Waste-to-Energy fly ash valorisation

Digital webinar, October 7th, 2020

Workshop Report

IEA Bioenergy: Task 36: 10 2020

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Waste-to-Energy (WtE) fly ash valorisation webinar

Foreword

IEA Bioenergy Task 36 - Material and Energy Valorisation of Waste in a Circular Economy - seeks to raise public awareness of sustainable energy generation from biomass residues and waste fractions including MSW (Municipal Solid Waste) as well as to increase technical information dissemination. This workshop represents one of several workshops that focuses on resource and energy recovery from waste, which is critical in the transition from a linear to a circular economy.

As outlined in the 3-year work programme, Task 36 seeks to understand what role energy from waste and material recycling can have in a circular economy and identify technical and non-technical barriers and opportunities needed to achieve this vision.

Past workshops in this 3-year work programme have explored opportunities for nutrient recovery, especially nitrogen and phosphorus from waste (Stockholm, May 2019), technology pathways for energy recovery from waste (Brisbane, November 2019), challenges and opportunities for feedstock recycling from waste (digital, June 2020) and Trends and Drivers in Alternative Thermal Conversion of Waste (digital, September 2020).

See http://task36.ieabioenergy.com/ for links to the workshops.

Practical details

IEA Bioenergy Task 36 digital webinar. Organised by Michael Becidan (SINTEF Energy Research, Norway), Inge Johansson (Task 36 leader, Rise, Sweden) & Mar Edo (Rise, Sweden).

12 noon – 3.30 PM, CEST, October 7th, 2020 on Zoom. Ca. 180 registered participants (up to 120 connected simultaneously).

Presenters

- Hirofumi Sakanakura, *National Institute for Environmental Studies*, Japan
- Jonas Wibom, Business developer, *Ragn-Sells* – **Ash2Salt®**
- Siegfried Reithaar, Sales manager, *AIK Technik* – **Fluwa/Flurec®**
- Erik Rasmussen, Project leader, *Stena Recycling* – **HaloSep®**
- Morten Breinholt Jensen, Head of technology, *NOAH* – **NOAH's R&D project**
- Peter Gunning, Technical manager and Head of R&D, **O.C.O Technology®**
- Karin Fedje, Associate Professor, *Chalmers University of Technology/Renova* – **Zn-recovery**
- Maria Swartling, Process engineer/researcher, *ScanArc* – **Arcfume®**

Agenda (CEST)

- 12:00 – 12:15 Welcome & Introduction
- 12:15 – 12:40 **Fly ashes in Japan**
- 12:40 – 13:00 **ASH2SALT**
- 13:00 – 13:20 **FLUWA/FLUREC**

10-min break

- 13:30 – 13:50 **HALOSEP**
- 13:50 – 14:10 **NOAH's R&D project**
- 14:10 – 14:30 **O.C.O Technology**

10-min break

- 14:40 – 15:00 **Renova's Zn-recovery**
- 15:00 – 15:20 **ARCFUME**
- 15:20 – 15:30 Wrap-up

Link to presentations (pdf) and videos:

http://task36.ieabioenergy.com/publications/webinar-valorisation-of-fly-ash-from-waste-to-energy/

Introduction

As Europe is the continent where WtE is the most established, it can be used to illustrate the current situation concerning the treatment of fly ash from WtE plants. Contrary to most/many waste management-related topics, there is **limited agreement and common standards in the EU concerning fly ash** (classification, handling, disposal, potential re-use, valorisation, etc.), adding a level of complexity to this challenge. However, WtE fly ash is usually considered as **hazardous waste** because of their chemical and physical properties (i.e. metals content, leaching), hence requiring specific handling, disposal and/or treatment.

What is the **current situation in the EU**?

Most fly ashes are being landfilled, often after washing and/or stabilisation/solidification, in dedicated sites such as salt mines in Germany or Langøya island in Norway to prevent the leaching of hazardous substances to the environment. A significant portion of European fly ashes are being transported across borders (within the EU) for final disposal, this interesting aspect may play a role in the future, especially regarding the proximity principle.

However, the push towards a more **Circular Economy** (and ever more stringent environmental regulations) are calling for drastic changes in the situation, especially concerning the possible **valorisation of fly ash** to recover valuable elements as well as reduced landfilling. Fly ashes are promising candidates as they contain an array of metals, salts, and minerals, including strategically critical elements.

What is happening on the valorisation front?

During this webinar, seven companies presented their fly ash treatment solutions, all offering (different degrees) of valorisation and/or re-use. Some of these technologies are commercially available, while others are under various stages of development. However, the main point is that **many industrial initiatives are taking place** in the field, a very positive development towards a more sustainable, resource-efficient future.

The presentations (the technologies)

1. WtE fly ash treatment in Japan

Mr Sakanakura, from the National Institute for Environmental Studies in Japan, presented an overview on the treatment technologies of fly ash from WtE incineration in Japan.

Two main paths are employed today in Japan:

- Thermal treatment (melting/vitrification, sintering) for use as construction material or as raw material for smelting. Also, limited, direct use (after washing) as raw material for cement is possible
- Chemical stabilisation (by various agents) or cement solidification before landfilling as a "specially controlled waste" with specific criteria to prevent leaching

Actual situation in Japan: out of 980 WtE facilities, 614 employ chemical stabilisation, 133 a combination of cement & chemical, 41 cement solidification, 13 melting and 88 do not report any treatment. Most of the fly ash is being landfilled despite the lack of space. Recycling is limited, mainly due to the fly ash properties, i.e. composition and leaching. Furthermore, Mr Sakanakura indicated that the focus is currently on the handling of bottom ash, mainly due to the large volumes generated.

2. ASH2SALT by Ragn-Sells (Sweden)

Fly ash washing & salts recovery.

Basic principle:

Step one *ash washing*: fly ash is washed with water, producing washed ash (to further treatment before landfilling or possibly recycling) and a leachate rich in salts. Step two *water treatment*: precipitation chemicals are added to the leachate to extract water-soluble heavy metals (sent to landfill). Thereafter, the salts-rich liquid continues to step three. Step three *salts recovery* includes the precipitation and separation of NaCl and KCl before evaporation to produce a $CaCl_2$ solution and aqueous ammonia. The three salts and ammonia are collected separately.

Status:

A full-scale plant (130 000 ton/year) is under construction in Högbytorp, Sweden. Testing is planned to start in November 2021 with final take-over in August 2022.

3. FLUWA & FLUREC by AIK Technik AG (Switzerland)

Acid fly ash washing & metals recovery.

Basic principle:

FLUWA - The acid from the wet flue gas treatment effluents is used to leach metals from the fly ashes. The filter cake is separated and landfilled while the Zn-rich filtrate is further treated. In the standard process, after neutralisation of wastewater, the Zn-rich filtrate from FLUWA can be processed by smelteries to produce Zn. FLUREC - In the process including the FLUREC process, the zinc is recovered from the filtrate as high-purity metal using liquid-liquid extraction and electrolysis. A cadmium, lead and copper mixture is also separated and used as a secondary product in lead and copper production.

Status:

Commercial. 12 FLUWA facilities are in operation in Switzerland. They treat fly ash from 18 Swiss WtE plants out of which 1 is using FLUREC. From 01.01.2021, all 30 Swiss WtE plants will have to implement acidic fly ash treatment. 4 FLUWA plants are operating in other European countries.

4. HALOSEP by Stena Recycling (Sweden)

Fly ash treatment with salts & Zn recovery.

Basic principle (*for WtE plants using wet Flue Gas Treatment; other versions exists for treatment of semi-dry Flue Gas Treatment and other ashes*):

Firstly, fly ash is mixed and reacted with the hot acidic scrubber liquid; this leads to the neutralisation of the scrubber effluents and the formation of a salt brine including metals in solution. Secondly, the fly ash particles with a size over 1 mm are removed; they represent less than 1 wt% of the fly ash and are returned to the WtE incinerator. The salt brine is purified by a multi-stage precipitation process producing a salt fraction (to be used for road de-icing and other industrial use) and a metal/Zn-rich fraction (to be sent to Zn recovery). Thirdly, the reacted fly ash is washed with water. Finally, the washed fly ash fraction is dewatered before landfilling or reuse as a construction material.

Status:

A 13-14 000 ton/year plant has been built at the Væstforbrending WtE plant in Denmark and full-scale tests will start in October 2020. The test period is expected to take about 12 months.

5. Fly ash treatment new technologies by NOAH (Norway)

Fly ash washing and salts recovery.

Basic principle – concept 1 "ReSalt":

The fly ash is neutralised with an industrial spent/waste stream of sulfuric acid. After the addition of lime, a gypsum slurry is formed. The slurry is separated into 2 fractions: a filter cake that could be sent to a (possibly Non-Hazardous Waste) landfill or find an industrial use, and a brine from which salts (i.e. NaCl, KCl, $CaCl_2$) could be recovered for industrial applications, eventually in combination with other salt-containing waste streams. Metal recovery could also be considered.

Status:

A pilot plant is expected to be operational in 2021 with final decision on a full-scale plant in 2022/2023.

Fly ash stabilisation.

Basic principle – concept 2 "CarbonTech":

Ash stabilization method based on accelerated carbonation. The fly ash is mixed with a CO_2-rich gas, preferably from an existing incineration process (for the added benefit of CCS). The fly ash becomes encapsulated in a carbonated matrix reducing leaching before landfilling.

Status:

A test centre is in place at Langøya island, Norway.

6. O.C.O. Technology (United Kingdom)

Stabilisation and aggregate (construction materials) from fly ash.

Basic principle:

Method based on accelerated carbonation. The fly ash is mixed with a CO_2-rich atmosphere and water at appropriate conditions. After a few minutes, the fly ash is encapsulated and chemically stabilised in a solid $CaCO_3$ matrix, also capturing, and storing the CO_2 (CCS). The resulting lightweight aggregate is used in various products including masonry blocks.

Status:

Commercial. 3 operational UK sites handling 140 ktonsWtE/EfW waste (APC residues, fly ash). Further UK expansion planned. Several international development projects. End-of-Waste status acquired in 2011 in the UK.

7. Zn-recovery from fly ash by Renova & Chalmers University (Sweden)

Zn recovery.

Basic principle:

The fly ash is mixed with acid effluents from the flue gas treatment system to leach out metals/Zn. After filtration, the leached/washed fly ash residue can be re-sent to the WtE incinerator to destroy dioxins, while the Zn-rich leachate/liquid is further treated. The Zn present in the liquid phase is precipitated/flocculated as $Zn(OH)_2$, separated by filtration and water washed. Solid $Zn(OH)_2$ can be used for Zn production.

Status:

A full-scale plant is in progress. Timetable: 2020: Building permit and projection; 2020-2021: Building and installation; 2022: Full scale testing and running.

8. ARCFUME by SCANARC (Sweden)

Metallurgical treatment of fly ash.

Basic principle:

Thermal/metallurgical treatment using a plasma. The fly ash is melted and vitrified at high temperature, typically 1250 °C. Fly ash is hence separated into two fractions: a Zn- and Pb-rich filter product that can be used as a raw material for metal production, and a glassy vitrified material that could potentially (if proven non-hazardous) be classified as a product/material for e.g. road construction.

Status:

Feasibility study and pilot-scale campaign carried out in 2018.

Concluding remarks

The webinar presentations clearly show that fly ash valorisation is a hot topic, especially as Circular Economy principles are slowly but surely unfolding into all aspects of society. Several technologies are (or will be) good candidates to contribute to more valorisation and/or re-use of WtE fly ash and possibly less hazardous waste landfilling. However, there is still a large acceptance in the public and the authorities for landfilling in many countries, especially if NIMBY principles prevail for waste processing plants. This acceptance is reflected in the relatively affordable costs of landfilling in many regions.

Trying to gather the experience and knowledge from the technology developers in their endeavour, one can attempt to answer 3 questions:

What are the main technological challenges encountered?

- Developing a concept to industrial, commercial solution is always a challenge.
- Demonstration at full-scale takes time and effort.
- Designing a robust yet flexible process that can handle a changing, heterogeneous material such as WtE fly ash is a main challenge, especially whilst ensuring the quality/purity of the various products and other streams out of the process. This is especially important to maximise incomes and limit the need for hazardous waste landfilling.
- The type of Flue Gas Treatment can affect the types of treatment technologies available.
- Optimising footprint, energy, chemicals, and water use is important

What possibilities/barriers exist for a wide application of your concept/fly ash valorisation?

- Landfill acceptance does not help the implementation of valorisation.
- Advanced, novel technologies require a wide range of know-how and experience.
- Collaboration with established WtE technology suppliers can be beneficial (e.g. Babcock Wilcox Völund & Renova, Hitachi Zosen Inova & Ragn-Sells).

- Some fly ash actors have joined forces and collaborate.
- Centralised versus decentralised deployment is an important aspect, both economically and logistically.

What policy measures are essential to promote fly ash valorisation?

- Support for secondary raw materials markets development; there is currently no premium for "green" recycled/recovered products.
- Common, clear, and stable standards, policies, legislation, and strategies (at the EU level for example)

To conclude, the existence of several fly ash valorisation technologies on the market in the coming years is positive, both for WtE plants operators/owners and society at large. Competition as well as complementarity between the various solutions will ensure that the WtE sector can contribute to a more sustainable Circular Economy as best as possible.