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Task 32

Biomass Combustion and Cofiring

Triennium 2016-2018

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Biomass Combustion and Cofiring

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Introduction

Task 32 aims to stimulate the expansion of the use of Biomass Combustion and Cofiring for the production of heat and power to a wider scale. This objective is to be reached by generating and disseminating information on technical and on non-technical barriers and solutions. Task 32 has a relatively strong focus on improved operational performance of commercial applications, which is reflected in the direct participation of several individual energy companies and industry groups in Task initiated studies, expert workshops, etc. Another important target group is policy makers, who need to set the appropriate boundary conditions for optimal market implementation based on sound scientific knowledge. Knowledge transfer to these target groups takes place in Task organised events and direct access to Task generated information and deliverables.

This report reflects the work of Task 32 in the period 2016-2018, done in various specific projects. The issues and the corresponding actions were formulated by the Task 32 member country representatives, in discussion with their national stakeholders and the Executive Committee of IEA Bioenergy with the aim to make maximum impact from the available resources.

Background

Biomass combustion technologies already make a dominant contribution to the global production of renewable energy. As biomass combustion technologies are already commercially available for many applications, it is increasingly recognised as an attractive and relevant renewable energy technology. This is particularly true for heat, which represents one of the largest shares of final energy demand in society. In contrast to many other forms of renewable energy, it can deliver high temperature heat, is dispatchable, and commercially available at widely varying scale

Biomass based power generation is also increasing rapidly. According to the IEA Roadmap on Biomass Heat and Power, biomass based power generation will increase by at least a factor of ten from today until 2050, accounting for 7.5% of world electricity generation. For the foreseeable future, this biomass based power generation is almost entirely based on combustion and cofiring technologies. The biomass combustion manufacturing industry is a substantial industry in OECD countries, not only as a result of increasing demand in OECD countries but also due to growing export of this equipment to non-OECD countries (such as China and India) where biomass is still available in abundance as process residues and the demand for electricity rises at steep rates. According to the above referred IEA Roadmap, associated global investments are approximately 378 billion USD in the current decade, of which one third is in the OECD.

Task objectives and work carried out

OVERVIEW

In the triennium 2016-2018, Task 32 contributed to further development and implementation of biomass combustion and cofiring systems in its member countries by exchange of information during semi-annually organised Task meetings, Task organised workshops on particular topics (with active industry involvement and organised with other Tasks or networks), as well as Task initiated studies on certain specific combustion related topics such as aerosols' emissions and cofiring. In these activities, Task 32 always seeks industrial participation, interaction with other Bioenergy Tasks, other IEA Implementing Agreements and European bioenergy industry organisations. A memorandum of understanding for collaboration exists with the industrial biomass power group of VGB Powertech (the European branch organisation of power producers). Several joint workshops and studies were carried out with such groups, as shown in this report.

The following specific activities were undertaken:

Task meetings

In the period 2016-2018, 7 internal Task meetings were held to discuss progress in Task initiated projects and to evaluate progress in implementation in members countries and results of national R&D programmes. Each Task meeting was combined with plant visits and/or a Task organised workshop on a specific combustion related topic.

Task 32 Studies

In order to address the aforementioned market issues, Task 32 prepared a number of specific publications in which the relevance of recent R&D projects was evaluated. An overview of these specific activities that were performed by Task 32 in the triennium 2016-2018 is given below. The full reports are available on the Task 32 website and can be obtained through the hyperlink provided in the title.

D1. Bioenergy for heat – the Hot Cases, Oskar Räftegård and Anders Hjörnhede (RISE), 2018

Heat makes up about half of the global final energy usage, while electric power and transportation fuels together make up the other half of the end use. Fossil fuels are today the predominant source for heating (about 80%). However, in many countries there is enough sustainable biomass available to substitute all fossil fuels that are used for heating today. Switching from fossil fuel fired boilers to biomass fired boilers could decarbonise 40% of the global energy end use!

This report provides fifteen case studies that show real life examples of modern and sustainable heating as well as co-generation of green power through biomass firing. The transition often goes hand in hand with improved local economy, since added value is derived from the utilisation of local residues and waste fractions instead of purchasing fossil fuels. Furthermore, new job opportunities are created. It also secures supply of affordable heat resources, now and for generations to come. Biomass is therefore not only CO_2 neutral and renewable, it can also strongly stimulate local socio-economic development.

D2. Bioenergy Hybrids

Task 32 contributed to the Inter-Task project on bioenergy hybrids with a case study on domestic biomass plus solar thermal heating systems. The project illustrated how dispatchable forms of bioenergy can effectively complement for the variable character of solar and wind energy sources.

D3. State of the art report on application of biomass combustion based CHP with case studies and identification and assessment of innovative developments, Christoph Schmidl

This report describes progress in the commercialisation and development of biomass fired CHP technologies. After an inventory of companies providing CHP technologies, two proven technologies were selected for more in-depth analysis of performance (Heliexpower, steam screw expander technology and Enogia, ORC technology). For a number of plants based on these technologies, operational data was evaluated. The second section of the report describes technologies for externally fired CHP.

D5 Report on consequences of real life operation on performance of stoves, Christoph Schmidl, Gabriel Reichert

This action evaluates how real-life conditions influence the combustion performance of woodstoves, and ways to simulate this in measurements. It concludes that there can be significant deviations between the two, and proposes modifications of the existing test methods to generate results that better reflect actual practice, e.g. as proposed in the Advanced Testing Methods for Better Real Life Performance of Biomass Heating Appliances (BEREAL) protocol. The report concludes that an implementation of a real-life reflecting test protocol as a quality label or standard should be considered as an instrument to push technological development further towards optimised real-life operation instead of performance under optimal type testing conditions. This would also enable a better differentiation of good and poor products for the end customer regarding typical real-life use.

The utilisation of a real-life oriented test protocol for determination of emission factors seems possible, but needs further investigations. The standardised measurement of emission factors according to a suitable test concept could be used for a regular update of emission inventories.

D7 Options for increased use of ash from biomass combustion and co-firing, Frans Lamers et al, 2018

This project reviews current uses of biomass ash in different Task 32 member countries and provides recommendations for improved use. It was performed under the coordination of DNV-GL with input from VGB, ECOBA, Vliegasunie, ESKOM, OPG, and other power utilities. Country reports on the current use of biomass ash were prepared for Sweden, Canada and the Netherlands.

D10. Inter task project to evaluate the costs/benefits for fuel pretreatment of biomass residues in the supply chain for thermal conversion

This concerns an inter-Task project, which was carried out with experts from Tasks 33, 34, 36, 40 and 43. In the framework of this project, five case studies and a policy report were written to illustrate how pretreatment technologies can help to broaden existing bioenergy supply chains.

- Case study 1: Biomass Torrefaction, Michael Wild, Lotte Visser
- Case study 2: Moisture, physical property, ash and density management as pre-treatment practices in Canadian forest biomass supply chains - Evelyne Thiffault. Shahab Sokhansanj, Mahmood Ebadian, Hamid Rezaei, Ehsan Oveisi Bahman Ghiasi, Fahimeh Yazdanpanah, Antti Asikainen and Johanna Routa
- Case study 3 (waste gasification, by Dieter Stapf, Giovanni Ceceri, Inge Johansson, Kevin Whitty).
- Case study 4: The steam explosion process technology, Patrick Wolbers (DNV GL), Marcel Cremers (DNV GL), Travis Robinson (NRCan), Sebnem Madrali (NRCan), Guy

Tourigny (NRCan), Rob Mager (Ontario Power Generation), Rune Brusletto (Arbaflame)

- Case study 5: Leaching as a biomass pre-treatment method for herbaceous biomass, Koen Meesters, Wolter Elbersen, Pascal van der Hoogt, Hristo Hristov

The results of the case studies were used as input for a policy report, which also contains more general information on the possible impact of pretreatment on biomass availability. A new database module on pretreatment operations was prepared for the existing IEA Bioenergy technology database.

Two other reports there were published, but were not part of the original workplan are listed below:

Technical report on particle emission measurement techniques for boilers and stoves, Hans Hartmann, Claudia Schön, TFZ)

This report evaluates the advantages and limitations of a number of existing and new measurement methods for particle emissions from small-scale combustion devices. It addresses how various factors influence the result of existing measurement techniques and evaluates the opportunities for improvement when using the proposed new EN-PME method.

Aerosols from Biomass Combustion, Technical report on behalf of the IEA Bioenergy Task 32, Thomas Nussbaumer, 2017

During biomass combustion, inhalable particulate matter smaller than 10 micrometres (PM10) can be generated which can cause adverse health impacts. The CO_2 mitigation strategy involving biomass therefore needs to consider potential health impacts and ensure low PM emissions. This report summarises the current knowledge on the health relevance of combustion generated PM, describes the mechanisms which can cause PM in biomass combustion, describes different particle types, and provides information on measures to reduce PM from biomass combustion. It is important to distinguish carbonaceous and inorganic pollutants as well as primary and secondary aerosols. Organic pollutants are particularly relevant to residential biomass combustion and can be avoided at near-complete combustion conditions. Particles resulting from incomplete combustion in manual devices exhibit a high cytotoxicity, while particles from properly operated automated biomass boilers and furnaces are mainly inorganic (derived from ash constituents in the biomass) and exhibit significantly lower or even undetectable cytotoxicity. In addition, inorganic particles can be removed effectively by air pollution control equipment such as electrostatic precipitators or fabric filters. In summary, biomass can play an important role in future energy supply in an environmentally friendly manner through implementation of state-of-the-art combustion devices and their appropriate operation.

The future role of thermal biomass power in renewable energy systems – a study of Germany, Morten Tony Hansen, Lars Pauli Bornak, Alberto Dalla Riva, Hans Henrik Lindboe, 2018

Bioenergy, being a dispatchable form of renewable generation, has the potential to play a key role as a stabilising element in a future green power system dominated by variable renewable energy. Following the interest expressed in the framework of IEA Bioenergy, Task 32 has decided to further explore the role of thermal biomass power plants in the future, using a system approach. In this analysis, development of the European power system is projected highlighting a thermal-dominated area, exemplified by Germany. The role of biomass technologies towards 2040 is analysed in two scenarios, Reference and Biomass+, utilising the Balmorel model, a fundamental mathematical model of power and heat systems reproducing the day-ahead market dispatch and future development of the generation fleet.

This led to the following conclusions:

- The existing and estimated future market conditions alone will not drive any substantial amount of thermal biomass power into the German energy system up to 2040,

- Given favourable framework conditions, thermal biomass power will supply base load electricity and heat for district heating,

- System flexibility services will mainly be provided by other sources such as hydropower, pumped and other electricity storages and gas-fired power units.

Updated database on biomass co-firing

Task 32 has been maintaining a database of experiences with biomass cofiring on its website since 2003. In the past the information has been incorporated into the joint IEA Bioenergy Technology database. In 2018 it was decided to stop further maintenance of the cofiring database module, since the rapidly increasing effort required to maintain the growing number of plants cofiring biomass can no longer be justified under the ambitions of Task 32, while at the same time there are (commercial) market intelligence data providers that can offer similar statistical information.

Webinars

Task 32 prepared three webinars to allow interested stakeholders to directly interact with the authors. An overview of such webinars is shown below.

Biomass Torrefaction: Technology Status and Commercialisation, Applications for Torrefied Biomass and its Role in Logistics and Trade, 27 Oct 2016

This webinar examined the recent technical and commercial challenges that have been faced by torrefaction developers over the last few years. It was jointly organised by experts from Task 32 and 40, and elaborated upon applications and logistics of torrefied biomass, including co-firing with coal as well as other options that are being investigated.

Aerosols from Biomass Combustion – A Potential Drawback with Technical Solutions, 22 March 2018

The webinar provided the results of an IEA Bioenergy Task 32 survey on the properties and health relevance of different particle types summarised as salts, soot, and tar from biomass combustion, and on measures to reduce the resulting emissions. The conclusions include the finding that biomass can be used as an environmentally friendly fuel, if state-of-the art combustion devices are applied and appropriately operated, while open fires and inappropriate use of biomass combustion systems need to be avoided.

Biomass Pretreatment Options to Diversify the Resource Base, 25 April 2019

This webinar presents the results of an IEA Bioenergy inter-Task project that focused on opportunities for biomass pretreatment. It shows how currently available pretreatment technologies and technologies under development can help the supply chains for available solid biomass resources for thermochemical conversion. Five carefully selected case studies describe key options for pretreatment of solid biomass resources for energy generation, including their costs, effectiveness and commercial status.

Workshops

Six workshops were organised, typically in combination with a Task meeting. Through the hyperlinks in titles of the below descriptions, detailed information can be obtained from the Task 32 website.

As compared to the original workplan some minor deviations occurred. A planned separate workshop on biomass cofiring was changed into a conference session on biomass cofiring at the Wood Pellet Association of Canada (WPAC) conference on wood pellet production and utilisation. Secondly, the workshop on new emission measurement methods was not originally planned in the workplan.

D4. Workshop on Biomass Combustion Generated Nanoparticles, Zürich, 14 June 2016

Fireplaces and wood log stoves that burn wood in a suboptimal manner are an important source of particle emissions around the world. By phasing out polluting woodstoves and introducing better stoves, improving stove installations and educating stove users, large emission reductions can be achieved. Moreover, there is evidence that the health impacts of fine particles from well operated biomass combustion devices is much less harmful than that of sub-optimally operated devices. As biomass heating constitutes an important option to contribute to renewable energy production in many countries, it is important to recognise the differences in environmental impacts and societal consequences for different types of combustion systems, and take appropriate policy measures.

The workshop showed that there is an enormous difference in the relevance of biomass combustion particles between well designed and operated stoves and boilers on the one hand, and inappropriately designed or used devices. While in a modern and automatically operated biomass boiler with state of the art flue gas cleaning, particle formation may be primarily in the form of inorganic components, which are then also almost fully captured in an electrostatic precipitator or baghouse filter, older biomass stoves and boilers that do not avail of proper flue gas cleaning devices and are inappropriately used, may cause significant particle emissions with also greater toxicity.

Workshop on new emission measurement methods, 19 Jan 2017

With existing test methods for biomass boilers and stoves, the emissions are tested under stationary and optimal test conditions. Under practical circumstances however, emissions may be significantly higher, e.g. during cold start-up or while operating under part-load. This implies that the emissions measured during type approval do not necessarily reflect actual emissions in the field and may be significantly underestimated.

In order to obtain a result during emission testing that better represents practical conditions, it is therefore desired to modify existing standards to reflect better how the devices are actually used in practise.

Task 32 organised this workshop to present an overview of existing emission measurement standards, and evaluate the new method that was proposed in the framework of the BEREAl project. The workshop showed that the new load cycle methods that have been developed for logwood stoves and pellet boilers in the framework of recent research programmes, better reflect real life emissions than actual test methods. It was therefore concluded that efforts should be made together with industry and national governments, to introduce such methods.

D6. Conference on wood pellet production and utilisation, with Task 32 and WPAC, Ottawa, 18-22 sept 2017

Task 32 organised a session on recent experiences with biomass cofiring at the WPAC conference in Ottawa, 18-22 September 2017 with various speakers. The conference was followed by a field trip to two power stations of Ontario Power Generation that were formerly fuelled with coal, but have been converted to white wood pellets and black (steam exploded) wood pellets.

D9. Workshop on Production and Utilisation Options for Solid Recovered Fuels, Copenhagen, 17 May 2018

In the circular economy, the production and utilisation of Solid Recovered Fuel (SRF) is increasingly recognised as an important element in waste management practices. SRF is produced from non-hazardous waste from biological and fossil origins and can therefore be regarded as a partly renewable fuel. It usually has undergone a sorting process and therefore delivers a fuel that meets strict quality requirements. Narrow specifications of the fuel allow for more targeted end user applications, thereby benefitting the economic and environmental performance. Recently there have been several new experiences in the production and use of SRF. This workshop provided an update on the potential market volumes of SRF, policy developments and experiences of market actors involved.

D13 Workshop on Future perspectives of bioenergy development in Asia, Tokyo, 7-7 Sept 2018.

Initiated by Task 32 and Task 40, this workshop was held in Tokyo, Japan in collaboration with NEDO, METI and UNU/IAS on potential technical and organisational improvements to biomass supply chains, including pre-treatment technologies, bio-refineries, logistics/trade, final conversion/end-use and overarching topics such as sustainability assurance frameworks and policy support options.

The reason for organising the event was that many East and South East Asian countries see rapid development in the use of both liquid and solid biomass for modern bioenergy. Apart from using domestic biomass, Japan and South Korea have started to import large volumes of biomass (wood pellets and palm kernel shells) for cofiring with coal from countries in the Pacific Rim such as Indonesia, Vietnam and Western Canada. In Thailand, Malaysia, Indonesia and several other Asian countries, the trade and use of liquid biofuels in transport and the modern use of solid agro-residues for combustion and anaerobic digestion is increasing rapidly, facilitated by conducive support frameworks.

The workshop provided technical information to decision makers in Asian member countries, but also demonstrated how IEA Bioenergy can support these countries in their development. The event was attended by approximately 70 industrial stakeholders as well as policy makers, academics and local biomass associations from Japan and other countries in Southeast Asia. A field trip was held to the Showa Shell Kawasaki Biomass Power Plant (49MWe using wood chips and palm kernel shells).

Conference sessions on the key results of the triennium 2016-2018 and biomass pretreatment, IEA Bioenergy Conference, San Francisco, 5-6 Nov 2018

As part of the IEA Bioenergy conference 2018, two workshop sessions were organised. The first one showed the key results of Task 32 in the triennium 2016-2018, while the second was particularly focused on the results of the inter-Task project on biomass pretreatment options.

Work executed versus workplan

A comparison of the actual work executed versus the original work plan is shown in the table below. All deliverables planned are finalised, including two that were left to be finalised from the previous triennium.

No.	Topic	Result
left from previous triennium 2013-2015		
D7	Technical report on standardization in particle emission measurement techniques	Report available Q4 2018
D14	Policy paper and background technical report on the health impact of combustion aerosols	Report available Q2 2017
deliverables in current triennium 2016-2018		
D1	Strategic study on renewable heat from biomass boilers	Report available Q1 2019
D2	Input to strategic Study on Bioenergy Hybrids	case study provided Q2 2018
D3	Best practice report of biomass combustion based CHP	Report available Q4 2018
D4	Expert WS on new emission reduction options	Workshop held Q2 2017

No.	Topic	Result
D5	Report on part load operation of boilers	Changed to report on part load operation of stoves (available Q4 2018)
D6	Expert WS on biomass cofiring	Held as part of WPAC conference, 2018
D7	Review on fly ash utilisation from high percentage cofiring	Report available Q4 2018
D8	Updated cofiring database	updated until mid 2018, then decided to stop further maintenance
D9	WS with T36+42 on challenging biomass fuels	WS held May 2018
D10	Inter-Task project on fuel pretreatment of biomass residues	Report and case studies available since April 2019
D11	BIO-CCS/CCU inter-Task-study	Input delivered until end of the project in 2018
D12	Website	continuously updated
D13	Task 32 and 40 outreach meeting to Asia	Held Q3 2018 in Tokyo
Additional to original workplan		
	Thermal biomass plants in RE-based energy systems	Report finalised Jan 2019

No.	Topic	Result
	Workshop on new emission measurement methods	19 Jan 2018
	Webinar on biomass torrefaction	27 Oct 2016
	Webinar on biomass pretreatment	25 April 2019
	Webinar on aerosols from biomass combustion	22 March 2018
	End of triennium conference	5-6 Nov 2018

Success story

In the triennium 2016-2018 Task 32 continued to pay significant attention to lowering emissions from residential biomass stoves and boilers. This included a special report with policy relevant summary and an expert workshop on the health aspects of biomass combustion based aerosols. This work clearly explains why the health impact of particles originating from an old woodstove is much larger than that of a modern pellet boiler of the same capacity. This not only has to do with the larger quantity of dust emitted, the difference in chemical composition also results in a much higher toxicity of the particles. Another study clearly showed how the user can have quite a negative impact on emissions in practise, if the woodstove is not properly operated. For such reasons it can be concluded that modern, fully automated biomass boilers with adequate flue gas cleaning have little or no effect on ambient PM concentrations and health impact, while the use of older woodstoves and fireplaces that are not optimally used, and cause high emissions should be discouraged, particularly in urban areas where there is larger exposure. Finally, in order to avoid mistakes in measuring particle emissions, novel sampling and measurement methods were assessed.

Several actions were made to illustrate how biomass combustion technologies (eventually combined with power generation) can be applied in an optimal manner, in industry and for space heating. This included a special report on optimal CHP applications, and a series of case studies on biomass combustion in various sectors of society. The role of biomass combustion in the future

energy system was analysed in a separate study for Germany. Together with other IEA Bioenergy tasks, a study was done where several real life cases showed the added value of biomass pretreatment before practical use.

Conclusions and recommendations

Task 32 has a unique role to provide an independent platform for hands-on information exchange amongst both manufacturers and operators of biomass combustion plants, and to translate findings of fundamental and applied R&D work to industry and policy makers.

In the period 2016-2018, Task 32 organised several expert workshops and produced a number of topical reports. The work of Task 32 is greatly appreciated by market actors (end users, equipment suppliers and policy makers), as indicated by the interaction in the workshops organised and from the feedback on reports published. One success factor is the provision of publications with detailed insight on key technical performance figures on costs, reliability, efficiencies, and emissions from various technology concepts such as torrefaction, steam explosion, low emission stoves and boilers, better ways to assess emissions under real life conditions during type testing, new particle removal technologies, or mitigating high temperature corrosion.

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Further Information

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www.ieabioenergy.com

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