Slutrapport

Projekt akronym og titel	RecAsh – Recovery of Resources of Bottom Ash
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Projektets kontaktperson (projektleder)	Torben Overgaard
Administrator	Afatek I/S
Status pr.	15.02.2019
Projektets varighed, inkl. evt. forlængelser	15.02.2016 – 15.02.2019
Øvrige parter	Boes Consulting, Danish Waste Solutions ApS, DTU, Teknologisk Institut.
Evt. hjemmeside for projektet	
Totalt budget	9.691.911 kr.
Bevillingsbeløb	5.756.617 kr.
Medfinansiering	3.935.294 kr.
Ekstern finansiering	0 kr.

A. Final report – executive summary

The success criteria for the project was to:

1. Reach a deeper understanding of the parameters influencing the maturation and drying out of IBA in piles.
2. Reduce stockpiling time for maturation of IBA from an average of 3-4 months to 1-2 months.
3. Increase the amount of matured and dry IBA enabling metals separation to smaller grain sizes (between 0.5-4 mm) without decreasing the environmental and geotechnical quality. Thereby increasing the total non-ferrous metal recovery from IBA with approx. 25 %.
4. Maintain the utilisation of IBA (mineral part) as subbase material for road construction.
5. Establish data for development of a road standard on use of IBA (mineral part) for base course material in road construction.

The following fulfilment has been achieved:

1. An understanding of the parameters governing the maturation and drying out of IBA in full scale scenarios has been established leading to an optimisation of the processing of IBA at the plant. In the optimised process the IBA is stored as raw ash including the ferrous scrap using a telestacker leading to faster maturation and drying out of the IBA.
2. Average stockpiling time for the maturation of IBA has been reduced from 88 days for the reference IBA to 68 days for the optimised IBA.
3. Already before the start-up of the RecAsh project the drying out of the IBA was improved to an extend where some piles of IBA could be screened down to 1 mm. During the optimisation even, larger parts of the IBA can be screened down to 1 mm and some trial with screening to 0.5 mm has also been performed. As some improvement was done before the start-up the increase in total non-ferrous metals recovery could only reach 7.7 %.
4. The geotechnical quality of the reference IBA and the optimised IBA has been thoroughly investigated and compared to the standard base course material, SG II. The geotechnical quality of the IBA is improved by the optimisation process compared to the reference situation and the utilisation of IBA (mineral part) as subbase material for road construction is hereby maintained.
5. New knowledge on several geotechnical parameters, e.g. the resilient modulus and permanent deformation, of IBA has been established. The results indicate that the optimised IBA could be a possible future candidate not only for use as subbase but also for use as base course material in road construction. The collected data can be used in the development of a new road standard on use of IBA (mineral part) for base course material in road construction.

If we compare the above results with the success criteria for the project, we will see that the criteria are fulfilled to a large extent.

Afatek will carry on working with optimisation of the IBA handling and processing in the non-ferrous metals plant.

Further work on a possible implementation of IBA as base course material will also continue after the end of the RecAsh project.

B. Value creation

This project has three major lines of possible value creation one is the optimisation of the handling and metal recovery from the IBA, the second is the continued use and possible upgrade of the mineral part of IBA as road construction material, and the third is the use of

the knowledge from the project to secure new orders for the companies involved in the project.

The processing of the IBA in the Afatek plant has been optimised during the project. This has resulted in a reduction in the storage time of the IBA before metal sorting from an average of 88 days to an average of 68 days. This reduction of around 30 % in storage time results in a considerably reduction in costs. The number of working hours for the handling has also been reduced by the optimization with an estimated operational saving of around DKK 2 mill. per year.

The optimisation of the IBA handling has also led to a better maturation and drying out of the IBA. As a result of this the recovery of the Non-ferrous metals has improved in the metal sorting plant. The overall improvement in recovery of non-ferrous metals is around 8 % and this corresponds to an added value of around DKK 3 mill. per year.

Also, Afatek has through the project gained a thorough understanding of the processes leading to a faster drying out of the IBA. This knowledge will be utilised in further optimization of the treatment and in the design of future IBA treatment plants.

The second line of research has been the investigation of the geotechnical properties of the present as well as the optimised IBA to maintain its utilisation as subbase material for road construction. This research has collected data for development of a possible future road standard on use of IBA for even base course material in road construction.

The geotechnical and environmental results of the optimised IBA in the project shows that it is possible to continue the use of IBA for road construction purposes like in sub base layer. The results also indicate that IBA could possibly be used for higher value purposes like base layer material in road construction. If it is decided by the Danish Road Directorate that IBA can be used for base layers the geotechnical results from this project will be background data for a new General Working Specification. The use of IBA as base layer material could mean a large increase in its sales value for Afatek. In an overall social context, the use of IBA as base course material would be a supplement to use of the sparse natural raw materials in base course layers.

The RecAsh project contributes to knowledge generated via a large number of research projects at DTU in relation to residual products. DTU's participation in RecAsh has ensured the utilization of the existing knowledge within the project and an ongoing expansion of knowledge with experience from the project. This has contributed to the education of PhD students and Post Docs in the subject area and to DTU's continued collaboration with the industry.

For Danish Waste Solutions ApS the participation in the RecAsh project has generally strengthened their competencies in one of their core areas, and specifically they have already used some of the results in a project in the Czech Republic.

For Boes Consulting the participation in the RecAsh project has strengthened their general knowledge on bottom ash and especially on ways to characterise materials geotechnical properties. This knowledge will lead to more assignments in the future.

The Danish Technological Institute has participated in the RecAsh project in a minor role, where their contribution was mainly focused on modelling the chemical / physical processes that take place in slag piles. For the modelling, DTI used their own commercially available software 4C-Temp-Stress. However, the simple and constant geometry of the piles and relatively constant chemical composition implies that simple calculation rules can be applied. Thus, there is no market for the sale of 4C-Temp & Stress software or related consultancy services to this industry. The experience from the RecAsh project has been transferred to

employees in DTI's road group and it is obvious that future cooperation between the RecAsh project group and DTI's "Road sector's Development and Test Laboratory" should be possible. The experience of the RecAsh project has also been passed on to two other groups at DTI (Buildings & Environment and Life Science) who work with various environmental aspects in the building and construction sector and in the waste sector. Thus, the project has not resulted in concrete value creation at the Danish Technological Institute, but a latent value creation has taken place through the competence / knowledge build-up that has taken place.

The companies Rambøll A/S and Babcock & Wilcox Vølund which are members of the Steering committee all use the experiences in this project to secure assignments and/or orders both in Denmark and abroad.

Especially Rambøll have used experiences from the RecAsh project to enable the company to give better advise and hereby increase the possibility to secure and develop several projects i.e.:

1. Rambøll have used information gathered in the RecAsh project in their consultancy services to Australia's first Waste-to-Energy Project, which reached Financial Close on 17 October 2018. Ramboll was instrumental in structuring the project, as well as negotiating the contract with Acciona Construction for designing and building the plant and negotiating the contract with Veolia Australia for operating the facility.

2. Singapore's new Integrated Waste Management Facility (IWMF) will be the world's largest energy recovery facility. The plant design is based on the most advanced waste-to-energy technology. By co-locating the facility next to a new water reclamation plant (Tuas WRP) it will be possible to achieve the highest energy efficiency and lowest greenhouse gas footprint. Rambøll is responsible for the IWMF facility. Rambøll staff experts are relocated to Singapore working from a project office and backed up by a pool of experts in home office.

The present "Semi-Dry" processing of IBA at the Afatek plant is considered state-of-the-art in the world. Afatek will continue development of the process in daily work and in future projects.

C. Scientific results

A short summary of the scientific results in the project can be found in the appendix "RecAsh Summary Report".

Status reports on the individual working packages are also included as appendices as well as a conference presentation and two published papers.

The final Gantt diagram showing the fulfilment of the individual tasks can be seen in the appendix "Gantt diagram and Milestones and Deliverables tables". All tasks in the Milestones and Deliverables tables have been fulfilled. In the Gantt Diagram only one work package has not been finalised, i.e. WP4.4. Full-scale trials. This work packages concerns full-scale trials with IBA used in road construction, but unfortunately no opportunities arose to initiate this work during the project. Luckily, we have been able to obtain some preliminary results from another full-scale trial which also included use of IBA both as subbase as well as base course material. This project called "Forsøgsstrækning på Nordhavnen" shows very high bearing capacity and low tendency for rutting for the sections with IBA as base course and with IBA as base course as well as subbase after 5 years of use. The bearing capacity and rutting in the IBA sections are comparable to the sections where standard base materials (SG II) and subbase materials (sand) were used.

D. Management and cooperation

The collaboration and communication between the individual partners in this project have been outstanding. All partners were working along the same line and showed strong commitment to the vision of the project.

There have been no changes in the organisation of the project during the period.

Appendices:

RecAsh Summary report.

Gantt diagram and Milestones and Deliverables tables

WP1 Status report: Establishment of maturation model.

WP2 Status report: Measurements and optimisation.

WP3 Status report: Metal recovery.

WP4 Status report: Geotechnical testing on IBA.

Recovery of Resources in Bottom Ash – Semi Dry Concept. Presentation by Søren Dyhr-Jensen made at Expert Forum "Removal, Treatment and utilisation of waste incineration bottom ash", Vienna Austria, October 3, 2018.

Recovery of Resources in Bottom Ash – Semi Dry Concept. Kallesøe, J. & Dyhr-Jensen, S. in "Removal, Treatment and Utilisation of Waste Incineration Bottom Ash" by Holm, O.; Thomé-Kozmiensky, E. ISBN 978-3-944310-44-2. 2018.

Optimizing the large-scale ageing of municipal solid waste incinerator bottom ash prior to the advanced metal recovery: Phase I: Monitoring of temperature, moisture content, and CO_2 level. Nørgaard, K.P., Hyks, J., Mulvad, J.K., TI, Hjelmar, O. Accepted for print in Waste Management 85 (2019) 95–105.