Task 36
Material and Energy Valorisation of Waste in a Circular Economy

Final Task Report
Triennium 2019-2021

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INTRODUCTION

In 2012, the World Bank estimated that around 1.3 billion tonnes of municipal solid waste (MSW) are generated each year globally, and it is estimated that will rise to 2.2 billion tonnes by 2025 due to increased urbanisation in developing and emerging economies and the associated increase in per capita production of waste. A more circular approach to resource management in the world could make a significant contribution to mitigate negative climate effects, increase the generation of sustainable bioenergy, improve energy efficiency, and limit the over exploitation of virgin resources.

For this the work in 2019-2021 has been expanded and not only focused about the integration of energy from waste, but also how the material recycling can contribute to a better system solution/circular economy. The scope is shown in the illustration below. The objectives of the Task for the triennium 2019-2021 have been to collect, analyse, share, and disseminate best practice technical and strategic non-technical information on the material and energy valorisation of waste in a circular economy. This includes the valorisation of the biomass/biogenic fraction of waste into different bioenergy products (heat, power cooling, liquid and gaseous biofuels) but also the possibility of producing renewable chemicals.

The work has been done through a number of different actions, including task meetings, workshops, case studies and task reports. This end of triennium report will summarise the most important take aways from the work of the triennium. The work has also been summarised in the task report "Material and Energy Valorisation of Waste in a Circular Economy" that will be published in April.

Figure 1. Scope of subjects for the work of IEA Bioenergy Task 36 during 2019-2021

BACKGROUND

The role of waste in the circular economy

The maturity of waste managements systems around the world varies strongly; from almost non-existent to systems designed to try to close the loop while still phasing out hazardous substances. The trend in EU for the last 2 decades has been to divert organic waste from landfills (Figure 2) while also limiting the methane emissions from existing landfills. Despite the targets set up the strategies chosen in different member states differs (as well as the fulfilment of the targets).

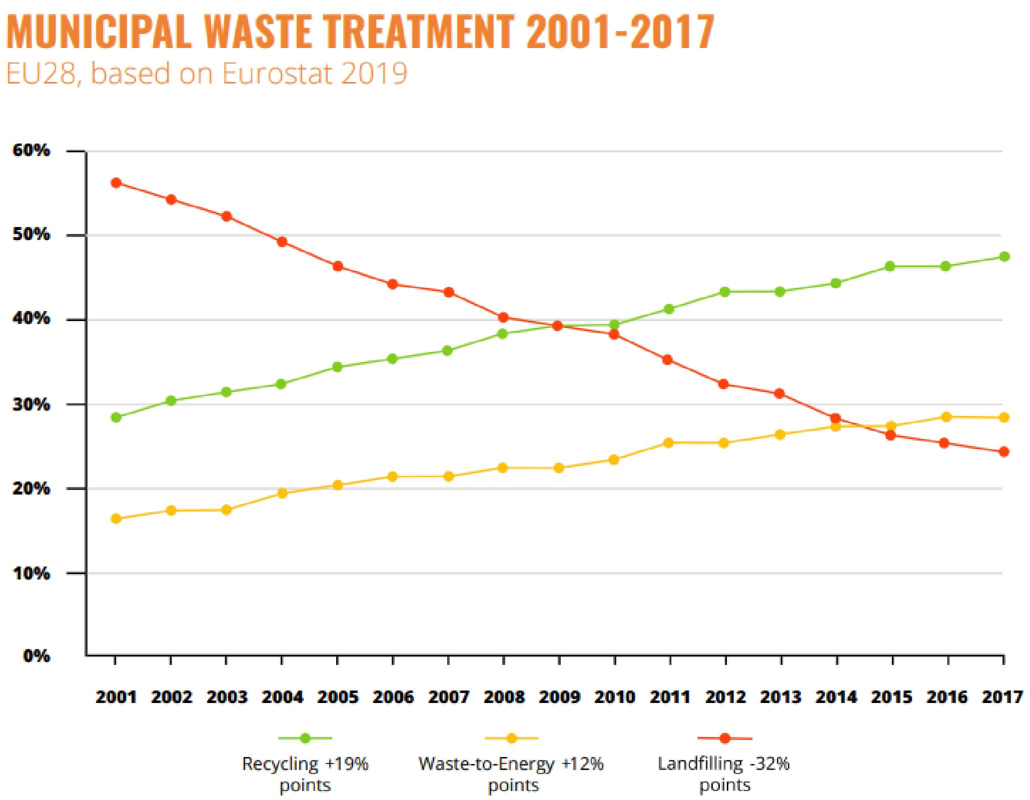

Figure 2. MSW treatment strategies over time in Europe. Graph by CEWEP, Source: Eurostat 2019

When looking at the members in IEA Bioenergy Task 36, the maturity of the systems as well as the priorities differs. In the task of the work one important factor has been to communicate around the development of the systems. What seems to have worked- and what has not worked. The journey of the more mature systems can be used to cut some corners for the nations where waste is getting some more focus.

The global attention to circular economy will also affect the more mature systems, where some of the waste handlings have been more of linear thinking than circular.

Policy

Policy and legislation regarding waste and waste treatment methods (reuse, recycling, energy recovery etc.) also differs between the members of Task 36. Even through the European countries there are differences even though the baseline is set by the directives and regulations issued by EU. On the other hand, there are also differences in the policy/legislation between states in a single country as well (which has been clear in both Australia and the USA) In many cases the policy and legislation have been important drivers to introduce major changes in waste management and the transition toward a more circular management. The market unfortunately often favors the simplest and less costly alternatives, and if virgin resources do not bear their full cost compared to their environmental impact, circular solutions can struggle to be competitive from a pure economic point.

Technology

There are a number of mature technologies on the market when speaking about the recycling and recovery of waste. Waste incineration is a widely used technology that is in general robust and well suited for co-generation of heat and power. It can generate partly renewable energy that is just wasted if the alternative is landfill. The pure WtE power plants will suffer from lower electric efficiency compared to pure biomass fired boilers. The use of incineration is also important from a sanitation point of view where hazardous compounds can be phased out of the material cycle. But in it's base the incineration will destroy the material that it treats and generate residues that need to be handled.

Anaerobic digestion is another technology that gets more mature and widely spread. This could be applied from small local scale to larger industrial scales. The digestate generated can also be utilized as fertilizer- provided that the feedstock is properly separated. In many cases the AD has been dependant on subsidies to be profitable for the operators/plant owners. When it comes to biosolids/sewage sludge, there are upcoming legislation in a number of countries where the applications of this materials will not be allowed on farmland, at the same time the legislation sets demand on the recovery of phosphorous.

There are well established recycling operations for materials like paper and glass. For plastic there are mechanical recycling. The mechanical recycling of plastics suffers from the complexity of many materials used today. Multilayer packaging materials is just one of the streams that pose a challenge. The mechanical recycling cannot remove chemical impurities and there are quite strict limitations to what the recycled material are allowed to be used for. The real market for recycled plastic material has also been restricted to a few “high value” streams. The market of recycled plastics is also hugely affected by the world market price of crude oil, making it more volatile than for example the energy recovery.

There are upcoming technologies, both regarding WtE and recycling technologies. Some of these might also be a hybrid where chemical recycling through gasification or pyrolysis routes might generate both new chemical/materials as well as excess heat that could be recovered.

Acceptance

Waste management operations often suffers from the NIMBY- effect (not in my back yard). But the acceptance varies and countries with more mature systems might have a bit less of the opposition. On the other hand, the trends around circular economy, and awareness of the need to limit emissions of greenhouse gases, starts new discussions and moves the discussions from traditional objections like the risk for dioxin formation to the emissions of fossil Co2 in WtE plants.

REPORT ON THE TASK'S OBJECTIVES

The objectives have been to collect, analyse, share, and disseminate best practice technical and strategic non-technical information on the material and energy valorisation of waste in a circular economy. This includes the valorisation of the biomass/biogenic fraction of waste into different bioenergy products (heat, power cooling, liquid and gaseous biofuels) but also the possibility of producing renewable chemicals.

The strategic non-technical information can include aspects like policy, broader considerations of environmental impacts as well as other aspects that might be hard to assess from an economical point of view.

To reach the objectives there have been a number of activities during the triennium including:

- Task meetings
- Technical visits
- Workshops
- Conference contributions
- Smaller projects on specific topics

Since the area is wide the topics that were put as priority are illustrated in Figure 1. The subjects under Topic area A were the ones considered as core topics.

Topic A -The role of waste in the circular economy

Policies directed towards a Circular Economy

Aims – Policies and legislation play an important role both as a facilitator and a barrier for different aspects in the waste management (i.e. waste-to-energy treatments) and the transition to a circular economy. During the triennium the aim has been to increase the knowledge about different policies that are present in the different member countries and what experiences there have been around those policies.

Activities – The topic has been covered in country reports, in conference contributions and a review of policies around Waste to Energy has been initiated but not been finalised yet. The topic has also been part of the discussions about barriers in more technical oriented workshops and task reports.

Outcome/Conclusions – even though the specific policy review about WtE is not finalised, some general conclusions around policy and the importance of policy settings and legislation can be drawn. It is clear that policy and legislation are important enablers and there are examples of different measures being implemented driving the transition towards circularity. This encompasses policies regarding diversion from landfills, shifting the economic burden for recycling towards producers through extended producers' responsibility, demands on recycling of phosphorous from biosolids/sewage sludge, green certificates or feed in tariffs for bioenergy.

The importance of policy is also highlighted by an ongoing theme as we talk about new and emerging technologies: they almost inevitably come at a cost. Policies and incentives are key to driving the uptake of these technologies, which as well as achieving positive outcomes, will lead to reductions in the costs of these approaches as deployment increases and technologies mature.

Another conclusion is that in general it seems that the promotion of renewable energy is far more advanced through policy settings than for "renewable" chemicals and materials which can be a barrier for the development of those.

Different policies need to be evaluated in their specific settings meaning that just because a policy has been tried in one country does not necessarily mean that it will generate the same result in another country. However, there are inspiration and lessons to be learned from all the countries and continued effort should be made to exchange those experiences.

The role of Waste to Energy and material recycling

Aims – When discussing a circular economy, recycling is a fundamental principle, but how can and will material recycling and waste to energy interact and contribute to the circularity? This topic was intended to give some insight in developments in this area.

Activities – The topic has been covered in discussions at task meetings, a topic report, three workshops/webinars and a case study. The activities have encompassed subjects like valorisation of residues from WtE, Nutrient recovery and carbon material recycling (feedstock recycling/chemical recycling)

Outcome/Conclusions – The traditional incineration based large scale WtE technologies generate residues, generally in form of bottom ash and fly ash/residues from the air pollution control (APC-residues). This triennium the focus was on the fly ash, and that residue is a result of the flue gas cleaning process, thus containing substances that we want to avoid emitting to the air. At the same time, they also contain resources in form of salts (that can be extracted as nutrients, dust-/ice-abatement etc) and metals (zinc being the most developed example). A webinar with different technology suppliers was organised where they presented their solutions. Most of the technologies presented originates from the northern European countries and they are in different development stages. The development has been driven by the trends towards a more circular society, but it is also clear that in some countries there are barriers present discriminating the recovery of resources from waste compared to the virgin production. The costs for the treatments are generally higher than the common practice today (landfilling or refilling of mines) and that can be a barrier unless policy alternatively the general push for circularity offsets that. The fact that there are multiple technologies available now on the market as well as more upcoming will ensure that the WtE Sector can contribute to a more sustainable Circular Economy.

Phosphorous is a limited resource and important as nutrient for the production of both food and energy crops. The mining of phosphorous is also both concentrated to a few countries and associated with large environmental impact both in the mining phase as well as the refining into commercial mineral fertilizer. Even though the price is a critical factor, especially in developing countries, the price of phosphorous has historically been too low for mor advanced recycling operations. Biosolids/sewage sludge has been applied to farmland, compost and biofertilizer/digestate from anaerobic digestion are other sources/ways to bring back nutrients to farmlands. Since a number of years, the use of biosolids has been debated with regards to the risk of spreading pathogens and pharmaceutical residues. New legislation has developed in Germany and Switzerland where the use of biosolids on farmland in general will not be allowed. For cities/communities above a certain size, demands are also set to find ways to recycle the phosphorous. This is driving a development of technologies for that purpose. Some of those are based on incineration with recovery from ashes, others on the production of char from hydrothermal carbonisation (HTC) or pyrolysis processes.

New technologies are also applied to materials that have traditionally been composted or burned. The manufacturing of biochar from garden waste is an upcoming topic. The char is most often intended for soil amendment purposes but could also be used in processes to phase out fossil fuels. During the triennium a technical visit was made to a pilot plant in Stockholm that produces biochar from park and garden waste (see Figure 3). There is also an interest from energy companies to implement biochar to be able to both produce energy (primarily heat) and at the same time gain negative carbon emissions from carbon seq

Figure 3. Technical visit at Stockholm Vatten och Avfall. The picture shows part of the pilot pyrolysis rector for production of biochar for soil amendment in city environments (city plantations)

The trend towards nutrient recovery might affect the energy recovery of certain biobased waste fractions, both in the direction towards alternative technologies (HTC, pyrolysis) but in the case of biosolids also towards incineration followed by an extraction process on the ash.

New waste streams/waste fuels

Aims – the circular economy will change the waste directed towards energy recovery, the aim has been to follow the development but also in the future be able to prepare operators for the changes to come.

Activities – the topic has been covered in discussions at task meetings, a report with a case study from Sweden was published in the beginning of the triennium.

Outcome/Conclusions – The push towards waste minimisation, increased reuse and recycling and shifts away from certain products (as well as the introduction of others) will change the waste flows directed towards energy recovery. This will have an influence both on the traditional incineration-based technologies as well as the alternative technologies being developed/implemented. One trend that is seen in the Scandinavian countries is that an increased demand for fossil free heating (district heating) putting pressure on the WtE sector. Together with increased prices on fossil carbon emissions (EU ETS allowances) that has intensified upstream work to minimise the plastic content. This work encompasses everything from price models to increased information to the clients.

When recycling increases (both through increased collection/recycling of organic waste and increased recycling of plastics) the residual waste will change, the plastics that will be diverted first will be the ones that can most easily be recycled. That means that the plastics remaining will be those with high amounts of contaminants like metals and halogens, presenting a more challenging fuel. While that also boils down to an important function of the WtE plants, being a kidney in the society and detoxifying the Technosphere.

Digitalisation and implications for waste management and energy from waste

Aims – to start discussing the potential around digitalisation in the sector and what effects we can see from that.

Activities – the topic has not been that high on the agenda, but a case study of sorting technologies was initiated at the end of the triennium. These case studies are not yet published

Outcome/Conclusions – There were no major conclusions drawn, but the topic will also be carried over into the new triennium.

Efficiency in EFW plants

Aims – to take the place in a circular economy, the plants need to recover the inherent energy in the waste in an as efficient was as possible. The aim was to follow the development in this area.

Activities – the matter has been followed in the task meetings and one of the task members also have a larger research project around the matter. Also there was a case stuydy on the use of heat within industry.

Outcome/Conclusions – There has not been any major improvements in the efficiency during this period. That is not that surprising since the main technologies used are mature, while when considering the newer technologies, data are scarce. The single largest overall efficiency improvement though is to be able to co-generate and get use for the generated heat.

Is there a place for decentralised solutions in the circular economy?

Aims - to get a perspective on what the drivers to develop decentralised solutions when the large-scale solutions most often have a significant economy of scale advantage.

Activities – the matter has primarily been covered in one case study within this area.

Outcome/Conclusions – there are different drivers that can offset the economy of scale advantages. One of those is the fact that it might be easier to get the public acceptance to take care of the waste locally as well as seeing that the products (nutrients and energy) benefit the local area. Policies and regulations can also offset the economic driver. In some cases the logistic challenge to transport the waste will also be a driver to develop small scale decentralised solutions.

<u>Flexibility</u>

Aims – This subject is both about the flexibility in a plant to be able to accept/accommodate changes in feedstock, but also how the output can be changed or how the output can help create a flexibility in the energy system.

Activities – This subject has primarily been dealt with in two intertask projects, one around the potential use of heat in industries and one around CCS.

Outcome/Conclusions – Despite growing global ambitions towards increased material recycling, combustion-based waste-to-energy will likely continue to play an important role in coming decades as a means of managing waste streams that for one reason or another may be difficult to treat otherwise.

Typically, 40–60% of municipal solid waste used as fuel in WtE facilities are of biogenic origin in developed countries, meaning that implementation of carbon capture and storage (CCS) to WtE partially can be classified as bio-CCS and lead to net negative CO2 emissions.

There are currently several ongoing projects exploring CCS in WtE settings, but one of those that has come a bit further with pilot tests are Fortum Oslo Varme plant in Norway. The case study summarised those pilot scale results. As of second quarter of 2022 it seems that the Oslo plant have secured the funding for a full-scale plant.

The CCS might become a very important tool for all combustion-based energy sources, providing energy with very low or even negative CO2 emissions and at the same time giving a plannable source of both electricity and heat.

<u>Assessing non-economic aspects of waste and waste treatment</u>

Aims – The aim has been to start looking into the non-technical aspects of energy from waste.

Activities – This subject has primarily been dealt with in a workshop as well as the inclusion of LCA-assessment in some of the case studies published. Two case studies has also been initiated (one published) looking at public acceptance of WtE.

Outcome/Conclusions - In the Brisbane workshop around new technology pathways, we also had a presentation from CSIRO on the social licence to operate and studies made on this matter regarding WtE. This is an important area since combustion-based bioenergy in general often suffers from NIMBY, and that is an even larger challenge for WtE and waste treatment facilities overall. If the opposition gets too large, the plan for the infrastructure often is postponed or cancelled. There are different ways to work with it- one way that was chosen by the city of Copenhagen was to put demands on the new facility that it should be accessible for the public (without compromising the safety). The end result was a plant that is a combined WtE plant and recreational facility with climbing wall, artificial ski slope and café on the rooftop.

Not all plants can go in the direction of the Copenhill plant, but the social acceptance and social licence to operate will affect the sector and to find it’s role in the circular economy, the plant owners and operators will have to adapt. This subject will also be important to follow and an important part of the 2022-2024 triennium.

CONCLUSIONS AND RECOMMENDATIONS

There are large differences for the energy recovery and material recycling throughout the member of the task. Thus, that is also a great base to work with to exchange knowledge, ideas and inspiration. The countries that have not based their waste management on large scale WtE facilities gets an insight into what a modern WtE plant can accomplish- and at the same time the other countries get inspiration from new ideas where other technologies might be more suitable for the conditions (and skipping some of the mistakes that has been made in the countries with a more mature waste management).

One conclusion is that you cannot really separate the matters of energy and materials, to go towards thew circular economy we will need both. Even though there will (and should) be a lot more materials going to material recycling (and thus saving energy) there will still be a need to manage waste that is not recyclable today. There is also a lot of debt built in into our society where materials that are not allowed to be used today are built into buildings and infrastructure. WtE has an important function to take care of materials containing substances that we do not want to come back in recycled products.

Considering emerging pathways and their potential for producing products other than power and heat demonstrates the importance of naming conventions, technology classifications, and the potential policy impacts of the blurring of lines between energy from waste and materials recovery. It is possible, for example, that EfW doesn't count as recycling, but can count as resource recovery, which has some interesting implications for how multi-product technologies such as hydrothermal liquefaction are classified: HTL counts as EfW if it's making an energy fuel but as materials recovery if the same product is used differently.

The borderline and flexibility in the use of some products from EfW also puts a challenge into the policy framework. In many countries the production of renewable energy is incentivised and encouraged, while the use of the same EfW product for further refinement into new products most often are not. This might cause sub-optimized systems where the largest environmental gain might not be encouraged.

Definitions, regulations, and policies can have an impact on technological choices, preferences, and policy settings that extend beyond their performance. For example, the EU (Ref. Brussels, 3.12.2008 COM(2008) 811 final GREEN PAPER On the management of bio-waste in the European Union) defines AD biogas production for energy purposes as energy recovery. AD may be classified as recycling (material recovery) when the digestate is used on land (biofertilizer). Furthermore, the fact that liquid biofuels are considered as energy recovery may (at least partially) explain why technology developers working on chemical recycling (mainly for plastic waste) tune their process towards the production of chemicals, i.e. material recovery (rather than biofuels) as this will make their technology very attractive as a potential contributor in achieving the EU material recycling targets.

Another key consideration is the relative value that a community or government places on landfill diversion. Certain technologies are interesting to communities because they can result in significant increases in waste reduction compared to the business-as-usual practices (e.g. anaerobic digestion). An example being explored in several countries is the use of HTL which can convert >90% of municipal sludge and greatly reduce disposal liabilities to the entities responsible for managing it.

These kinds of considerations are also relevant when considering the public acceptance of waste- to-energy technologies, and the importance of terms such as 'incineration' to the social licence to operate. While this is particularly stark in countries such as Australia, where the general public's familiarity with the technology concepts is low, it is also a challenge in EU and North America and can form another driver for 'advanced' technologies such as those under discussion so far.

For the waste management and energy recovery sector to transition towards a more circular approach, technologies, options, and pathways are not likely to be enough. Policy settings that encourage the deployment and uptake of (often more expensive) new technologies, and regulations that specify the extent to which waste can be landfilled or recyclable material used as manufacturing feedstock, for example, are known to drive change.

Just as important as policy settings and the tools to respond to them is the public's acceptance of new technologies. Combustion-based WtE, even in countries where it is established and demonstrably effective, often attracts opposition and criticism, and countering these is a complex undertaking. Information, while important, is seldom sufficient; strong community engagement processes, coupled with an understanding of expectations and concerns and insights into local issues are critical. While there is a stigma attached to combustion-based WtE in some countries, the emerging alternative pathways are not guaranteed to have a simpler process towards public and community acceptance – there are different challenges associated with technologies that are less proven or less understood

The work undertaken by the Task over the triennium was the beginning of a refocusing of the Task's priority areas away solely from combustion-based waste-to-energy to consider broader aspects in the context of the emerging Circular Economy. We have seen how there are some established and emerging pathways for nutrient and material recovery associated with current technology pathways, and there is a relatively high degree of understanding of the role of these in a broader waste management system.

We have also considered a wide range of emerging and advanced technologies that diversify the feedstocks and products that are relevant when considering waste management, energy recovery, and the Circular Economy. What remains is some uncertainly related to the wide range of TRLs, cost models, and value propositions that exist in this space, the context within which they are feasible, and of course their relative merits from an environmental and economic perspective.

The next triennium will continue this work, seeking to better understand the new technology pathways that have been identified and further evaluate them from a technology readiness, sustainability, and CE perspective (see Figure 12). This will provide some important perspective as waste management authorities and governments continue to seek technological solutions to increasingly complex waste-related problems.

As resource and energy recovery from waste becomes more sophisticated, this will require more advanced solutions and schemes for addressing difficult streams. These could include new processes to sort waste streams through the use of robotics, AI/ML, or other technologies. Aggressive recycling goals will also require the development of more readily recyclable materials and/or development of chemical recycling strategies that can manage plastic streams that cannot currently be recycled through traditional mechanical recycling processes.

Hydrogen is emerging as an important aspect of the decarbonization of a range of sectors including transport, electricity, heavy industry, and manufacturing. Although considered only briefly in the work undertaken this triennium, the projected scale of global demand for renewable and low- carbon hydrogen demand will mean that a range of production pathways are likely to be needed. Hydrogen as a product from waste management is technically-feasible but largely unproven at scale—ongoing work in this Task will consider how waste can be one solution to renewable and low-carbon hydrogen production (via our own activities as well as proposed inter-task activities).

This planned program of work reflects the challenges faced by the waste management sector as the environment within which it operates changes. These include choosing the adoption of new technologies vs the potential to retrofit existing processes; the likelihood (and impact of) changes in policy and legislation; and how to effectively navigate the increasingly-complex number of options with regards to feedstocks, technologies, and products—all while bringing the community along on the transition journey.

The work started under 2019 have worked well even with the Covid situation and the work for the new triennium will be structured similarly. The online event might be exchanged for hybrid events in some cases, and the work will benefit from starting to meet physically again, but the frequency of the physical meetings will be lower than before the pandemic. At the physical meetings there will be a focus on the knowledge exchange and discussions that might be more challenging in the online environment.

ANNEXES

1. List of Participating Countries and National Team Leaders
2. Task leadership and Operating Agent
3. State-of-the art Report
4. Technology Progress Reports
5. Task meetings and participation in major events
6. Deliverables
7. Variations from original proposal
8. Co-ordination with other Tasks within IEA Bioenergy
9. Co-ordination with other bodies outside of IEA Bioenergy
10. Industry participation

Annex 1

LIST OF PARTICIPATING COUNTRIES AND NATIONAL TEAM LEADERS

- Australia, NTL Dr. Daniel Roberts (CSIRO)
- Germany, NTL Prof. Dr.-Ing. Dieter Staph (Karlsruhe Institute of Technology) Italy, NTL Dr. Giovanni Ciceri (RSE)
- Norway, NTL Ph.D. Michaël Becidan (SINTEF)
- South Africa, NTL Prof. Cristina Trois (University of KwaZulu-Natal) Sweden, NTL Tech. Lic. Inge Johansson (RISE)
- United States of America, NTL Beau Hoffman (Bioenergy Technology Office, U.S. Department of Energy)
- Ireland, NTL Dr. Fionnuala Murphy (University Colleague Dublin)

Annex 2

TASK LEADERSHIP AND OPERATING AGENT

Task leader:
Tech. Lic. Inge Johansson (RISE, Research Institutes of Sweden)

Task leader assistant:
Ph. D. Mar Edo Giménez (RISE, Research Institutes of Sweden)

Operating Agent:
Jonas Lindmark (Energimyndigheten)

Annex 3

STATE-OF-THE-ART REPORT

Please refer to the work programme 2019-2021.

Annex 4

TECHNOLOGY PROGRESS REPORT

Progress have been reported to the Exco and are summarised in the different deliverables (workshop reports, task reports, minutes from meetings).

ANNEX 5

TASK MEETINGS AND PARTICIPATION IN MAJOR EVENTS

TASK MEETINGS

Minutes from the task meetings are available to the task members through a Teams site as well as through a locked area at the Task 36 webpage (https://task36.ieabioenergy.com).

DATE	LOCATION/FORMAT	PURPOSE	ORGANIZED BY
5-8th/05/2019	Stockholm / Physical	Kick-off	Sweden
19/09/2019	---/ on-line	Follow-up	
10-12/11/2019	Brisbane (AUS)/Hybrid	Regular meeting	Australia
02/03/2020	Online	Follow up	
22/06/2020, 07/07 2020	Online	Regular meeting	
09/10/2020	Online	Follow up	
08/12/2020	Online	Follow up	
08/02/2021	Online	Follow up	
10/02/2021	Online	New triennium discussions	
07/04/2021	Online	Follow up	
21/06/2021	Online	Regular meeting	
18/10/2021	Online	Working session final report	
08/12/2021	Online	Kick-out	

WORKSHOPS/Webinars

There are workshop reports available for the four first events at

DATE	LOCATION/FORMAT	Theme	ORGANIZED BY
07/05/2019	Stockholm / Physical	Nutrient recovery[i]	Sweden
12/11/2019	Brisbane (AUS)/Hybrid	New technology pathways[ii]	Australia
15/06/2020	Online	Waste for feedstock recycling: challenges and opportunities[iii]	USA
07/10/2020	Online/webinar	Waste to energy fly ash valorisation[iv]	Norway
10/06/2020	Webinar	Transitioning towards a decarbonised circular economy	South Africa together with SABIA

CONFERENCE CONTRIBUTIONS

During this triennium we had the ambition to coordinate our meetings with local/national conferences to be able to maybe bring an international perspective to those events. This was unfortunately disturbed by the pandemic, so the concept was not fully implemented.

We did however contribute to the following conferences:

- Bioenergy strong Australia 2019 – where four presentations were held from the NTLs of USA, South Africa and Sweden (2). The presentations are also available online at 2019 Strong Conference - Bioenergy Australia.

- 24th Annual green Chemistry & Engineering Conference System Inspired Design (Online). Task 36 designed and moderated a full afternoon session on the topic International opportunities & Success Stories for the production of Chemicals/Fuels from Waste. The task also contributed with presentations from Germany and Australia.

- IEA Bioenergy end-of-triennium conference. As it was time to summarize the work of IEA Bioenergy 2019-2021, Task 36 assisted and moderated with one of the sessions of the conference. We also contributed with two of the speakers in the conference representing Australia and Sweden.

- Our NTL has participated in a number of national events, spreading the knowledge of IEA Bioenergy. There have also been contributions to events by APEC and SABIA during the triennium.

Annex 6

DELIVERABLES

	Deliverable type	Detail	Partner/ Collaboration	Information/dissemination
M1	Task meeting	*Stockholm*		Minutes available for the members of the task
A2.1. 1	Workshop/ seminar	*Nutrient recycling*		Workshop proceedings available at the website together
A2.1. 2	Topic/work shop report	*Nutrient recycling*		Workshop report published at the website of the task
M2	Task meeting	*Brisbane*		Minutes available for the members of the task
A2.2. 1	Webinar	*Valorisation of fly ash EfW plants*		Webinar proceedings available at the website together with a summary of the workshop
A2.2. 2	Topic/work shop report	*Valorisation of fly ash EfW plants*		
P1	Progress report	*Progress report to ExCo*		
M3	Task meeting	*Online*		Minutes available for the members of the task
A4.1	Workshop/ seminar	*The possibilities and challenges with digitalisation? (may be subject to change)*		Workshop proceedings available at the website together with a summary of the workshop
A4.2	Topic/work shop report	*The possibilities and challenges with digitalisation*		
E1	Audited accounts	*Audited accounts for T36*		
I1	Intertask	*Intertask report: Deployment of bio-CCS: case study on Waste- to-energy*	T32, T33, T37, T39, Deployment	Report available at task website. Has also been communicated towards Australia in a webinar
M4	Task meeting	*Online*		Minutes available for the members of the task
A2.3. 1	Workshop/s eminar	*Waste for feedstock recycling: challenges and opportunities*		Workshop proceedings available at the website together with a summary of the workshop
A2.3.2	**Workshop report**	*Waste for feedstock recycling: challenges and opportunities*		
B	**Co-processing of waste**			
P2	**Progress report**	*Progress report to ExCo*		

M5	**Task meeting**	*online*		Minutes available for the members of the task
A1.0 & A2.0	**Workshop/seminar**	*The role of Waste in Circular economy (may be subject to change)*		Workshop proceedings available at the website together with a summary of the workshop
A1	**Summary report**	*Policy review waste to energy*		
A2	**Task report on the role of Waste Management systems in the Circular economy**	*Report collecting the work done during the triennium concerning the role of waste, energy from waste and material recycling in the circular economy.*		Task report to be published at the website in April 2022
E2	**Audited accounts**	*Audited accounts for T36*		
P3	**Progress report**	*Progress report to ExCo*		
M6	**Task meeting**	*Online*		
W1	**Webinar**	*Webinar about the role of waste in the circular economy*		Plan for 2022
I2	**Intertask**	*Industrial Process Heat Case Study: Waste-to-Energy for the production of steam for paper production*	T32, T33, T34, T40	Case study published at the website
E3	**Audited accounts**	*Audited accounts for T36*		
	End of triennium report	*Report summarizing the triennium of 2019-2021*		
Additional deliverables that have been initiated during triennium (or replaced those not happening)				
M7	**Task meeting**	*online*		Minutes available for the members of the task
M8	**Task meeting**	*online*		Minutes available for the members of the task
M9	**Task meeting**	*online*		Minutes available for the members of the task
M10	**Task meeting**	*online*		Minutes available for the members of the task
M11	**Task meeting**	*online*		Minutes available for the members of the task
M12	**Task meeting**	*online*		Minutes available for the members of the task
M13	**Task meeting**	*online*		Minutes available for the members of the task
TR1	Task report	Biomass pre-treatment for bioenergy. Case study 3: MSW pre-treatment for gasification,		Report available at task website

TR2	Task Report	Trends in the use of solid recovered fuels		
TR3	Task Report	Trend and drivers in alternative thermal conversion of waste		Report available at task website, also communicated through a webinar
CS1	Case study	Waste-to-Energy and Social Acceptance: Copenhill WtE plant in Copenhagen		Report available at task website
CS2	Case study	Hydrothermal Carbonization - Valorisation of organic waste and sewage sludges for hydrochar production		Report available at task website
CS3	Case study	Decentralised Micro-biodigester systems for rural South Africa		Report available at task website
CS4	Case study	Distributed Biogas Upgrading/methanation: Power-to-gas		Hopefully published in April 2022
CS5	Case study	Waste-to-Energy facilities in Ireland: Dublin Waste-to-Energy and Indaver		
CS6	Case study	Sorting technologies in modern waste management		First case study (of two) to be published in April 2022
WS4	Workshop	Technology pathway for energy recovery from waste in a circular economy,		Presentations available at task website
WSR 4	Workshop report	Technology pathway for energy recovery from waste in a circular economy,		Report available at task website
WS5	Workshop	Transition towards a decarbonised circular economy	SABIA	Organised together with SABIA as part of their annual conference
WSR 5	Workshop report	Transition towards a decarbonised circular economy	SABIA	

NEWSLETTERS

Six newsletter was published during the triennium. Contributions was also made to IEA Bioenergys central newsletters.

Annex 7

VARIATIONS FROM ORIGINAL PROPOSAL

There has been quite a bit of modifications in the work programme during the year regarding budgets and deliverables.

First the planned work on the co-treatment of waste was cancelled since it was imagined to be a cooperation with other tasks, and the main tasks considered had to put priority to other subjects due to decreased number of task members (and thus budget).

There has also been changes to the subject of the workshops indicated in the original programme. The workshops were originally planned to be in physical format but was replaced with online events 2020-2021.

We also got a new member in Ireland, that joined in 2020. This increased the budget. Together with the cancellation of the co-processing and that no (or very small budget) was needed for meetings, workshops, and travels there were a number of new work items initiated. This was mainly several case studies and the separate task of trying to incorporate LCA analysis into the case studies (where enough data was available).

Unfortunately, there has also been quite a bit of delays during the triennium. This is a general problem and to some part due to the work situation of the people engaged in the work, but also do to lack of responses and the difficulties presented by the pandemic in gathering data for some of the studies.

Annex 8

CO-ORDINATION WITH OTHER TASKS WITHIN IEA BIOENERGY

During the triennium Task 36 has contributed to two intertask projects:

– Industrial Process Heat Case Study: Waste-to-Energy for the production of steam for paper production

– Deployment of bio-CCS: case study on Waste-to-energy

Task 37 have assisted in reviewing two of the case studies published/under development.

Annex 9

CO-ORDINATION WITH OTHER BODIES OUTSIDE OF IEA BIOENERGY

The webinar/workshop about Transition towards a decarbonised circular economy was arranged together with SABIA.

The workshop on Waste for feedstock recycling: challenges and opportunities was arranged together with ASC Green Chemistry Institute (side event to conference).

Annex 10

INDUSTRY PARTICIPATION

The primary participation from the industry has been in workshops/webinars and as contributors to the case studies that has been developed during the triennium. The industries give a valuable insight in the ongoing challenges on the market as well as the state of the art when it comes to technologies. The following organisations and industries have been involved in different activities:

Organisation	Kind of interaction
Stockholm Vatten & Avfall (SE)	Hosted a technical visit at their pilot biochar plant
E.ON (SE)	Hosted a technical visit to their new WtE plant in Högbytorp (Stockholm)
Ragn-Sells (SE)	Presented their circular solutions around fly ash management but at the technical visit at E.ON and at the webinar around valorisation of ashes
Queensland Government (AUS)	Giving presentations at the Brisbane workshop around Biofutures and the developing EfW policy.
University of Queensland (AUS)	Contributed to the workshop in Brisbane
Pyrocal (AUS)	Presentation at the Brisbane workshop
National Renewable Energy Laboratory (US)	Presentation at the workshop around feedstock recycling
Argonne National Laboratory (US)	Presentation at the workshop around feedstock recycling
Lanzatec	Presentation at the workshop around feedstock recycling
National Institute for environmental studies (Japan)	Presentation at the webinar around valorisation of ashes
AIK Technik (AUT)	Presentation at the webinar around valorisation of ashes
Stena Recycling (SE)	Presentation at the webinar around valorisation of ashes
NOAH (NO)	Presentation at the webinar around valorisation of ashes
Renova (SE)	Presentation at the webinar around valorisation of ashes
O.C.O. Technology (UK)	Presentation at the webinar around valorisation of ashes
Scanarc (SE)	Presentation at the webinar around valorisation of ashes
Enerkem	Contribution to the End-of-triennium conference
University of Natural resources and life sciences (AUT)	Contribution to the End-of-triennium conference
ARC- Amaeger resource center (DK)	Contribution to case study
Ingelia (Spain)	Contribution to case study
Southern California gas company (US)	Contribution to case study
Electrochaea Gmbh (DE)	Contribution to case study
Covanta (IE)	Contribution to case study

IEA Bioenergy

Technology Collaboration Programme

Further Information

IEA Bioenergy Website
www.ieabioenergy.com

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