hydrotreated vegetable oil (HVO)/hydrotreated esters and fatty acids (HEFA)) biofuels/renewable diesel/green diesel, Biojet/sustainable aviation fuel (SAF), cellulosic ethanol, 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, economic and life cycle assessment and to monitor the various policies that have been successfully used to increase the production and use of transport 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. These include:

1. **Technology and Commercialization** with a focus on:

   - Helping develop and commercialize cost-effective processes for the production of sustainable low carbon intensity biofuels, particularly the production and use of "drop-in" biofuels from oleochemicals and lignocellulosic biomass to decarbonize 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-optimize fuel- engine systems to maximize transport performance efficiencies and associated greenhouse gas reduction potential using advanced biofuels; and

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

2. **Policy, Markets, Implementation and Sustainability** which encompasses issues that address policy/legislative/regulatory and infrastructure concerns and needs regarding expanding transport biofuels markets. This Task activity also provides information and analyses on policies, markets and implementation issues that help participants foster commercialization 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 its work to better clarify commonalities/differences in methodological structures, calculation procedures and assumptions used within four of the world's most well-recognized biofuels LCA models (EU's BIOGRACE, Canada's GHGENIUS, USA's GREET and Brazil's VSB).

3. 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 joint webinars with groups such as the BC SMART Low Carbon Fuels Consortium

BACKGROUND

Sixteen countries participated in Task 39 during the last triennium (2019-2021). The primary goal of the Task was to facilitate the commercialization of conventional and advanced transport biofuels and enhance the decarbonisation of the multi-faceted transport sector. However, with an increasing focus on the more difficult to electrify, long-distance transport sector. During the last triennium, Task 39 delivered several cooperative research projects which assessed policy, markets and sustainable biofuel implementation issues. The reports from these research projects are available on the Task's website (http://task39.ieabioenergy.com/publications/). Publication via the peer reviewed literature has also been encouraged, to reach the broader transport biofuels community. More information about the research reports and peer-reviewed articles are provided in the next section. Webinars 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.

Task 39 also strengthened its collaborations with the other IEA Bioenergy Tasks (e.g. InterTask project with Task 40 and Task 45 and joint workshop with Task 44). We continued our good rapport with other groups such as such as IEA HQ, IRENA, FAO, GBEP, other IEA TCP's (e.g., AMF, Hydrogen, etc.) and various national and international programs. It should be stressed that Task 39 continues to benefit from extensive industry involvement of companies and institutions at the forefront of biofuels development. These include Boeing, Borregaard DSM, ENI, GoodFuels, International Air Transport Association (IATA), IFPEN, ISCC, Haldor Topsoe, LanzaTech, LBST, Licella, Neste, Novozymes, Renewable Energy Group (REG), Roundtable on Sustainable Biomaterials (RSB), (S&T)2 Consultants, skyNRG, Steeper, UPM, World Wildlife Federation, etc.

Task 39 covered several topics related to decarbonization of long-distance transport sectors including aviation, marine, trucking and rail. The aviation and marine sectors, in particular, have fewer alternatives to achieving carbon emission reductions compared to light duty/short distance "urban" transport sectors. Task 39 helped develop short-term and long-term opportunities that influenced the production and use of sustainable, low carbon intensive biofuels. Examples of Task 39 reports completed during the triennium include; 1) "Biofuels in marine shipping: Issues affecting utilization of advanced biofuels in the marine sector", 2) "Progress in commercialisation of biojet fuels/SAF: 3) Technologies, potential and challenges", "Recent progress in the production of low carbon intensive drop-in fuels; 4) Stand-alone production and coprocessing" and, 5) "Feedstock-to-biofuel(s) supply chain analysis; a focus on CAPEX and OPEX cost reduction opportunities for advanced biofuels".

In terms of policy and sustainability assessments, Task 39 continued to facilitate LCA studies by focusing on the development of regional life cycle inventory data such as the data available from sugar cane production and processing Brazilian RenovaBio program. Task 39 also updated its periodically issued "Implementation Agendas" report that compares-and-contrasts biofuels policies across its member countries. Task 39 also led a study on "biofuels production and use status in emerging economies (including Brazil, Argentina, Columbia and Guatemala)". Another project reviewed existing/proposed certification processes for oleochemical and lignocellulosic-

based biofuels supply chains which highlighted certification scheme improvement opportunities. As both policy and sustainability issues will continue to play crucial roles in biofuel development this will continue to be a key activity for the Task in the next triennium.

Task 39 also coordinated an InterTask project between Task 39, Task 40 and Task 45, that evaluated the reasons why there have been boom-and-bust cycles of biofuel technologies development, demonstration and deployment, and how we can learn from them

Task 39 also updated its online Biofuels Demonstration Plants Database with information on all European facilities (121) verified and updated. There are currently about 290 active entries in the database, of which 220 are at TRL 6-9.

As part its communication strategy, Task 39 also organized (at least) twice-per-year business meetings. The minutes of the business meetings are documented and posted on the Task 39's website (access to

minutes is limited to Task 39 membership and business meeting participants). Task 39 continued to actively organize and participate in other virtual webinars and conferences with the goal of sharing the networks insights on how decarbonization of the transport sector can contribute to a "green economic recovery". These activities included three webinars concerning, "IEA Bioenergy Webinars", the Task 39 sessions on Transport Biofuels in "the Biofuture Summit II / BBEST2021 Virtual Conference", and the "End of Triennium Conference 2021". The flyer, recoding and presentation slides of some of the joint webinars are posted on Task 39 website (Events and Conferences).

- List of Task 39 Business meetings, Joint workshops & Webinars in the 2019-2021 triennium
    - Task 39 business meeting in Ispra, Italy/Joint JRC-Task 39 workshop, Biofuels Sustainability - Focus on Lifecycle Analysis, 15-17 May 2019
    - IEA Bioenergy Webinar: Drop-in Biofuels - The key role that co-processing will play in its production, 25 September 2019
    - Task 39 business meeting, Stockholm, Sweden, 16-17 September 2019
    - Task 39 business meeting, 2 April 2020 (virtual)
    - IEA B. Webinar: Advanced Biofuels – Potential for Cost Reduction, 24 April 2020
    - Task 39 business meeting, 23 June 2020 (virtual)
    - BC-SMART Biofuels Consortium/IEA B. Task 39-hosted panel discussion (virtual), Crystal ball gazing: How do we decarbonise long distance transport during/after COVID-19?, 30 June 2020
    - Task 39 business meeting, 23-24 November 2020 (virtual)
    - Task 39-Task 44 Joint Workshop, 25 November 2020 (virtual)
    - BC-SMART Biofuels Consortium/IEA B. Task 39-hosted panel discussion (virtual),
    - Decarbonising the Marine Sector: Progress and Aspirations, 4 December 2020
    - Task 39 business meeting, 19-21 April 2021 (virtual)
    - Participated in BBEST 2020-21/Biofuture Summit II conference, May 2021 (virtual)
    - Task 39's presentation for the IEA Bioenergy Webinar entitled, "Sustainable Aviation Fuel/Biojet Technologies – Commercialisation Status, Opportunities and Challenges", June 2021
    - February 2021-through-August 2021: Three virtual Task 39 "brainstorming sessions"
    - Task 39 business meeting (End of Triennium), 23-24 November 2021 (virtual)
    - Organized two sessions in the IEA Bioenergy End of Triennium Conference, 1st December 2021 (virtual)

In addition to the Task 39 commissioned reports, conference and workshop proceedings the Task disseminated information through its periodic newsletters. These featured country reports, hyperlinks to media stories and reports and updates on Task 39 activities and progress.

REPORT ON THE TASK'S OBJECTIVES

Task 39 successfully met the vast majority of the target deliverables stated in the Task's programme of work for the 2019-2021 triennium. Overall, nine commissioned projects and one InterTask project (with Task 40 and Task 45) were delivered. In addition, Task 39 contributed to two IEA Bioenergy InterTask project reports.

The list of Task 39's deliverables for the 2019-2021 triennium include:

Lessons learned success stories in biofuels (InterTask project with Task 40 and Task 45)

This InterTask project documented "learnings" from past boom-and-bust cycles of biofuel technologies development, demonstration and deployment. The work assessed different countries, with an emphasis on major biofuels producing member countries including the US, Sweden, Germany and Brazil. The project assessed "best" policy framework conditions and the measures used to stimulate production and use of sustainable transport biofuels. The team included members of Task 39, Task 40 and Task 45. The primary research questions were: "What are the key reasons for the success of sustainable advanced biofuel projects?" and "What is required to re-stimulate vigorous biofuels development and commercialization? The project was comprised of six Work packages (WPs) including WP1 (Status quo biofuel projects), WP2 (Meta-analysis existing studies), WP3 (Case studies technologies), WP4 (Case studies supply chains), WP5 (Synopsis / synthesis of key issues) and WP6 (Project management and dissemination).

Work package (WP) 1 performed an overview on conventional biofuel capacities, including a brief summary of the development and status of advanced fuel projects in selected countries. It also described current policies and issues related to governance of biofuel development with policy instruments (e.g. targets, quotas, sustainability requirements etc.) and their impact/success. This serves as an update of both the state-of-art in biofuels development and current market development. It also assessed the differences in countries, comparing the "success stories" that could be deployed and sharing the acquired knowledge and experience.

Work package (WP) 2 involved a literature review, specifically addressing lessons learned from biofuels with TRL equal or higher than 7. To this end, a template for qualitative analysis of biofuels was developed and the required data gathered. A visual analysis involving spider diagrams was carried out. Specifics are discussed in more details in the posted report.

WP3 involved case studies (either technical or/and economic successes) in which the development and timeline of the various technologies were presented. Three cases studies from Germany were elaborated and discussed with partners including one technical and economic success (sunliquid®), one technical success involving a technology platform (bioliq®) and one technical success which lacked an economic incentive (CHOREN). In addition, the projects Chemrec, Gobigas and SunPine were also described. They showed three, distinct routes and technologies to making advanced biofuels in Sweden, involving medium-to-large scale implementation.

In WP4 various supply chain case studies were assessed in terms of cost-effectiveness, reliability and the sustainability of feedstock as they are crucial to the successful development of advanced biofuels. The case studies also considered various options. This included, successful biorefineries and pulp mills using consistent feedstock (Brazil), European experiences in the development of bio-based supply chains for torrefied woody biomass, "pioneering" biorefineries in the US (traditional pre-processing for herbaceous feedstocks) and conceptual depots producing conversion-ready feedstock and co-products.

WP5 involved organising a workshop on 25 November 2021 with the title "Guidelines to overcome barriers for commercialization of advanced biofuels". It was held in a hybrid form, with the "in-person" part held in Sweden with 60 delegates from 14 countries, with half attending in person. The workshop targeted people involved in creating a sustainable transport sector. The speakers and delegates involved a high blend of policymakers and leading academics, researchers, engineers, as well as executives and representatives from companies and organizations. The event involved several presentations that formed one of the deliverables for WP5. The workshop included six breakout sessions with different topics and questions discussed. The groups addressed the following topics:

1. “Boom and bust of Swedish and international biofuels projects”
2. “Biofuels in aviation and marine – successes and learnings”
3. “Carbon tax and carbon pricing - lessons and successes for biofuels?”
4. “Technical and economic analysis of biofuels”
5. “The place of biofuels in an electric vehicle world”

The workshop discussed the need for biofuels – bioliquids and green gases –as a way to replace fossil fuels (needed to reach the Paris Agreement goals!). However, much bigger investments will be needed to boost production. Stronger policy support and enhanced innovation will be required to reduce the costs of development and scale up.

The event tried to answer the research questions below:

- What are the key factors required to enhance the production of sustainable, advanced biofuels?
- What is required to re-stimulate vigorous biofuels development and commercialization?

The workshop also discussed the key components needed to overcome the technical, economic, societal and political barriers in past and ongoing booms and busts cycles of biofuel technologies. Also, how to stimulate increased production and consumption of advanced transport biofuels.

Feedstock to Biofuels: Opportunities for advanced biofuels-Supply chain analysis & reduction in CAPEX/OPEX

This project build on the EC’s “Cost of Advanced Biofuels” and IEA Bioenergy’s “Potential for Cost Reduction for Advanced Biofuels” reports. Currently, the cost of most advanced biofuels are much higher than those of conventional biofuels and their fossil fuel equivalents. Primarily, due to high capital/operational costs (CAPEX/OPEX) and challenging economic conditions, most “advanced” commercial biofuel plants are currently not operating at full capacity or are idle. Consequently, there is an urgent need to better identify ways to reduce the capital/operating costs at larger economies of scale. The report described the various potential ways to reduce capital and operating costs for advanced biofuel production. The various “feedstock-to-biofuels” routes were described, with specific references to “second-generation” (2G) ethanol process that have been developed in Indian, Brazil, German and the US. The report described biomass availability in each of the specific regions, variation in, a) the chemical composition, b) biomass supply chain approaches and, c) the different process schemes that have been followed. This included the type of pretreatment used by the various 2G ethanol technology developers, the life cycle analysis (LCA) and the environmental impact assessment used to try to quantify GHG emissions. The report also described the energy consumption challenges that are encountered during many lignocellulosic-to-bioethanol processes. As concluded in the report, to lower the Opex costs of producing second-generation (e.g. biomass derived) ethanol, there is a need to better develop cost effective pretreatment technologies. This will include low or no chemical input, onsite second-generation (2G) enzyme production as well as greater valorization of the lignin component to higher value chemicals. Advances in these and other areas (such as more effective pentose fermentation) will be required before 2G ethanol production is cost competitive with 1G ethanol production.

Progress towards biofuels for marine shipping: Status and identification of barriers for utilization of advanced biofuels in the marine sector

As a continuation of the 2017 IEA bioenergy Task 39 report: Biofuels for the marine shipping sector, the updated report highlighted the most significant barriers impeding the commercialization of biofuels used by the marine sector. Interviews were conducted with seven key stakeholders involved in the marine freight transportation sector. The interviews indicated the considerable complexity and many considerations that will be involved in decarbonising the marine fuel sector. One major barrier is the lack of any economic incentives. Many stakeholders raised several concerns such as, the overall level of uncertainty related to the price of biofuels, the sustainability criteria that will be used, plus onerous

regulatory policies. However, little concern was expressed regarding the technical barriers of scale-up, establishing supply chains, or adopting engine and fuel systems for low-CI biofuels. In contrast, the uncertainty regarding enabling policies and technical/economic progress was commonly expressed. Encouragingly, a number of the stakeholders highlighted biofuels as the most promising short- to mid-term solution for both reducing carbon emissions and meeting reduced sulphur targets. Also, with increasing international attention given to sulphur emissions and ship energy efficiency, the price gap between fossil- and biofuels is declining.

Advanced Biofuels Demonstration Facilities Database

The Task 39 pilot and demonstration plants database is an on-going activity. It updated annually as new information becomes available through conference, presentations, news articles and Task 39-member updates. This database, provides information and the location of advanced biofuels production facilities in Task 39 member countries and the rest of the world. It can be accessed at: https://demoplants.best-research.eu/

Task 39's demonstration biofuels production plants database is maintained by Austria's BEST – Bioenergy and Sustainable Technologies GmbH organization. Technologies covered in the database include gasification, fermentation, hydrotreatment, fast pyrolysis, hydrothermal liquefaction, lignin depolymerisation and e-fuels biomass hybrids. The database was updated with information on most countries and on all European facilities (150) verified and updated. There are about 300 active entries, out of which 240 are at TRL 6-9. During the past triennium, the demand and the production of advanced transportation fuels from biomass and other renewable feedstocks increased. In particular, several facilities producing HVO, jet fuel components and SAF were built or are in the planning phase. There is also a trend towards diversification and combination of technologies. For example, fossil refineries are integrating co- processing units, hybrid systems. So-called waste streams are also increasingly used for the production of advanced fuels.

Improvement opportunities for low-carbon, sustainable biofuel policies and certification schemes, Part 1: A review of policy frameworks

In many cases, emission reduction and climate mitigation are the driving forces behind the production and use of biofuels. As a result, the overall sustainability and quantifying the reduced carbon intensity of the final fuel has to be measured. Currently, several sustainability and greenhouse gas (GHG) requirements are described in the policy framework of various feedstock- to-biofuel supply chains in different regions of the world. In some of these policies (e.g., EU- RED, ICAO-CORSIA) the regulation has (partially) been outsourced with public enforcement and monitoring of compliance involving "specific" certification schemes.

The objective of this study was to get a better understanding of:

- How existing GHG emission reduction and sustainability requirements and their compliance and verification approaches, in selected policy frameworks for feedstock-to-biofuel supply chains are aligned or differ,
- To improve understanding of the implications of those (regional) differences in the selected policy frameworks on biofuel flows globally, and;
- To give general recommendations for decision-makers (especially governments and certification schemes) on how to improve the robustness of compliance and verification approaches for feedstock-to-biofuel supply chains for the global biofuel market.

The analysis described differences between selected policy frameworks over a range of issues, including the requirements for GHG emission reductions and the sustainability criteria used. It also categorized the various feedstocks, the requirements for key information, specifics regarding chain of custody, verification and assurance requirements and the approval of certification schemes.

As these issues are interrelated, a combination of even small differences can result in differences in the

stringency and robustness of policy frameworks regarding the sustainability of biofuels.

The global sustainability framework for biofuels is as strong as its weakest link. In a sector where biofuels and their feedstocks are internationally traded, there is a risk that feedstock flows move to, or are traded through countries with less enforcement or less stringent rules. This may affect overall biofuel trade, but more importantly, the overall "robustness" of the system.

To improve the robustness of compliance for sustainable feedstock-to-biofuel supply chains for the global biofuel market, it is therefore recommended to align and harmonize where possible definitions (especially on wastes and residues), sustainability criteria, GHG emission reduction requirements and GHG LCA methodologies, and related certification and verification requirements. Next to that, it is recommended to increase the understanding how a combination of– even small - differences in GHG emission reduction requirements, and related certification and verification requirements may affect the overall robustness of policy frameworks on the sustainability of biofuels.

Life Cycle Inventory (LCI) Data for Brazilian Sugarcane Production

This report developed an LCI dataset for sugarcane production that came available due to the implementation of the RenovaBio program in Brazil. As part of the RenovaBio certification program, producers were required to have a third party verify the information that they used to calculate the carbon intensity of their ethanol production. The audited results were published for public comment. At the end of the comment period the information was removed from public view. The process ran through 2019 and 2020. In 2020, there were 67 mills that published their performance data and there were a few cases where the mills used conservative default values rather than actual values for some of their inputs. Thus, this reduced the sample size.
The data set that was developed from this public information represented 153 million tonnes of sugar cane production in total. Of that, 138 million tonnes of sugarcane that were produced using all actual values. The details of the dataset are presented in the report. The information in this report should be of value to lifecycle database and model developers.

The LCI parameter values for some of the major inputs were found to be significantly higher than the values currently used in the GREET model and in the JRC modelling. It was also noted that the carbon intensity for sugarcane ethanol production reported by these mills was also significantly higher than the default values in GREET and the JRC database. An early version of the updated data has already been included in GHGenius.

Biofuel's production and use status in "emerging" economies

This project evaluated the status and potential for biofuels production (ethanol and biodiesel) in emerging economies. Specifically, developing countries with large populations and high energy demand. The assessment methodology considered sustainability dimensions and focused on several key performance indicators based on Life Cycle Analysis (LCA), Techno-economic assessment (TEA), and Exergy analysis (EXA). Nine developing countries with substantial potential to produce biofuels were assessed. They included Argentina, Brazil, Colombia, Guatemala, India, Malaysia, Nigeria, South Africa and Thailand. The work initially focused on Latin American countries with the results giving an overview of current ethanol and biodiesel production. The LCA work showed that 63 $mtCO_2$/year could be avoided by replacing fossil fuels with biofuels. Further reductions could be obtained if biogas was used to produce nitrogen- based fertilizers. In addition, estimates on the land-use present showed that converting 5% of pastureland into energy crops could double biofuels production in these Latin American countries. The exergetic evaluation showed that the main process inefficiencies were due to the Combined Heat and Power (CHP) units for sugarcane ethanol and palm biodiesel production. However, the CHP units provided steam and electricity to the biorefinery, making them energy self-sufficient and improving profitability. This is reflected in the TEA analysis since biorefineries integrated with CHP units could also export surplus electricity to the grid. The economic indicators NPV (Net Present Value), IRR (Internal Rate of Return), and MSP (Minimum selling price) were used to assess the economic feasibility of biofuels production. The results described the economic feasibility of all biorefineries, emphasizing the competitive potential of ethanol and highlighted the strong dependence of biodiesel on the cost of the raw material. Integrated analysis involving LCA-TEA-EXA indicated that biofuels in emerging economies can be successfully used to decarbonize the energy matrix of these countries.

Progress in Commercialisation of biojet fuels/SAF: Technologies, potential and challenges

This project provided an extensive analysis of the current and potential technologies for producing Biojet/SAF. The report also highlighted several commercial-scale facilities that will come online over the next few years. As emphasized in the report, some of the Biojet/SAF processes have encountered high capital and feedstock costs while some are dealing with technology challenges. The report recognized that, as Biojet/SAF fuel prices are likely to remain significantly higher than conventional jet fuel, the "right" policies will be needed to bridge the price gap and incentivize the production and use of biojet fuels. As concluded in the report, all of the technologies/pathways to Biojet/SAF will need to be pursued if we are to deliver the significant fuel volumes required to decarbonize aviation. However, although ongoing improvements and optimization of the various processes will continue to reduce the cost of Biojet/SAF production and use, meeting the sector's decarbonisation targets will be challenging.

The authors of the report presented the main findings of this report in an IEA Bioenergy webinar held on July 13, 2021. The recording of the webinar and the presentation slides can be found at the IEA Bioenergy Website.

Recent progress in the production of low carbon intensive drop-in fuels- Stand-alone production and coprocessing

Task 39 originally published the report, Potential and Challenges of Drop-in Biofuels, in 2014. The report was updated in 2019 (Drop-in Biofuels - The key role that co-processing will play in its production). The continuation of this work (over 2019-2021) was divided into five parts: 1) an update of the more technical aspects of the previous reports; 2) a new section expanding on biojet and marine biofuels; 3) an update of co-processing pathways and insertion points at petroleum refineries and estimating the carbon intensity of drop-in biofuels produced through co- processing; 4) a section on the policies that will be required to promote the production and consumption of drop-in biofuels; and 5) the life cycle analysis (LCA) of the production and use of drop-in biofuels. As concluded in the report, the production and use of drop-in biofuels will be essential if the world is to meet its carbon reduction targets. Hard-to-decarbonise sectors such as aviation and marine will need these lower carbon intensive (CI) fuels. However, the production of lower-carbon-intensive (CI) fuels must rapidly increase if targets, such as those outlined in COP26, are to be met.
Co-processing biogenic feedstocks (lipids, biocrudes, etc.) within existing petroleum refineries can provide an alternative, fast and effective way to rapidly increase the volumes of drop-in, lower carbon-intensive fuels. Although some infrastructure and operational modifications will be required to facilitate co-processing at an existing refinery, the cost is likely to be significantly lower than building a dedicated, standalone biorefinery. The report highlighted potential operational challenges when introducing a variable feedstock and highlighted the work that will need to be done to mitigate any risks to the refinery.

Implementation Agendas: Compare-and-Contrast Transport Biofuels Policies (2019-2021 Update)

Task 39 has been evaluating the effectiveness of technology-push and market-pull policies to encourage the production and use of transport biofuels in member countries since 2007. This evaluation has been a central part of a regular report, entitled "Implementation Agendas- compare and contrast policies used to develop biofuels markets", (abbreviated to the "Implementation Agendas" report). The Implementation Agendas report is a collective effort between the Task 39's member countries. It summarises each country's current biofuels policies, assesses the market penetration of biofuels and, more importantly, compares-and-contrasts the relative success of the various policies used to promote transport biofuels development and use. The information discussed in the Implementation Agendas report is based on the data collected via a questionnaire sent to each Task 39 country representative. The collective responses are then compiled and used to update the country specific chapters.

Five updates of the report have been published by Task 39 in the past including 2007, 2009, 2014, 2017

and 2019. This latest update describes the ongoing developments in biofuels markets and policies since the last report that was published in February 2020. A summary of the updated additions to the report include:

- Additional country chapters for India, Norway and Ireland, the countries that joined Task 39 in the 2019- 2021 triennium
- Historical GHG emissions inventory data and the contribution that the transport sector made to the national GHG emission inventory of each member country
- Historical biofuel developments and the related GHG emissions policies in each member country
- Existing and emerging sustainability certification schemes for transport biofuels and feedstocks
- Compliance costs of biofuel policies (e.g. $/tCO2, $/GJ)
- Historical biofuels and feedstocks imports-and-exports
- Co-processing trials/demonstrations at oil refineries

Biofuels production and consumption data for the 11-year period of 2010-2020 showed that, in most of member countries, biofuels policies played an important role in developing and growing regional and national biofuels markets. Based on the information collected from member countries, existing biofuels policies have shown a range of strengths and limitations. A mixture of market-pull and technology-push policy instruments is typically used to try to establish or grow current biofuels markets and enabled some member countries to meet their ambitious GHG emissions reduction goals and fulfil their commitments to the Paris Agreement. Member countries that have achieved the most success in growing their production and use of biofuels have used a mixture of market-pull and technology-push policies.

Advanced Biofuels - Potential for Cost Reduction (IEA Bioenergy InterTask project)

The Task 39's management team (Drs. McMillan, Saddler and Ebadian) distributed the project questionnaire to 25 advanced biofuels companies in North America and then collected and compiled cost data from 10 responding companies, contributing a section summarising this information. Task 39 also prepared two other sections, one on feedstock costs and availability in North America and the other on the role of biofuels policy in the potential cost reduction of advanced biofuels. Members of the project team presented the main findings and results in an IEA Bioenergy Webinar held on 23 April, 2020. The full report is available on the IEA Bioenergy website (here)

The Role of Renewable Transport Fuels in Decarbonizing Road Transport (IEA Bioenergy InterTask project)

Experts from the IEA Bioenergy and Advanced Motor Fuels Technology Collaboration Programmes with support from the European Commission's Directorate General for Energy recently completed a study on the role of renewable fuels in reducing the climate impact of road transport for a number of countries, including Brazil, Germany, Finland Sweden, and the USA. The analysis considered developments up to 2050 based on national policies, vehicle fleet projections, and the availability of renewable transport fuels. The objective of the assessment was to quantify the role that renewable transport fuels play in decarbonising road transport as well as to provide insights to policy makers about how individual countries differ from one another, which options for decarbonisation they have, and to provide best practice examples of successful policies.

The report was completed in November 2020, and is available on the IEA Bioenergy website (here). Task 39 contributed to three chapters of this report (1) Role of policy on production and use of emerging biofuels; 2) Availability and costs of sustainable bioenergy feedstocks; and 3) GHG emissions of emerging biofuels pathways) as well as assisted with finalizing the report.

Other commissioned reports that were completed during the 2019-2021 triennium include:

- Compare and Contrast Transport Biofuels Policies- Implementation Agenda, 2018-2019 Update (2020)
- Comparison of biofuel life cycle analysis (LCA) tools, Phase 2, Part 2: biochemical second generation (2G or cellulosic) ethanol production and distribution (2020)

- Assessment of likely Technology Maturation pathways for biojet production from forest residues. The ATM Project, jointly sponsored by Boeing (2019)
- Drop-in Biofuels- The key role that co-processing will play in its production (2019)
- Comparison of Biofuel Life Cycle Analysis (LCA) Tools Phase 2, Part 1: FAME and HVO/HEFA (2019)

Task 39 also published several peer-review manuscripts that are listed below:

- Challenges in determining the renewable content of the final fuels after co-processing biogenic feedstocks in the fluid catalytic cracker (FCC) of a commercial oil refinery (Su et al., 2021; Journal of Fuel) (link)
- Determining the amount of "green" coke generated when co-processing lipids commercially by fluid catalytic cracking (FCC) (Su et al., 2021; Journal of Biofuels, Bioproducts and Biorefining) (link)
- Biofuels in Latin America: Sustainability Assessment of Argentinian, Brazilian, Colombian, and Guatemalan cases (Canabarro et al., 2021, submitted to the journal of Renewable and Sustainable Energy Reviews)
- Biofuels policies that have encouraged their production and use: An international perspective (Ebadian et al., 2020, Energy Policy Journal) (link)
- Potential synergies of drop-in biofuel production with further co-processing at oil refineries (van Dyk et al., 2019; Journal of Biofuels, Bioproducts & Biorefining) (link)
- Comparison of biofuel life-cycle GHG emissions assessment tools: The case studies of ethanol produced from sugarcane, corn, and wheat (Pereira, L.G. et al., 2019; Renewable and Sustainable Energy Reviews (link)

Task 39's commissioned reports and publications can be accessed via the Task 39's website.

Task 39 Newsletters

In addition to the commissioned reports, Task 39 disseminated information through its periodic newsletters. In addition to providing updates on Task projects and meetings, every issue included a feature story highlighting biofuel development in a member country or region of interest. It also provided hyperlinks to recent media stories and reports of interest to the biofuel stakeholder community. These newsletters also detailed the latest developments in industry and government policies pertaining to transport biofuels. During the 2019-2021 triennium, 9 newsletters were developed and distributed to over 2000 recipients. Feature articles highlighted biofuel production, use and policy developments in Brazil, the Netherlands, Denmark, Germany, Sweden, India, Ireland and Norway.

- Issue #51: Feature article, Biofuels production and consumption in Brazil: Status, advances and challenges (Apr 2019)
- Issue #52: Feature article, 'Poldering' a new climate agreement in the Netherlands (Aug 2019)
- Issue #53: Feature article, Biofuels Production and Consumption in Denmark: Status, advances and challenges (Dec 2019)
- Issue #54: Feature article, Biofuels production and consumption in Germany: Status, advances and challenges (May 2020)
- Issue #55: Feature article, Sweden targets world's highest biofuel blending (Oct 2020)
- Issue #56: Feature article, India biofuel economy roadmap - challenges & prospects (Dec 2020)
- Issue #57, Feature article on biofuels-related developments in Ireland (June 2021)
- Issue #58, Feature article on biofuels-related developments in Norway (December 2021)
- IEA Bioenergy Newsletters/Bulletins
  - IEA Bioenergy Summary Series: Comparison of international life cycle assessment (LCA) biofuels models (July 2019)
  - IEA Bioenergy Bulletin: Workshop Summary on joint workshop of Task 39 and the European Commission's Joint Research Centre, Ispra, Italy (Sept 2019)

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., Biofuels Digest, Advanced Biofuels USA and Oils and Fats, etc.

Newsletter readers were also asked to review the most recent updates of the Task's Demonstration plant database.

Non-technical barriers

Although the COVID-19 pandemic restricted in-person meetings, since the beginning of 2020, Task 39 has held regular **virtual** business meetings, partly to make sure all of the projects were making progress despite ongoing work-related challenges caused by the pandemic. Only one project that was planned to be carried out in the 2019-2021 triennium (entitled, "Techno- economic analysis of advanced biofuels (including feedstock/technology pathways)", was not pursued by Task 39, primarily due to the lack of a champion to lead the project and limited budget.

SUCCESS STORY

The primary success of Task 39 during the 2019-2021 triennium was to encourage the decarbonizing of the transportation sector, particularly the long-distance transport sector (Aviation, Marine, Rail, Trucking) via a combination of commissioned reports, seminars, webinars and newsletters. Due to many "issues' such as complex supply chains, fuel specifications, price sensitivity, etc., Task 39 covered many aspects of the biofuel production and use including technology, commercialisation, sustainability, policy, markets and implementation. This work helped better identify the short- and long-term opportunities and challenges related to reducing the cost and carbon footprint of the transport sector. Task members have been invited and engaged in many workshops, seminars and studies such as the preparation of "biofuels for aviation- technology brief". The two sessions organized by Task 39 in the IEA Bioenergy End of Triennium Conference in December 2021 on "Emerging biofuels markets and the importance of LCA and certification" and "The potential of drop-in biofuels to decarbonise aviation" were among the most registered and attended sessions in the conference. This indicated the importance of these topics to the biofuel stakeholders. Active industry involvement, particularly the long-distance transport sector such as aviation/Boeing, helped facilitate the development and deployment of sustainable and low-carbon intensity lower carbon intensity biofuels used to decarbonize the transport sector.

During the 2019-2021 triennium, Task 39 tried to expand Task membership. The addition of India, Norway and Ireland showed the multiple benefits of gaining enthusiastic new members. India is one of the fastest growing economies and the third largest consumer of primary energy in the world (after the US and China). In collaboration with Brazil, the US and Germany, the Task 39 Indian representatives identified potential opportunities across the feedstock-to-biofuel supply chain to reduce capital and operating costs for advanced biofuels production. These four- member countries are at the forefront of the commercialization of advanced biofuels. The membership of Norway in the 2019-2021 triennium provided the opportunity to highlight the use of biomethane for the transportation sector. Norway has 40 operating biogas plants that process municipal, food and industrial organic wastes (and the number is growing). Of these, 10 plants produce biogas for transportation, mainly for buses and trucks. The worlds' largest liquefied biogas plant, Biokraft, is located in Norway and is processing fish farming and paper mill waste. The details of the biogas and biomethane production and use in Norway are provided in the Task 39 Newsletter#58.

Another success of Task 39 was to strengthen collaborations with other IEA Bioenergy Tasks (e.g., InterTask project with Task 40 and Task 45 and joint workshop with Task 44). The Tasl also continued its excellent rapport with other groups such as such as IEA HQ, IRENA, FAO, GBEP, other IEA TCP's (e.g., AMF) and various national and international organizations and programs such as the US DOE, Brazil FAPESP, EC, etc. In addition, Task 39 continued to benefit from extensive industry involvement of companies and institutions at the forefront of biofuels development. These include Boeing, Borregaard, DSM, ENI, GoodFuels, International Air Transport Association (IATA), IFPEN, ISCC, Haldor Topsoe, LanzaTech, LBST, Licella, Neste, Novozymes, Renewable Energy Group (REG), Roundtable on Sustainable Biomaterials (RSB), $(S\&T)^2$ Consultants, skyNRG, Steeper, UPM, World Wildlife Federation, etc.

CONCLUSIONS AND RECOMMENDATIONS

It is hoped that the impressive list of completed reports, seminars, webinars and newsletters indicates that Task 39 has contributed to enhancing transport-biofuel production and use in the member countries and at a global scale. The Task has documented on-going changes in the biofuels technologies and commercialisation, policy and sustainability landscape and supported the development and deployment of advanced and drop-in biofuels. In particular, the Task has highlighted the opportunities and challenges of decarbonize long-distance transport sectors (aviation, shipping, rail and trucking).

Task 39 has also coordinated an InterTask project between Task 39, Task 40 and Task 45 to evaluate the reasons underlying the past and ongoing boom and bust cycles of biofuel technologies development, demonstration, deployment and replication. This project identified the best policy framework conditions and measures for stimulating increased future markets for production and use of sustainable transport biofuels. In addition, the Task identified potential opportunities across the feedstock-to-biofuel supply chain to reduce capital and operating costs for advanced biofuels production. In addition to the member countries, Task 39 evaluated the status and potential for biofuels production in emerging economies, specifically for developing countries with large populations and high energy demand with the primary focus on four countries (Brazil, Argentina, Columbia and Guatemala). Task 39 will continue this project in the 2022-2024 triennium by focusing on two new groups of emerging countries: Group II (South Africa, China, India and Nigeria) and Groups III (Russia, Malaysia and Thailand). This project will elucidate the potential of biofuel production/use in emerging economies to meet the national, regional and international GHG emissions reduction targets of the transport sector.

Measuring the overall sustainability of transport biofuels require ongoing use and improvement of analytical tools such as LCA. Reliable LCA results are needed to facilitate sound policy decisions to help implement and accelerate the commercialization and adoption of conventional and advanced biofuels. During the last triennium, Task 39 focused on developing high-quality regional data for LCA models and making this data available to model developers/users to incorporate into their assessments. In addition, Task 39 continued to evaluate the LCA methodologies and data used to assess the effectiveness of co-processing in reducing the carbon intensity of different fuel fractions produced in the existing oil refineries.

Task 39 also carried out a project to enhance our collective understanding of existing GHG emission reduction and sustainability requirements. We also assessed compliance and verification approaches and the different policy frameworks used in the feedstock-to-biofuel supply chains. This project provided general recommendations for decision-makers (especially governments and certification schemes) on how to improve the robustness of compliance and verification approaches for feedstock-to-biofuel supply chains for the global biofuel market. The Task's sustainability analyses form an important basis of collaboration with other IEA Bioenergy Tasks (Tasks 33, 34, 36, 37, 40, 42, 43, 44 and 45). As oleochemical, lignocellulosic biomass and other processing "wastes" can be used as biogenic feedstocks, their conversion pathways to various biofuels was also assessed.

As part of its multifaceted communication strategy, the Task has a strong track record of effectively disseminating information and maintaining a highly accessed website. The Task publishes three newsletters a year as well as many highly cited reports/papers. The Task has encouraged its members to also publish in the peer reviewed literature and to organize and participate in conferences and workshops, acknowledging their association with IEA Bioenergy. The Task is VERY engaged with stakeholders from industries.

The proposed Task 39 program of work for the next triennium (2022-2024) builds on Task 39's already established strong and active participating network of experts from industry, academia and government research institution. This has been developed and expanded over the last decade. The proposed program of work will continue to span technology, commercialization, sustainability and policy aspects of producing and using low carbon intensity transport biofuels. The active, strong participation of industry will continue to be emphasized.

Technology and commercialization

This component of the POW will address the technical/commercial aspects of producing and using low CI liquid and gaseous biofuels for transport, including conventional and advanced biofuels. Drop-in biofuels and other lower CI biofuels used by the long-distance transport sector will be increasingly emphasised. While assessing technology/commercialisation aspects, the Task will highlight any obstacles that have been encountered or have restricted the expansion of biofuels, while suggesting potential solutions and policy recommendations. The proposed program of work highlights the use of low CI biofuels used in the aviation, marine and truck transport sectors, as well as biogas/biomethane and Bio-SNG (a.k.a. Renewable Natural Gas, RNG). The Task will also assess the potential of electrofuels (or power-to-liquids/gases, PTL/G) particularly the strategic relevance and potential of electrofuels (jointly with Tasks 44 and 45) in the context of emerging availability of low-cost electricity from renewable energy sources.

Co-processing of biogenic feedstocks by oil refineries will continue to be a priority as the oil sector knows it has to decarbonise. Co-processing allows existing infrastructure to be used with minimum capital investment, plus makes use of existing distribution systems. Aspects such as the policies use to "encourage" co-processing plus challenges such as "following the green molecules" will continue to be focus for the Task

Through the proactive engagement of both established and new Task network members (representing government, industry and research communities), the Task will continue to lead and coordinate activities in three main program areas: technology/commercialization, sustainability and policy.

Sustainability

As sustainability and carbon intensity (CI) metrics are playing an ever-increasing role in the policies used to develop and use biofuels, ways in which sustainability/LCA are assessed will continue to be a priority for the Task. For example, there will be an increasing focus on better defining the CI of transport biofuels, particularly those used to decarbonize the hard-to-electrify sectors (long-distance aviation, marine, rail and trucking).

Task 39 members will continue to improve the understanding and confidence in the accuracy of the leading LCA models being used to assess the sustainability of biofuels. This work will leverage the expertise and ongoing sustainability analysis work occurring in many member counties (e.g., EU, US, Brazil, Canada, etc.).

The overall sustainability assessment of a biofuel is extremely impacted/constrained by the source (sustainability) of the biomass feedstock used to produce the biofuel. Over the next triennium, the potential development of certification schemes across the "waste", oleochemical and lignocellulosic supply chains will be evaluated, from feedstock production, through delivery of final products (e.g., biojet and renewable diesel), to end users. This work will impact sustainability certification schemes and help identify the most appropriate metrics for their use. These activities will be coordinated with Task 43 and Task 45 as well as with agencies such as FAO, IEA and IRENA.

The concept of low-Indirect Land Use Change (iLUC)-biofuels will also be investigated as this will be a key parameter in the development of any new photosynthetic plant-based biofuels (in collaboration with Tasks 40, 43 and 45).

Policy

Policies continue to be a key aspect that influence the rate and extent of development, deployment and use of biofuels. Typically, a mixture of market-pull and technology-push policies have been used to

stimulate increased biofuel production and use. Task 39 has played a key role in encouraging the production and use of more sustainable, lower CI transport biofuels. We have done this by publishing key findings such as its periodically updated "Implementation Agendas" compare and contrast report. This type of report summarized the national policies that have been used to promote greater deployment of transport biofuels. The report also evaluated the effectiveness of existing and emerging biofuels policies to stimulate increased production and use of sustainable, lower CI transport biofuels.

This policy comparison-and-evaluation will be extended to include recent and under- development national and regional carbon taxes. It will also assess policies such as the low carbon fuel standard (LCFS), mandates, etc., for difficult-to-decarbonize sectors such as aviation and marine. The short-term and long-term impacts of these policies on the growth of the advanced biofuel industry will be assessed, including the success of policies such as California's and British Columbia'a LCFS, Canada's Clean Fuel Standard Regulations, Brazil's Renovabio initiative, Germany and Sweden's GHG emissions reduction mandates, etc. In addition, the adoption and implementation of these policies in other regions will be compared with regard to their ability to increase biofuels production and achieve significant transport-related GHG emission reductions. As a specific example, the Task will investigate the expected impact of the new ICAO CORSIA agreement on international aviation emissions. These policies will impact future biojet fuel development and deployment as well as IMO's on-going development of LCA methodologies and guidelines for the use of low-carbon fuels in the international marine sector.

We will also continue efforts to expand Task membership. As evidenced by ongoing communications, there is increasing interest from countries such as Indonesia, Malaysia and Mexico to join the IEA Bioenergy TCP and Task 39. We also hope that China will join Task 39 in the coming triennium. In addition, we are trying to re-recruit past members (e.g., Finland, Italy and the UK) and recruit new members such as Estonia, France, Chile, Indonesia, Malaysia, Mexico and Thailand. The Asia-Pacific region economies are growing rapidly, with substantially increased manufacturing and consumption leading to significant increases in freight transport especially for long-distance trucking, cargo shipping and aviation.

Another Task goal for the next triennium is to enhance collaboration with other IEA Bioenergy Tasks. As mentioned before, in the 2019-2021 triennium, Task 39 launched an InterTask project, entitled "Assess successes and lessons learned for conventional/advanced biofuels deployment". The IEA Bioenergy project team includes members of Task 39, Task 40 and Task 45. In addition, Task 39 and Task 44 held a joint workshop on 25 November 2020. The workshop's objectives were to provide an overview of the "flexibility" options, gain any insights into concepts for more flexible biofuel and biopower production, discuss the challenges and success factors needed to implement these concepts in energy systems with high shares of renewables, and explore potential Task 39-Task 44 collaborations related to the future role of biofuels- producing biorefineries in grid balancing.

During the coming/current triennium, Task 39 will continue its good collaborations with other IEA Bioenergy Tasks, i.e., Tasks 33, 34, 36, 37, 40, 42, 43, 44 and 45. Possible collaborations with other Tasks (prospective joint projects) are discussed in the proposed programme of work. Examples of possible collaborations are :

- Task 33: Thermochemical gasification routes to low CI transport fuels, especially the timeline and costs for large scale production and deployment of gasification-based low CI transport fuels
- Task 34: Thermochemical liquefaction routes to "biocrudes" and co-processing of such biocrudes to obtain low CI transport fuels, especially the timeline and costs for large scale production and deployment of biocrudes and their co-processing/upgrading potential
- Task 37: biogas/biomethane production and upgrading to Bio-SNG/RNG and its use in transport
- Tasks 40, 42 and 45: assessing supply chains, coproducts and sustainability
- Tasks 44 and 45: assessing the potential of electrofuels (or power-to-liquids/gases, PTL/G), particularly the strategic relevance and potential of electrofuels

- Tasks 40, 43 and 45: investigating low-iLUC-feedstocks for low CI transport fuels in the development of any new photosynthetic plants-based routes to fuels

ATTACHMENTS

LIST OF PARTICIPATING COUNTRIES AND NATIONAL TEAM LEADERS

Country	Country Representative(s)
Australia	Steve Rogers
Austria	Dina Bacovsky
Brazil	Glaucia Mendes Souza
Canada	Jack Saddler
Denmark	Sune Tjalfe Thomson Michael Persson
European Commission	Nicolae Scarlat Marco Buffi
Germany	Franziska Mueller-Langer Nicolaus Dahmen
Ireland	Stephen Dooley
India	Ravi P. Gupta
Japan	Yuta Shibahara Shiro Saka
The Netherlands	Paul Sinnige Johan van Doesum
New Zealand	Paul Bennett
Norway	Duncan Akporiaye
South Korea	Jin Suk Lee Kyu Young Kang Seonghun Park
Sweden	Tomas Ekbom Leif Jonsson
USA	Jim McMillan

TASK LEADERSHIP AND OPERATING AGENT

- **Task Leader:** Jim McMillan, National Renewable Energy Laboratory, USA
- **Task Co-Leader:** Jack Saddler, University of British Columbia, Canada
- **Operating Agent:** Oshada Mendis, Natural Resources Canada, Canada
- **Associate Operating Agent:**Jim Spaeth (US Department of Energy)
- **Task Coordinator:** Mahmood Ebadian, University of British Columbia, Canada

The Task leadership was shared between the National Renewable Energy Laboratory (USA) represented by Jim McMillan, and the University of British Columbia (Canada) represented by Jack Saddler. Both Task Leaders were engaged in all aspects of the Task's operations.

Task leaders were assisted by Mahmood Ebadian who served as Task coordinator, Editor of the Task Newsletter as well as Webmaster for the Task's website. Dina Bacovsky (Austria) managed the Task's demonstration plant database. Franziska Müller-Langer was the Task's primary liaison to IEA's AMF TCP. Country Representatives (also known as National Team Leaders) for each Task 39 participating country were responsible for coordinating their respective nation's participation in the Task.

STATE-OF-THE ART REPORT

Attached with this document

TECHNOLOGY PROGRESS REPORTS ATTACHED WITH THIS DOCUMENT INCLUDING:

IEA Bioenergy Task 39 Progress Report ExCo84

IEA Bioenergy Task 39 Progress Report ExCo86

IEA Bioenergy Task 39 Progress Report ExCo88

Task 39 Annual Report 2019

Task 39 Annual Report 2020

Task 39 Annual Report 2021

TASK MEETINGS AND PARTICIPATION IN MAJOR EVENTS

Please see the list of Task 39 meetings and participation in major events on page 3

DELIVERABLES

- The deliverables for the Task in 2019 included: 1) organisation of two business meetings and one webinar; 2) two bi-annual progress reports and audited accounts (submitted to ExCo); 3) development and maintenance of the Task 39 website; 4) published three newsletters; 5) two news items prepared for IEA Bioenergy Bulletins; 6) published two peer-reviewed manuscripts.
- The deliverables for the Task in 2020 included: 1) organisation of three business meetings, one joint workshop and two webinars; 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) two news items prepared for IEA Bioenergy Bulletins; 6) published one peer-reviewed manuscript
- The deliverables for the Task in 2021 included: 1) organisation of three business meetings, two joint workshops and one webinar; 2) two bi-annual progress reports and audited financial accounts (submitted to ExCo); 3) further development and maintenance of the Task 39 website; 4) two newsletters; 5) published two commissioned reports 6) published three peer-reviewed manuscripts. It is noted the rest of committed commissioned reports were published in first quarter of 2022

The Task deliverables are posted on Task 39 websites as follows

- 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/
- Task 39 webinars (flyers, slides and recordings): https://task39.ieabioenergy.com/events- conferences/

VARIATIONS FROM ORIGINAL PROPOSAL

As mentioned previously, one project that was planned to be carried out in the 2019-2021 triennium (entitled, "Techno-economic analysis of advanced biofuels (including feedstock/technology pathways)", was not pursued by Task 39. This was result of a lack of champion to lead the project and no budget being available.

CO-ORDINATION WITH OTHER TASKS WITHIN IEA BIOENERGY

During the 2019-2021 triennium, Task 39 coordinated an InterTask project between Task 39, Task 40 and Task 45 to evaluate reasons underlying the past and ongoing boom and bust cycles of biofuel technologies development, demonstration, deployment and replication.

Task 39 contributed sections to two IEA Bioenergy InterTask project reports including "Advanced Biofuels - Potential for Cost Reduction" and "The Role of Renewable Transport Fuels in Decarbonizing Road Transport (IEA Bioenergy InterTask project)".

Task 39 and Task 44 held a joint workshop on 25 November 2020. The workshop's objectives were to provide an overview of the "flexibility" options, gain any insights into concepts for more flexible biofuel and biopower production, discuss the challenges and success factors needed to implement these concepts in energy systems with high shares of renewables, and explore potential Task 39-Task 44 collaborations related to the future role of biofuels-producing biorefineries in grid balancing.

We also continued our good rapport with other groups such as such as IEA HQ, IRENA, FAO, GBEP, other IEA TCP's (e.g., AMF, Hydrogen, etc.) and various national and international programs to assess and help develop and deploy sustainable, lower carbon intensity biofuels technologies, markets, and policies.

Task 39 leadership routinely reviewed and provided feedback on draft IEA reports, most recently on the draft "Bioenergy Review Update".

CO-ORDINATION WITH OTHER BODIES OUTSIDE OF IEA BIOENERGY

Task 39 has benefited extensively from having participants from many global regions. Although IEA Bioenergy tends to be more "Eurocentric" in its participation and priorities, Task 39's more "global perspective" has proven useful in helping better understand and build on specific strengths found on each continent. Consequently, our network members have benefitted immeasurably from applying "lessons learned" from one region to the other. For example, South and North American members have had a strong focus on conventional and advanced ethanol and other liquid biofuels generated through the biochemical conversion (sugar) platform, while European partners have tended to have an established track record on biodiesel as well as a strong focus on thermochemical pathways to liquid fuels, e.g., as demonstrated by companies such as Neste Oil and Preem. Each participating country within Task 39 is now benefitting from R&D investments made by other member countries. This is evident in several of the trans- Atlantic projects being undertaken by Task 39 stakeholder companies such as Boeing, REG, Borregaard, DSM, Novozymes, etc. These projects have incorporated elements of conventional and advanced biofuels as well as biochemical and thermochemical conversion platforms into their overall commercialization strategies.

INDUSTRY PARTICIPATION

Examples of industry and institutional participants include Boeing, Borregaard DSM, ENI, GoodFuels, International Air Transport Association (IATA), IFPEN, ISCC, Haldor Topsoe, LanzaTech, LBST, Licella, Neste, Novozymes, Renewable Energy Group (REG), Roundtable on Sustainable Biomaterials (RSB), (S&T)2 Consultants, skyNRG, Steeper, UPM, World Wildlife Federation, etc.

The Task's structure allows participants to work together in a comprehensive manner on prioritized 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 harmonization of TEA and LCA methodologies for estimating biofuels production economics and emissions reduction and sustainability potentials.

Examples of companies that have participated in Task 39 webinars are Renewable Energy Group, Neste and GoodFuels (biofuel producers and suppliers), Maersk, Seaspan, Canadian National Railway, City of Vancouver (biofuels users) and the Canadian Oilseed Processors Association (feedstock producer).

Project No.	Planned Deliverables (Topic / collaboration)	Project Status
T39-T1	Lessons learned success stories in biofuels (InterTask project with Task 40 and Task 45)	**In Progress**
T39-T2	Biofuels in marine shipping report/Issues affecting utilization of advanced biofuels in the marine sector	**Completed**. The full report can be downloaded here.
T39-T3	Biojet fuel/SAF/decarbonization of the aviation sector	**Completed**. The full report can be downloaded here.
T39-T4	Advanced Biofuels Demonstration Facilities Database	**Updated.** The database can be viewed here.
T39-T5	Feedstock to Biofuels: Opportunities for advanced biofuels- supply chain analysis & reduction in CAPEX/OPEX	**Completed.** The full report is posted on Member Only section of Task 39 website
T39-T6	Recent progress in the production of low carbon intensive drop-in fuels- stand-alone production and coprocessing	**Completed**. The full report is posted on Member Only section of Task 39 website
T39-T7	Techno-economic analysis of advanced biofuels (including feedstock/technology pathways	**Not pursued** due to the lack of champion to lead the project and the budget issue
T39-P1	Biofuel's production and use status in “emerging” economies	**In Progress**
T39-P2	Life Cycle Inventory (LCI) Data for Brazilian Sugarcane Production	**Completed.** The full report is posted on Member Only section of Task 39 website
T39-P3	Implementation Agendas: Compare-and-Contrast Transport Biofuels Policies (2019-2021 Update)	**Completed.** The full report can be downloaded here.
T39-P4	Improvement opportunities for low-carbon, sustainable biofuel policies and certification schemes, Part 1: A review of policy frameworks	**In Progress**
--	Task 39 Newsletter	**Completed.** A total of 8 task newsletters were developed and published to the Task’s website and distributed to over 2000 newsletter subscriber recipients. Each issue included a feature article highlighting commercial, technical and policy developments related to biofuels production and use in a specific country, most often but not always a Task member country. In the 2019-2021 triennium, these country feature articles were on Brazil, The Netherlands, Denmark, Germany, Sweden, India, Ireland, and Norway. These newsletters are available at: http://task39.ieabioenergy.com/newsletters/
--	IEA Annual Report (Task progress)	Six Bi-annual progress reports and audited financial accounts were submitted to the ExCo.

IEA Bioenergy

Technology Collaboration Programme

Further Information

IEA Bioenergy Website
www.ieabioenergy.com

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