



IEA Bioenergy
Technology Collaboration Programme

Task 33

Gasification of Biomass and Waste

Final Task Report
Triennium 2019-2021





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Technology Collaboration Programme

Gasification of Biomass and Waste

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INTRODUCTION

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Task Secretary:	Jitka Hrbek (Austria)
National Team Leaders:	Jitka Hrbek (Austria) Donatella Barisano (Italy) Thomas Kolb (Germany) Patricia Thornley (United Kingdom) Robert Baldwin (USA) Joakim Lundgren (Sweden) Mohan Rao (India) member since 2021 Berend Vreugdenhil (Netherlands)

This task focusses on gasification of biomass and waste as key technology for the energy transition. Deployment or implementation of gasification technology is successful in the CHP application market, and has a large potential for the production of SNG, fuels, chemicals or hydrogen. However in these applications the deployment is lagging behind. Seen the challenges we face (security of supply put on the radar by the war on the Ukraine) this is high on the agenda of the task. Therefore in the past triennium the focus has been on highlighting as much as possible the possible uses of gasification and through the Task meetings a platform has been given to discuss R&D and Technology developments of the participating countries. Furthermore through organizing webinars and workshops additional dissemination has been made possible.

The scope of work for the current triennium is built upon the progress made in the previous triennia. In the previous years, information exchange, investigation of selected subtask studies, promotion of coordinated RD&D among participating countries, selected plant visits, and industrial involvement in technical workshops at Task meetings have been very effective. These remain the basic foundations for developing and implementing a programme of work that addresses the needs of the participating countries. Although Corona has put a brake on these activities

The task monitors the current status of the critical unit operations and unit processes that constitute biomass and waste gasification process, and identifies hurdles to advance further development, operational reliability, and reducing the capital cost of gasification systems. The task meetings provide a forum to discuss the technological advances and issues critical to scale-up, system integration, and commercial implementation of gasification processes.

The task has continued the practice of inviting industrial experts to the Task workshops (although limited in this triennium) to present their practical experiences and to discuss the options for development of critical process components to advance state-of-the-art gasification systems. The interaction with industry provides the opportunity for the National Team Leaders (NTLs) to evaluate refinements to existing product lines and/or processes. Academic experts are also invited and when the need arises to seek information and cooperation in order to address and support basic research needs.

In this triennium a lot of thought was also put in the continuation for the next triennium, observing the global shift making the transition away from fossil fuels and in many countries seeing gasification technology surfacing as a key in this transition.

BACKGROUND

Task meetings, workshops and webinars during triennium

Event (What/Where)	When	Status/Result
Task meeting in Karlsruhe	June 2019	Country report available Minutes draft ready http://task33.ieabioenergy.com
Workshop Karlsruhe on Gas cleaning, experiences, new developments, analytics and diagnostics	June 2019	Workshop report Workshop presentations http://task33.ieabioenergy.com/content/workshop_events
Task meeting in Birmingham	November 2019	Country report available Minutes available for members http://task33.ieabioenergy.com
Workshop Birmingham on Waste Gasification	November 2019	Workshop report Workshop presentations http://task33.ieabioenergy.com/content/workshop_events
Webinar on Gasification (past, present and future)	January 2020	https://www.ieabioenergy.com/blog/ieaevent/iea-bioenergy-webinar-the-past-present-and-future-for-biomass-gasification/
Online task meeting	June 2020	Country report available Minutes draft version available http://task33.ieabioenergy.com
Workshop was cancelled due to COVID	June 2020	
Online task meeting in November 2020	18-19 November 2020	Country report available Minutes available for members http://task33.ieabioenergy.com
Workshop		Cancelled due to Covid
Webinar: Gasification: A crucial technology for the energy transition. A global perspective	24 February 2021	Available at http://task33.ieabioenergy.com
Online task meeting in June 2021	2-3 June 2021	Country report available Minutes available for members http://task33.ieabioenergy.com
Workshop June 2021		Cancelled due to Covid
Hybrid meeting Trisaia December 2021	1-3 December 2021	Country report available Minutes available for members http://task33.ieabioenergy.com
Workshop Trisaia on Gasification - a key technology in the energy transition and for the circular economy	2 December 2021	Workshop report available Workshop presentations available http://task33.ieabioenergy.com/content/workshop_events

Barriers for gasification implementation

Deployment of gasification as CHP application is successful. However, there are a few barriers why the implementation of gasification technology is more difficult in the other sectors (Green Gas, Fuels, Hydrogen, Chemicals). First of all the investment costs significantly increase going from a CHP application to a catalysis application. The technology and its implementation is more complex (additional, sometimes new gas cleaning needed) and the track record for these applications is much smaller. How the

integration of gasification can be performed was studied in this triennium and the report on the integration of gasification into existing industries, provides insights what the benefits are of using gasification technology in existing industries. This report shows the potential and will generate more understanding of this added value.

http://www.ieatask33.org/app/webroot/files/file/publications/special%20projects/2021/Biorefinery/Gasification_integration_final.pdf

REPORT ON THE TASK'S OBJECTIVES

At the start of the triennium the following objectives have been defined:

- 1) *to provide a non-biased information source for policy makers, the public and professionals to understand the potential, state of technology and challenges associated with commercialization of biomass and waste gasification*

The task has organized webinars, workshops and provided country reports on the deployment of gasification technology in our member countries. In this work we provide support in assessing gasification technologies through our report on “*Emerging Gasification Technologies for Waste & Biomass*” and insights on how gasification can be implemented into existing markets. This can be read in the report: “[Gasification applications in existing infrastructures for production of sustainable value-added products](#)”. The task has also delivered a [status report](#) on gasification at the end of the triennium, which focused this time on R&D and included contributions from Spain and France.

In particular the methodology developed in the [Emerging Gasification Technologies](#) report is broader applicable to other technologies as well and allows you to evaluate a new technology with limited information. A new technology is split into different segments for which an assessment can be made.

This comprises the following steps:

1. Feedstock handling system
2. Gasification reactor with heat supply
3. Product gas separation and cleaning
4. Integrated operation

Each of these steps is evaluated separately to assess the TRL and given a weight factor. The sum of these individual components then gives an overall weighted average, which gives an insight into the status of the new technology line-up. In the report several examples have been developed, giving an idea on how to approach this, also for people with less experience in the field.

- 2) *to promote commercialization of biomass and waste gasification technologies to produce fuel gases and synthesis gases that can be subsequently converted to substitutes for fossil fuel-based energy products and chemicals, and lay the foundation for secure and sustainable energy supply*

The Task meetings have been good opportunities for technology suppliers to give updates to a broader public via the Task meeting reports. The country updates are a source of information people find a great value. The report on the implementation of gasification in existing industrial settings also gives a good understanding of the value of this technology. (See next chapter)

The task had set out to organize workshops, which is a typical platform also for technology providers to share their content. Due to COVID-19 we have had not had many of these opportunities, with only three occasions during the triennium. The first two took place in 2019 in Birmingham and focussed on waste gasification and the second in Karlsruhe and focussed on Gas cleaning, at the end of 2021 (a hybrid meeting) which took place in Trisaia focussed on the whole spectrum of gasification applications. All the workshops were well attended (mostly online though) and had a good industrial participation.

- 3) *to assist IEA Bioenergy Executive Committee activities in developing sustainable bioenergy strategies and policy recommendations by providing technical, economic, and sustainability information for biomass gasification systems*

These activities have been supported as much as possible by providing unbiased, up to date and clear technical and economical information on the various gasification technologies. Through the network of Task33 NTL members we have established good contact with many of technology providers and typically their willingness to share information with us is high.

What has been observed in the past three years is the increasing attention towards gasification as a key technology in the energy transition as well as providing energy/fuels with low to negative carbon

footprint. Even the production of hydrogen produced through gasification technology is starting to be recognized by a broader audience. This is seen also been taken up by IEA Hydrogen TCP with a subsequent collaboration for the current triennium to support each others activities in this field.

Task33 has provided a platform for technology developers from member countries through a. the biannual meetings where updates were given about the status of the different developers. Throughout the years you can see companies making decisions based on a unique set of boundary conditions, which forces some to focus on the core business and other technology developers to diversify into other market segments. Segments which are not 100% related to bioenergy, but where the gasification technology also plays a significant role.

What we can conclude from this is the following

- Gasification technology in itself is shifting more and more from just being applied to produce heat and power, towards high end applications such as fuels, chemicals and hydrogen.
- There is an increasing trend to use gasification technology for the processing of waste (plastic and biomass containing) into fuels and/or chemicals. An important question for IEA Bioenergy is, if we think that the plastic fraction of waste should end up in fuels or should end up in new plastics. This is a sensitive topic, because policy that will be developed can either make or brake certain technology platforms
- IEA Bioenergy TCP has certain tasks related to technology (T32, T33 and T34), especially in Task33 more overlap is seen with plastics processing even in mixed streams where the biogenic content is as low as 30%. These developments based on biomass, waste (RDF/MSW) or plastic waste (low biogenic content) go hand in hand. We should not focus on the plastic end applications, but we should also not discard them because it is not considered “bio”. For Task33 the developments in the waste (rich in plastics) sector is quite relevant to the gasification community in general.

- 4) *to conduct subtask studies to review and evaluate information from the current world-wide RD&D programs and operating gasification systems to identify and resolve barriers for advancement of economical, efficient, and environmentally preferable gasification processes*

The [status report on gasification](#), released early 2022, had the R&D as its main focus. What became clear is that the application of the product gas is becoming more relevant. CHP and/or co-firing routes are well established and continue to grow based on local policy. However, there have been large scale developments toward fuels, chemicals and hydrogen as well. This is one of the reasons the task is also developing into an application based task (starting with gasification) in the next triennium in order to be more visible to the outside world and more relevant for technology developers.

The following pictures show the scale at which current pathways are being demonstrated. From left to right the Fulcrum bioenergy plant to produce FT, the RedRock Biofuel plant to produce FT and the ABSL plant in Swindon to produce Green Gas.



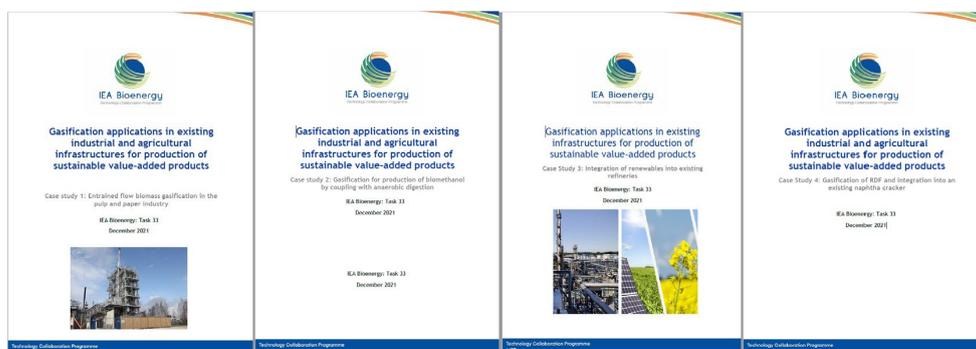
- 5) *to enable National Team Leaders to develop forward looking strategies and policies to implement programs in their respective countries, and help 'leapfrog' resource consuming repetitive and redundant exercises.*

All the information shared by the NTL's in Task meetings is shared through the Task website. For more sensitive information there is a login needed, for which all NTL's have access. How this specific information database has helped in strategy and policy development within NTL's respective countries is not known.

SUCCESS STORY

In the proposal for this Task33 one of the main challenges for gasification was written down as follows: *“Gasification is a technology that holds a promise of valorising a large variety of biogenic feedstocks and solving waste issues that exist today. However, the market uptake of biomass gasification, and waste gasification to a smaller extent, has not been very successful. Traditionally, these barriers are related with feeding and tar in the product gas. More recently some good show cases for biomass gasification in Europe failed because the economy of the process is very difficult. Guessing (Austria) stopped operating as a CHP unit and also GobiGas (Sweden) is facing difficulties with commercial upscaling. These energy products (Biofuels, Green Gas, electricity) can be produced much cheaper or have a fossil alternative which until today is too cheap. However, there are areas in the world where the boundary conditions favour gasification as a technology to produce power or Green Gas.”*

In the last year of the triennium a project was defined that focusses on the transformation of existing industries to become a bio-refinery. This [report](#) was written by Austria and supported with case studies from [Germany](#), [Italy](#), [Sweden](#), and the [Netherlands](#) and resulted in 4 show-cases that explored this concept. What it returned is a preview on how gasification can be utilized to i) valorise waste streams produced locally, ii) differentiate from an ending industrial activity to a new circular/biobased industry and iii) imagined how there is value in biomass.



The key messages from these studies are that:

1. Gasification allows utilization of waste streams towards high end products
2. Gasification can transform industry in both circular and biobased operations
3. There are tailored gasification based solutions applicable to different industries

CONCLUSION AND RECOMMENDATIONS

The knowledge developed by IEA Bioenergy Task33 can be found on the website. Besides being a valuable source of information regarding the different developments within member countries it also provides useful reports to support policy makers or industry with making informed decisions.

For the past triennium the relevant knowledge that has been generated is the following.

1. A method has been described in the emerging gasification technologies report that allows the evaluation of new technologies, not only limited to gasification but applicable in a broader sense.
2. Insights in how existing industrial complexes can benefit from introducing gasification technology either to include biogenic residues into their feedstock mix (moving away from fossil) or by utilizing waste streams produced onsite and finally also how gasification technology can be used to contribute to a circular economy. This is considered the transformation of industries towards bio-refineries.
3. The meetings held in the past triennium as well as the [status report](#), which deals with gasification related R&D shows that the focus is shifting towards high end applications (using catalysis to go to fuels, chemicals and hydrogen).

Two other major observations can be made over the past years. First of all that there is great interest in the production of hydrogen, where in 2016 Task33 already published a good report dealing with the cost of [production for hydrogen](#) based on gasification. Slowly the important role biomass can play there is reaching policy makers as well. The task has set out to highlight this in the next triennium and to achieve more impact has dedicated a subtask within our work program for next years. Furthermore we have successfully reached out to IEA Hydrogen TCP to collaborate in this field, providing them with relevant information through showcases that explain the gasification pathway towards hydrogen including cost figures. Task33 is also supporting the ITP on hydrogen in the next triennium.

The second observation is related to the GHG balance. More emphasis is made by governments to go to net-zero. The use of biomass allows in many cases to go beyond climate neutral production of end-products. Depending on the technology chosen it is possible to co-produce bio-char (for instance with Syncraft or Torrgas technology), which when it is used in soil applications can create a carbon deposit for up to 80 years. Secondly, in most catalytic process another by product is CO₂, in high quality and large volumes, which can be used as well to generate negative emissions. This important aspect of utilizing biomass gasification deserves also a more prominent position within the work generated by the Task and by IEA Bioenergy.

These two observations are seen as important aspects of our task and we recommend that ExCo will use information developed by the task in the next triennium to educate and inform policy makers. Too often we see that the focus policy makers have is too narrow and limited to for instance electrolysers in combination with direct air capture. National policies that are subsequently developed only focus on supporting these technologies, whereas faster to market technologies are overlooked.

In the next triennium we will highlight the applications of gasification as can be seen in the work program for the next triennium. Within this work we will focus on the barriers towards implementation of two important pathways, being Green Gas (SNG) and biofuels. Both are essential in the coming years, but these technology pathways are currently maturing too slow with just a hand full of demonstrations sites being realized.

ANNEXES

1. List of participating countries and leadership
2. Task meetings
3. Progress reports
4. Meetings, webinars and workshops
5. Reports
6. Variations from original proposal
7. Collaborations with other task/organizations
8. Industrial participation during the triennium

Annex 1.

LIST OF PARTICIPATING COUNTRIES AND LEADERSHIP

Country	NTL	Participation
Netherlands	Berend Vreugdenhil (chair) Kees Kwant (operating agent)	Complete triennium
Austria	Jitka Hrbek (co-chair)	Complete triennium
Germany	Thomas Kolb	Complete triennium
Sweden	Joakim Lundgren	Complete triennium
Italy	Donatella Barisano	Complete triennium
UK	Patricia Thornley	Complete triennium
USA	Robert Baldwin	Complete triennium
India	Mohana Rao	Last year

Annex 2.

TASK MEETINGS

2019	June	Karlsruhe/Germany
2019	November	Birmingham/UK
2020	June	Online
2020	November	Online
2021	June	Online
2021	December	Trisaia/Italy hybrid meeting

Task results can be found online

Reports:

<http://task33.ieabioenergy.com/content/Task%2033%20>

Projects Workshops:

http://task33.ieabioenergy.com/content/workshop_events

Meetings:

http://task33.ieabioenergy.com/content/minutes_and_presentations/Last%20Task%20Meetings

Annex 3.

PROGRESS REPORTS

For the ExCo84, ExCo86 and ExCo88 meetings Task 33 has produced three progress reports and presentations, which can be found on the website of IEA Bioenergy.

Annex 4.

MEETINGS, WEBINARS AND WORKSHOPS

First task meeting in Karlsruhe, June 2019

Second task meeting in Birmingham, November 2019

Third online task meeting, June 2020

Fourth online task meeting, November 2020

Fifth online task meeting, June 2021

Sixth hybrid task meeting in Trisaia, December 2021

In January 2021 a webinar was organized dealing with the past, present and future of gasification. This was an alternative approach to highlight some of the results from the Lessons Learned report. It presented an overview of how gasification has been applied and in what direction it is heading. The attendance was limited by the platform at the time, which was 200.

In February 2021 a webinar was organized dealing with gasification as a crucial technology for the energy transition. The aim was also to present the global perspective, for which we invited China and India to join with a presentation as well. This was well attended and has allowed Task33 to interact more strongly with India and China.

In June 2019 a workshop on gas cleaning was organized in Karlsruhe. This was a physical event and had presenters from academia and industry. The workshop made clear there is a huge amount of analysis techniques available. Most of them also covered by the comprehensive IEA Task33 report on Gas analysis. However, during the presentation it became also clear there is not always the best alignment between technology development and industrial requirements.

In November 2019 a workshop on waste gasification was organized in Birmingham. This was a well attended workshop and provided a good overview of where the industrial developments are. State of the art is that gasification is used to produce heat and/or power mostly, but interesting developments are on the way towards fuels and chemicals.

In December 2021 the final workshop was organized on Gasification - a key technology in the energy transition and for the circular economy. This workshop was a hybrid, with participation online and onsite. It demonstrated through industrial examples the versatility of gasification and highlighted as well the positive effect it can have on the GHG balance.

Annex 5.

REPORTS

2-2022 [Status report on gasification of biomass and waste - Research special](#)

[Annex 1 - CHP - operational facilities](#)

[Annex 2 - CHP - non-operational facilities](#)

[Annex 3 - Fuel synthesis - operational facilities](#)

[Annex 4 - Fuel synthesis - non-operational facilities](#)

[Annex 5 - Other gasification technology - operational facilities](#)

[Annex 6 - Other gasification technology - non-operational facilities](#)

12-2021 [Gasification applications in existing infrastructures for production of sustainable value added products](#)

[Case study 1 - Entrained flow biomass gasification in the pulp and paper industry](#)

[Case study 2 - Gasification for production of biomethanol by coupling with anaerobic digestion](#)

[Case study 3 - Integration of renewables into existing refineries](#)

[Case study 4 - Gasification of RDF and integration into an existing naphta cracker](#)

[Attachment - chemical analysis of different feedstock](#)

3-2021 [Emerging gasification technologies for waste and biomass](#)

9-2021 [InterTask project: Industrial heat case study 2: Gasification of paper reject to displace natural gas usage in a pulp and paper process](#)

2-2019 [InterTask project: Biomass pre-treatment for bioenergy, Case study 3: Pretreatment of MSW for gasification](#)

Annex 6.

VARIATIONS FROM ORIGINAL PROPOSAL

The first task project on Emerging Technologies has been postponed to Q1-2021 due to staffing issues. The quality of the Lessons Learned report was not sufficient to publish it. The task member working on it was not part of the triennium so it was not updated. The important learnings were disseminated through the webinar organized on the status of gasification.

Due to additional budget available two major tasks were identified. First report was the collaborative report with task 42 on the integration of gasification technologies in existing industrial settings. Four case studies were developed and a webinar on the report is in the planning for 2022.

The second major change was the budget allocated to the status report on gasification. This has been increased to 23 keuro, due to additional countries supplying information that had to be processed and the overall low allocation for this project.

The earlier defined TP2 and TP3, respectively dealing with Market uptake and with Health and Safety issues were cancelled. This has been decided by the task members

Due to Corona, less Workshops have been organized than anticipated.

Annex 7.

COLLABORATIONS WITH OTHER TASK/ORGANIZATIONS

A presentation on what IEA Task 33 entails was given at a conference on “Fueling the Future with Renewable Gases” in September 2019 in Alkmaar, The Netherlands. This conference was organised as a match making event between industries interested in biomass gasification (or hydrogen). Organised by Energy Valley (NL), the Development Agency NHN (NL) and the Northern Connections .

Cooperation is sought out by ISGA-7, which we accepted and a Task meeting in France was planned. However, due to Corona this was eventually cancelled. Task33 did present at a conference organized by ISGA-7

Collaboration with Task32 on the application of High Temperature Heat has started, within this project Task34, Task35 and Task40 also collaborate.

Collaboration with Task42 has started, where the four cases studies on how to integrate gasification in existing industries will be evaluated using the TEE tool of Task42. This collaboration will continue into the next triennium

Collaboration with Task 44 on Flexible Bioenergy, by presenting at the workshop organized at CEBC in Graz, January 2020

During the preparation of the new triennium proposal we successfully reached out to IEA Hydrogen to collaborate on hydrogen production from biomass. This was identified as a topic of interest by them and fits perfectly within the setup of our new triennium.

Annex 8.

INDUSTRIAL PARTICIPATION DURING THE TRIENNIUM

Industrial participation within Task33 takes place through their involvement in preparing the country updates. Providing the a platform to share their ongoing developments as well as feedback from the task meetings through country updates.

Secondly, industry is invited for Workshops as speakers, allowing them to present their current status with respect to gasification.



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Further Information

IEA Bioenergy Website
www.ieabioenergy.com

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