IEA Bioenergy
Technology Collaboration Programme

Task 34
Direct Thermochemical Liquefaction

Final Task Report
Triennium 2019-2021

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INTRODUCTION

Task 34 aims at advancing multiple applications of liquefied biomass including heat, power, transportation fuel and the production of chemicals, focussing on market implementation. The scope of Task 34 are direct thermochemical liquefaction (DTL) technologies. These include thermal and catalytic fast pyrolysis, hydrothermal and solvo-thermal liquefaction, as well as feedstock pre-treatment, bio-oil/biocrude upgrading and co-processing in petroleum refineries. DTL technologies have great potential to contribute to the expanded use of bioenergy as they convert solid, bulky biomass into energy-dense liquid intermediates. These liquids are easier and cheaper to transport, as well as easier to manipulate for both subsequent processing and end use.

In the last few years, multiple fast pyrolysis plants have been in operation, producing commercial quantities of fast pyrolysis bio-oil in Northern America and Northern Europe to be used as heating oil. Hydrothermal liquefaction is less mature than fast pyrolysis and in its development stage, but commercial projects have been announced at the start of the triennium. Advanced applications of the bio-oils/biocrudes to produce transportations fuels and bio-chemicals are under development and include co-processing in refineries, gasification, or hydrogen upgrading.

The objective of Task 34 is to advance the international implementation of bioenergy technology in the areas of direct thermochemical liquefaction of biomass for bioenergy and material applications. This includes strategic analysis and thought leadership in order to identify technical and non- technical barriers to biomass DTL technologies implementation. The gained knowledge is leveraged to lead international and inter-technology collaborations to highlight the need for academic and industrial solutions to these barriers, and encourage more rapid and wider spread implementation of the technologies.

BACKGROUND

DTL technologies have different levels of technical maturity with examples ranging from TRL 7-9 under operation worldwide[1]. At the beginning of this reporting period, multiple fast pyrolysis plants have been in operation (and continue to operate today), producing commercial quantities of bio-oil to be used as fuel in boilers. These include several Ensyn plants (US/CA), Empyro (NL), and Fortum's integrated plant in Joensuu (FI) providing bio-oil for applications such as hospital heating, combined heat and power, or industrial heat[2]. ASTM and EN quality standards for the use of fast pyrolysis bio- oil in these applications have been developed with the active involvement of Task 34 members[3]. A steep increase in production capacity was observed during this triennium, with additional units being or having been erected primarily in Northern Europe. Hydrothermal liquefaction is less mature than fast pyrolysis and in its demonstration stage; commercial projects have been announced by Steeper Energy (CA/DK) and Canfor/Licella (CA/AU). However, there is still comparably less knowledge about these installations.

Advanced applications of the bio-oils/biocrudes to produce transportations fuels and bio- chemicals are under development and include co-processing in refineries, gasification, or hydrogen upgrading. Notably, there are strong developments towards co-processing of DTL oils, with the first commercial scale demonstration taking place in Sweden for fast pyrolysis bio-oil[4]. Such applications encounter the technical barrier that DTL oils represent a new organic matrix with decisive differences to fossil crude oils and a lot of unknowns regarding a widespread use[5]. Similar to the development of quality standards for heating applications, Task 34 accompanies new applications through collection and dissemination of state-of-the-art data/ methods[6] and supports their implementation through guiding standardization with Round Robins[7].

Despite the above-mentioned successful commercial activities, it is observed that DTL technologies are often prone to misconception as to their maturity, (commercial) availability and applicability of DTL oils – sometimes even within IEA Bioenergy. Task 34 addresses this non- technical barrier with intensive dissemination activities (e.g. maintaining a website with good traffic, bi-annual PyNe newsletter). Those activities have been further extended to dedicated reports that provide a state-of-the-art information and participation in an IEA Bioenergy Inter- Task project to increase awareness and visibility of DTL technology – within and outside IEA Bioenergy.

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[1] DTL Commercialization overview
https://task34.ieabioenergy.com/dtl-commercialization-report/

[2] Case study on the use of fast pyrolysis bio-oil in industrial boilers
https://itp-hightemperatureheat.ieabioenergy.com/publications/industrial-heat-case-study-3-process-steam-in-a- dairy-factory-via-fast-pyrolysis-bio-oil/

[3] Task 34 Round Robin archive
https://task34.ieabioenergy.com/round-robin-archive-2/

[4] DTL success story: Pyrocell and Preem refinery
https://task34.ieabioenergy.com/success-story-2021/

[5] Direct liquefaction brochure to explain the technology https://task34.ieabioenergy.com/dtl-brochure/

[6] Validation of methods to determine polar and non-polar components in FP Bio-Oil
https://task34.ieabioenergy.com/polar-and-non-polar-components-in-fpbo-in-relation-to-reach-registration/

[7] Article on IEA Task 34 Round Robin https://pubs.acs.org/doi/10.1021/acs.energyfuels.0c02090

REPORT ON THE TASK'S OBJECTIVES

Support of advanced DTL oil applications

At the start of this reporting period, fast pyrolysis bio-oil was solely used as heating oil and boiler fuel. This was and still is a very important step for market introduction of DTL technology in general, and specifically for fast pyrolysis. It allows commercial operation of fast pyrolysis units to date and consequently supports the demonstration of the technology. Moreover, important operational experience in an industrial environment is gathered.

Heating oil is an important commodity, but not of very high value. There are several other potential applications of DTL oils in general and an overview of the different possibilities is shown in Figure 1. From this overview it becomes obvious that current application is at the lower end of the potential added value from fast pyrolysis oil. Also from this triennium it was observed that the development of standards for DTL applications is still a bottleneck that requires supportive action. Method development to quantify relevant parameters for co-processing of fast pyrolysis oils in existing refineries was realized within R&D projects but results are still being disclosed. It follows that there is the need of a public body that helps bridging a gap between method development and creation of standards/ norms by the (multi)national bodies (i.e. ISO, ASTM, EN etc). In the past, IEA Bioenergy Task 34 has served to successfully bridge this gap for the development of standards for the application of fast pyrolysis bio-oil. This work has continued, and Task 34 disseminated a recently developed method that is capable of quantifying specific target compounds that require reporting for REACH registration of fast pyrolysis bio-oil. Moreover, a Round Robin on analysis of heteroatoms (N, S, Cl) was evaluated and published. The results underline that even though standards and norms exist, application to the matrix of DTL oils is far from being straightforward.

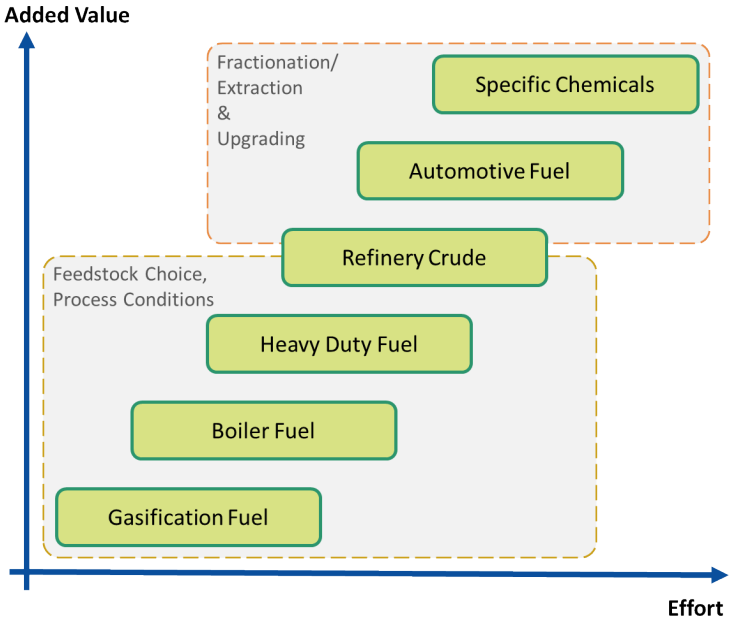

Figure 1 : Potential DTL oil applications and associated added value/ effort[8]

[8] Direct Thermochemical Liquefaction : Characteristics, processes and technologies
https://task34.ieabioenergy.com/dtl-brochure/

Task 34 has reacted on this findings in several ways. First, a website section was created that features an archive of previous Round Robins that were conducted by Task 34 and its predecessors (PyNe network) to provide a central platform that summarizes this information and also to increase awareness of the importance and difficulties associated with this development. Second, it was decided to continue organizing a Round Robin as part of Task 34 work. The focus will stay on heteroatoms (N, S, Cl) since data was not as reproducible as required for international standards and limits (e.g. for fuels to avoid emissions). Finally, it was decided to pro-actively follow up on the standardization of fast pyrolysis bio-oil co-processing and act as a hub to gather and disseminate data to foster transparent development in this field. Current projects show the high interest and relevance of co-processing fast pyrolysis bio-oil in existing refineries and one demonstration project at TRL 7 was published by Task 34 as success story to showcase this dynamic development[9].

Another conclusion from these activities was to focus on supporting application development in the subsequent triennium 2022-2024 by establishing a dedicated work package on 'Development of marketable commodities from DTL'. This work package includes surveys for production of transportation fuels and chemicals/ materials *via* DTL. Task 34 also anticipates that with increasing marketing of added value products, some of which are highly specialized, the possibility of a DTL based biorefinery emerges. Alike existing petroleum based refineries, these produce a variety of fractions for different applications. Consequently, less valuable residual fractions might emerge that hold relevance e.g. for gasification purposes (see Figure 1). Such uses will be prepared by scoping relevant quality parameters together with IEA Bioenergy Task 33.

Dissemination activities to counteract misconceptions regarding DTL technology

It has been proven since several years that fast pyrolysis bio-oil is a tradeable commodity and represents an end product as heating oil. This fact has been prominently placed as case study – the Task 34 contribution to the Inter-task project on 'High Temperature Heat for Industry'. This case study highlights commercial maturity, economic feasibility and greenhouse gas mitigation potential of fast pyrolysis bio-oil with detailed figures. With this highly visible contribution it is shown impressively that DTL oil indeed is a product and not an unstable intermediate that requires further upgrading before it can experience any use (a misconception experienced especially within IEA Bioenergy interaction/ reports). As detailed above, it is indeed possible to further process DTL oils to achieve applications with added value (see Figure 1). However, that is not required for state-of-the-art application as heating oil, which dominates nowadays use.

The Task 34 website already represents a valuable source of fact based information around DTL technology and products. Traffic is constantly up and even evolving. A major review of the content related pages was conducted during this reporting period to make sure all information is reflecting the dynamic development in this field. To further support a discussion based on up-to- date knowledge, an explanatory DTL brochure was created. It was written so that the technology involved, materials produced and terminology used is made available to a broader public. While this collected data is now available, it would surely be desirable to transform it so that it can be disseminated even further towards different target groups. This is something that is not expertise of Task 34 country representatives, but it could be subject to more general IEA Bioenergy dissemination efforts.

In addition to this more generic data around DTL, dedicated reports have been created to focus on the

[9] Success story: Pyrocell and Preem refinery https://task34.ieabioenergy.com/success-story-2021/

status of DTL commercialization[10] and relevant activities/developments in each of the Task 34 member countries[11]. More in-depth information is collected and disseminated via the bi- annual PyNe newsletter. Articles covered example areas of

- Production of transportation fuels via DTL (five)
- Production of chemicals materials from DTL products (four)
- Co-processing of DTL products in existing refineries (two)
- FPBO as heating oil (three)
- FPBO as fuel in gas turbines (one)
- Overview of DTL activities (eight)

In total, 34 articles were published in the PyNe newsletters this triennium.

Accessibility of PyNe contributions in general has been significantly increased by creating an online, searchable PyNe article database that includes all published PyNe articles starting from the first PyNe issue[12].

[10] DTL Commercialization overview https://task34.ieabioenergy.com/dtl-commercialization-report/

[11] DTL country reports https://task34.ieabioenergy.com/country-reports/

[12] PyNe article database https://task34.ieabioenergy.com/pyne-archive-1996-2020/

SUCCESS STORY

With the change from the previous triennium to the one of this reporting period 2019-2021, only one country representative continued work in Task 34. This represented a tremendous threat to both expertise and team effort lost. The previous decades of Task 34 and its predecessor PyNe were significantly linked to a well-known team of researchers in this field that were also very active in advancing fast pyrolysis technology. The start of this reporting period also sadly marked an end to this legacy being active for IEA Bioenergy.

Naturally, that also created the opportunity for changes in the way Task 34 is being conceived. The structure of work programme management was changed to allow for well-defined and transparent work package conduction. The inevitable loss of the strong network of experienced researchers was replaced by a rigorous structure that allowed Task 34 country representatives to create their individual contributions while getting to know each other and the way IEA Bioenergy is working.

While this process was surely not promoted by the impacts of the CoVid-19 pandemic, a remarkable rise in publications by IEA Task 34 was achieved nevertheless. This is indeed a true success story since it directly impacts visibility of Task 34 in the field of DTL. This is a decisive achievement to avoid 'being forgotten' after such critical changes. Moreover, new members become more knowledgeable in the field of DTL. This surely does not replace the legacy of previous PyNe contributors, but it is a decisive step to continue and build up expertise to maintain credibility for Task 34.

In previous triennia, around one-two articles/ reports were published by IEA Task 34. Between 2019-2021 six reports were published and one article finalized from last triennium. Additionally, interaction with other IEA Bioenergy tasks increased significantly (Tasks 39, 44, ITP), country reports were continued more regularly, new website sections created (e.g. Round Robin archive, PyNe article database) and publication of the PyNe newsletter continued – even an additional jubilee newsletter was set up.

Two measures certainly added to this success: a) assigning budget to each work package (which was not done previously in Task 34) and b) introducing work package descriptions to better identify aim and scope of each individual activity. This allowed every country representative to better identify with and consequently dedicate to their contribution. Simultaneously, most work packages defined in addition to the original work programme represented a scope that was adjusted to the individual work package lead capabilities. These measures are also included in the work programme for the upcoming triennium 2022-2024. Moreover, the increased interaction with other tasks continues its trend in the subsequent triennium 2022-2024 represented by planned activities with Task 33, 39, 42, 44, and both anticipated ITP's (H2 and BECCUS). Additional collaborations are being developed continuously.

CONCLUSIONS AND RECOMMENDATIONS

While it became clear that the current development for commercial fast pyrolysis installations is highly dynamic, it is also obvious that the vast majority of these installations market the resulting product as heating oil. At the same time, there is also dynamic development to enable added value use of DTL oils. These observations were already translated into the proposal for the subsequent triennium in that 'Development of marketable commodities from DTL' has been introduced as specific work package. Additionally, support by investigating feasibility of analytical methods to quantify quality parameters of the difficult DTL oil matrix will continue.

Much of the work conducted in Task 34 is related to dissemination of relevant, credible data in conjunction with DTL technology and products. However, Task 34 participants are technical experts and dissemination is confined to classical channels in that field (i.e. website, reports, scientific articles, newsletters). Active dissemination channels only address the DTL field of experts (newsletter, social media) and the passive channels (website, uploaded reports) are broadly available but lack a broad active dissemination. Task 34 is aware that this is discussed as part of the IEA Bioenergy communication group; these observations are added to the conclusions to support the relevance of expert communication of the results generated by IEA Bioenergy, including that of the individual Tasks.

ATTACHMENTS

LIST OF PARTICIPATING COUNTRIES AND NATIONAL TEAM LEADERS

- Benjamin Bronson (Canmet Energy) (Canada)
- Lasse Rosendahl (Aalborg University) (Denmark)
- Christian Lindfors (VTT) (Finland)
- Axel Funke (KIT) (Germany)
- Pramod Kumar (HPCL) (participation in 2021) (India)
- Bert van de Beld (BTG) (The Netherlands)
- Paul Bennet/ Kirk Torr (Scion) (New Zealand)
- Kai Toven (RISE) (Norway)
- Linda Sandström (RISE) (Sweden)
- Justin Billing/ Michael Thorson (PNNL) (USA)

TASK LEADERSHIP AND OPERATING AGENT

Task Leadership:
Axel Funke (KIT)
Alexandra Böhm (KIT)

Operating Agent:
Birger Kerckow (FNR)

TASK MEETINGS AND PARTICIPATION IN MAJOR EVENTS

Task meetings were primarily held through videoconferences due to the CoVid-19 pandemic.

2021	December	Videoconference
2021	November	Videoconference
2021	October	Videoconference
2021	May	Videoconference
2020	December	Videoconference
2020	May	Videoconference
2019	October	Aalborg/ Denmark
2019	June	Karlsruhe/ Germany

The full list is available at https://task34.ieabioenergy.com/meetings/

Task 34 participated in the end of triennium conference through a presentation by BTG.

DELIVERABLES

All deliverables are made available on the IEA Bioenergy Task 34 website (https://task34.ieabioenergy.com/) and most publications are additionally disseminated via social media – both as part of IEA Bioenergy and Task 34 management related accounts. One deliverable was published as article in a scientific journal.

- D1.2 Contribution to Task 39 report on marine biofuels
  https://task39.sites.olt.ubc.ca/files/2021/07/Progress-towards-biofuels-for-marine- shippingT39-report_June-2021_Final.pdf

- D 4.1a-f Publication of the PyNe newsletter: The newsletter is published bi-annually, i.e. six issues in this triennium. Additionally, a seventh jubilee issue was prepared marking the 50th issue in the 25th year of its publication (DAdd4.1).
  - https://task34.ieabioenergy.com/wp-content/uploads/sites/3/2019/07/PyNe44_final.pdf
  - https://task34.ieabioenergy.com/wp-content/uploads/sites/3/2019/12/PyNe-45_final.pdf
  - https://task34.ieabioenergy.com/wp-content/uploads/sites/3/2020/08/PyNe-46_V3.pdf
  - https://task34.ieabioenergy.com/wp-content/uploads/sites/3/2021/01/PyNe-47.pdf
  - https://task34.ieabioenergy.com/wp-content/uploads/sites/3/2021/07/PyNe48-kompl.pdf
  - https://task34.ieabioenergy.com/wp-content/uploads/sites/3/2021/12/PyNe-49-komplett_V2.pdf
  - https://task34.ieabioenergy.com/wp-content/uploads/sites/3/2021/12/PyNe50_V2.pdf

- D4.2 Direct liquefaction brochure to explain the technology to a broader public
  https://task34.ieabioenergy.com/dtl-brochure/

- D4.3 Website content refresh: The new branding of IEA Bioenergy developed during this triennium was applied to full extent to the website (and also to other publications). Additionally, content related pages that explain DTL technology and its products have been revised and updates implemented. These pages form the main body of the Task34 website and experience significant traffic.
  https://task34.ieabioenergy.com/

- D4.4a/b Two workshops in conjunction with the two face-to-face Task 34 meetings that were realized in 2019 in Karlsruhe/ Germany and Aalborg/ Denmark. The other planned workshops were cancelled due to the CoVid-19 pandemic.

- D4.5 DTL success story
  https://task34.ieabioenergy.com/success-story-2021/

- D4.6a-c Three country reports featuring political background, DTL stakeholders, ongoing commercial activities and major R&D projects.
  - https://task34.ieabioenergy.com/wp-content/uploads/sites/3/2020/04/2019_IEA-Bioenergy-Task-34_Country_Reports.pdf
  - https://task34.ieabioenergy.com/wp-content/uploads/sites/3/2021/06/2020_IEA-Bioenergy-Task-34_Country_Report_v1.pdf

  - https://task34.ieabioenergy.com/wp-content/uploads/sites/3/2021/12/2021_IEA-Bioenergy-Task-34_Country_Report_v2.pdf

- DAdd2.1 Validation of methods to determine polar and non-polar components in FP Bio-Oil https://task34.ieabioenergy.com/polar-and-non-polar-components-in-fpbo-in-relation-to- reach-registration/

- DAdd3.1 Assessment of hazards for DTL oils (finalized but publication pending)

- DAdd3.3 Commercialization overview https://task34.ieabioenergy.com/dtl-commercialization-report/

- DAdd3.4 Electrochemistry & Fast Pyrolysis Bio-Oil (finalized but publication pending)

- DAdd4.2 Task 34 Round Robin database that covers their chronology and results https://task34.ieabioenergy.com/round-robin-archive-2/

- DAdd4.3 PyNe article database to enable a search functionality for all PyNe issues https://task34.ieabioenergy.com/pyne-archive-1996-2020/

- D-ITP1: Case study on the use of FPBO in industrial boilers https://itp-hightemperatureheat.ieabioenergy.com/publications/industrial-heat-case-study-3-process-steam-in-a-dairy-factory-via-fast-pyrolysis-bio-oil/

- D-ITP2: Contribution to Task 44 workshop on bioenergy flexibility (unpublished)

- Report on Round Robin (delayed from previous triennium) https://pubs.acs.org/doi/10.1021/acs.energyfuels.0c02090

VARIATIONS FROM ORIGINAL PROPOSAL

There have been two primary reasons that led to significant deviations in deliverables and deadlines (full list of deviations is given below).

- Task 34 experienced an almost completely new person configuration – only one country representative from the previous triennium continued in this triennium. Consequently, the work programme for this triennium was developed by people with interests and expertise strongly deviating from the country representatives that needed to conduct the work. It is striking that almost all of the originally planned work packages experienced major trouble (except dissemination activities D4.x like website, country reports and newsletters). In contrast to this, all additional work packages that were developed by the current Task 34 country representatives were finalized (all except of one).

- Many task leads did not contribute the time resources required to conduct the work packages. For two work packages, alternative work package leads could be found to counteract the lack of dedication.

These reasons also led to significant underspending of the anticipated budget. In addition to that, travel and workshop budget was unspent due to the CoVid-19 pandemic and some work package leads didn't even request the budget associated with their work package. Total unspent budget amounts to $65k, with the following shares:

D2.1, D2.2 cancelled and some budget unspent	$15,000
D3.1, D3.2 postponed to mid 2022	$20,000
Unspent travel budget due to CoVid-19 pandemic	$30,000

Deviations in originally planned deliverables

- D1.1 Review of techno-economic assessments of DTL technologies

  This review has been conducted by a subcontractor renowned in this field and an overview of results from DTL TEA studies available in literature has been generated. It includes a synopsis of data from primarily North American and European based studies. From this review obvious issues have emerged that require to be addressed to conclude what reliable information can really be extracted and how meaningful results are for other stakeholders e.g. from industry. Task 34 country representatives have agreed that such conclusions will be a) best assessed among a group of technology experts, i.e. Task 34 b) this process will require more time to be of high quality and c) that expertise from Task 42 will be requested (as originally intended). The data has not been published, yet and will be finalized in the upcoming triennium.

- D1.2 Contribution to Task 39 report on co processing bio-oil/biocrudes in petroleum refineries
  The report from Task 39 on co-processing bio-oil/ biocrudes was finalized without involvement of Task 34 before even work in this triennium has started. Instead, it was decided to provide input for the upcoming Task 39 report on marine biofuels. This contribution has been finalized as noted in the deliverables section above.

- D2.1 Report on Round Robin
  Conduction of this work package was strongly delayed due to non-availability of the work package lead to manage the work. The lead was changed after the first year of this triennium to respond to this non-availability. However, it turned out that the very same problem also manifested with the new work package lead. Additional resources to finally get the work going could only be raised towards the end of this triennium. After the first steps of defining analytical parameters, sample

preparation, and contacting participating laboratories it became clear that a) there were not enough laboratories available to provide the required amount of datasets for a high quality study and b) available biocrude samples were too low in quantity to realize the planned analyses. After this fundamental issues appeared early 2022 it was decided that this work package was cancelled to allow focussing on a well balanced study in the upcoming triennium that considers these issues.

- D2.2 Advanced analytical techniques workshop/webinar
  This work package was cancelled early 2021 due to the ongoing pandemic and the low profile of Task 34 country representatives in the analytical field.

- D4.4c-e Workshops were cancelled due to CoVid-19 pandemic

- DAdd3.2 Materials Compatibility Workshop
  This workshop was followed up as potential webinar. After contacting potential participants the impression came up that interest was rather low. It was decided to cancel this workshop and find out more about the reasons for this low interest. It is known by the Task 34 country representatives that material issues do exits but it is unknown to which extent stakeholders have solved these issues and/ or are unwilling to convey their experience to a specialized audience.

Major deviations in deadlines (more than 3 months)

- D1.1 Finalization of the review was achieved Q3/2021 (planned Q4/2020)

- D3.1 Report on standardisation of bio-oil/biocrude analysis and application
  Not finalized due to the fact that important data is not disclosed and cannot be used for this report. Delay until Q4/2022 anticipated (planned Q4/2021).

- D3.2 Technical notes on R&D and commercialization experiences
  This work package was not even started due to unavailability of the work package lead. The lead was changed towards the end of triennium and finalization will be delayed until Q4/2022 (planned Q4/2020)

- D4.3 Website content refresh
  Content related review was achieved as scheduled, at least for the major parts. Implementation of the reviewed content was delayed due to a) the change in IEA Bioenergy corporate layout that was required in between and b) priorization of other tasks, e.g. conclusion of the triennium. It was finalized Q2 2022 (planned Q4/2020)

- Dadd3.1 Assessment of hazards for DTL oils
  Delay due to low availability of the work package lead. Finalized Q1/2022 (planned Q4/2020)

The overheads at Karlsruhe Institute of technology are around 100 % of the personal costs.

CO-ORDINATION WITH OTHER TASKS WITHIN IEA BIOENERGY AND BODIES OUTSIDE IEA BIOENERGY

- Contribution to the 'marine fuels' report from Task 39
    - Task 34 will continue to provide technical input in future, e.g. by an update on pathways to transportation fuels from DTL in the following triennium.
- Contribution to the ITP on 'High temperature heat for industry', both to the final report and by writing the case study around the use of FPBO for steam production in a dairy manufactory. This ITP has been concluded.
- Co-ordination with Task 44 to provide technical input for flexible use of DTL oils; participation/ presentation in a joint workshop
    - This collaboration is being followed up in the upcoming triennium as dedicated work package due to the high relevance for both Task 34 and 44

There was no co-ordination with bodies outside IEA Bioenergy in this triennium. This will be followed up once relevant bodies emerge.

INDUSTRY PARTICIPATION

The country representative of The Netherlands is from a company active in the field of DTL (BTG, a fast pyrolysis technology provider). Consequently, BTG was actively involved in the Tasks work programme, primarily in co-ordinating work with the ITP on 'High temperature heat for industry' and Task 44. Important input from the dynamics of commercial DTL technology uptake were provided and detailed information of current projects. To avoid a biased view on the field, core deliverables around commercialization were conducted by other partners, such as e.g. the DTL commercialization report and the DTL success story.

Other industrial partners are indirectly involved through co-operations with Task 34 country representatives (e.g. Valmet, a fast pyrolysis technology provider and Steeper Energy, a hydrothermal liquefaction technology provider). Direct contact was established in workshops.

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Technology Collaboration Programme

Further Information

IEA Bioenergy Website
www.ieabioenergy.com

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