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FLYASH TREATMENT

TECHNOLOGY ANALYSIS, ENVIRONMENTAL SCREENING, ECONOMIC ASSESSMENT AND FAMEWORK CONDITIONS IN DENMARK

Bright ideas. Sustainable change.

CONTENTS

1. INTRODUCTION

The majority of the Danish waste to energy industry have come together to conduct a study of future treatment options for waste to energy fly ash with national treatment and recycling. The objective of this project is to find the most attractive technology for municipal solid waste incineration (MSWI) fly ash treatment in Denmark with material recycling. The project is based on extensive analysis and assessments of literature data for the treatment processes.
The report consists of six elements:

- Summary conclusion
- Memo 1: Technology screening and analysis
    - Technical screening of a wide range of technologies
    - Technical and commercial readiness of mature technologies
- Memo 2: Environmental screening
- Memo 3: LCA on relevant scenarios
- Memo 4: Business case on relevant scenarios
- Memo 5: Framework conditions for fly ash treatment

The main objectives of Memo 1 and 2 are to select the most promising technology(ies) for use in Denmark within a 5 years' timeframe. The following memo 3 and 4 investigate the selected technologies and memo 5 summarise the current and near future expected framework conditions. Below individual introduction of the memos is presented.

The Danish EPA participated in the discussions during the course of this project and took active part in evaluating the results and interpretation of the framework conditions. However, the reporting and evaluations reported here is made by the suppliers (Ramboll, DTU Environment and DANWS) on behalf of the Danish WtE industry and not the Danish EPA.

1.1 Memo 1: Technology screening and analysis – prepared by Rambøll

This memo was the first report to be made and it consists of two main parts. The first part describes a screening of a wide range of technologies for MSWI fly ash treatment and provides a quick analysis and employs Technology Readiness Level (TRI) and Commercial Readiness Index (CRI) evaluations of each technology. This short analysis is used to choose which technologies are mature enough to go through the more extensive analysis that is provided in the second part.
The second part creates an overview of each technology with CRI of 3 or above. A more thorough analysis of these technologies is provided including process flow diagrams, mass balances and other relevant data tables such as transfer coefficients of chemical elements. Analysed data is all based on information from literature.

This report was made in the beginning of the project and the conclusions drawn created the rationale for which technologies were chosen for environmental screening.

1.2 Memo 2: Environmental screening – prepared by DTU Environment

The report provides a preliminary assessment of the potential fate of selected elements of typical environmental concern associated with the treatment and management of MSWI fly ash in Denmark.

The purpose of this study was to evaluate and compare potential emissions and metal recovery considering time horizons of 100 years (100y) and 500 years (500y) for a selected number of elements, and to quantify the “concentrating” and “dilution” potential of the technologies through a statistical entropy indicator.

The conclusions of this report are used for deciding which technologies should be analysed through a Life Cycle Assessment (LCA).

1.3 Memo 3: LCA on relevant scenarios – prepared by DTU Environment

This memo provides an LCA of selected scenarios for the treatment of MSWI fly ash in Denmark, in comparison with the current system, i.e. shipping and utilisation outside Denmark (baseline scenario). Four technologies are considered and extensively analysed with respect to their overall environmental impacts. The overall environmental impacts were calculated using both normalised impacts, e.g. PE / tonne fly ash (where PE indicates “person equivalent”), and characterised impacts, e.g. kg CO2eq / tonne fly ash. The report provides tables and graphs that compare the four technologies in different environmental impact parameters.

The conclusions drawn from the LCA combined with former conclusions establish the basis for two chosen technologies to be analysed.

1.4 Memo 4: Business case on relevant scenarios – prepared by Rambøll

A business case has been evaluated for two future possible methods of treatment of fly ash in Denmark to evaluate the financial impact of introducing such recycling of the fly ash and a potential solution.

In general, calculations are made in absolute terms thus, the treatment cost can be directly compared with the similar cost for export of fly ash. All internal cost that is not related to the subsequent treatment solution will not be included. In this way differences in CAPEX and OPEX for national treatment solutions can be compared with the experienced treatment and handling cost for utilization in Norway and Germany. All cost etc. as well as performance of systems will be included in the assessment (i.e. considering all other things equal).

1.5 Memo 5: Framework conditions for fly ash treatment – prepared by DanWS

The material-oriented framework conditions for treatment and handling of MSWI fly ash that are likely to be relevant for the assessment of the different treatment solutions may be divided into two groups: One regarding the material streams from the FA treatment that can be recovered for beneficial use, and one regarding residual waste streams that cannot be utilized and therefore must be disposed of. In this context both the legislative environmental framework conditions associated with the utilisation of the material streams recovered for beneficial use and the disposal of the residual waste streams from the fly ash treatment have been considered. The functional requirements for specific applications of the material streams (classified as waste or products) have also been considered.

The regulatory framework surrounding recovery and application of a material stream will depend on whether the material can achieve End-of-Waste (EoW) status or can be classified as a bi-product, or whether it remains classified as a waste. The potential impact of relevant legislation and functional criteria on the material streams from the various fly ash treatment processes is described and discussed.

2. SUMMARY CONCLUSIONS

The project Future safe handling of waste incineration fly ash including recycling and a national Danish solution includes a number of sub studies concluded in this memo

2.1 Technical screening

The first part of the project screened known relevant technologies according to following properties:

- Technology technical maturity
- Technology commercial maturity
- Material recycling

The technology maturity is estimated by technology readiness level (TRL) index and the commercial readiness index (CRI), was applied to complement the TRL by assessing the commercial maturity of technologies. Material recycling is defined as recycling of metals, salt and/or other material not ending at a landfill or final deposit site (recycling with a low degree of final landfilling).
In total 28 technologies were evaluated for all three parameters. The following technologies were concluded to be able to meet TRL 8 and CRI 3 within 5 years:

- Carbon8
- FLUWA/FLUREC
- Renova/Götaverken miljö
- HALOSEP
- NOAH, salt by evaporation

Furthermore the current solutions in German Salt mines and on Langoya, Norway is used as reference throughout.

2.2 Environmental screening

Based on a 500y time horizon, Scenario Carbon8 demonstrated higher emissions to the environment than all other fly ash treatment technologies. It is noteworthy, however, that very limited data on the potential leaching behaviour of Carbon8 products was available. Comparable emissions to the environment were estimated in the case of Scenarios Flurec, Fluwa, Halosep and Renova, although Scenario Renova performed slightly better in almost all cases. Negative substance concentration efficiencies were calculated in the case of Carbon8, and in contrast to the other technologies, the fate of the demolished concrete blocks containing Carbon8 is unclear, as they could be distributed potentially anywhere in the society.

2.3 LCA

The scenario representing status que (in Germany or Norway) presented the lowest burdens to the environment. The Washing and Recycling scenarios (FLUWA) showed lower impacts (or higher savings) than the scenario where fly ash is encapsulated in lightweight aggregates (Carbon8) in most impact categories and only in a few impact categories the Carbon 8 scenario presented lower impacts. Relatively large uncertainty behind the long-term effects from the lightweight aggregates made it difficult to define a simple ranking across the scenarios. In the case of Global Warming, the Washing and Recycling scenarios and Cabon8 performed similarly. In general, the impacts from the Washing and Recycling scenarios were slightly lower in the case of salts recovery, but they were very sensitive to uncertainties. The toxicity impact categories were the ones that showed the highest uncertainty in the results, especially with regards to the Carbon8 Scenario.

2.4 Business case

The Washing and Recycling scenarios (FLUWA) and production of an aggregate (CARBON8) were evaluated and the methods was compared to current costs. The conclusion is that all assessed options will most probably be more expensive than today ranging from a similar cost as today for Carbon8 and up to more than four times the cost with washing and recovery of zinc as a pure metal for recycling. It is also concluded that the scenarios with most recycling unfortunately also were the most expensive to perform. It is concluded that rising costs from just below 1 000 DKK/tonne of fly ash today to a cost of more than 3 000 DKK/tonne has the potential to ensure recycling of materials with a total value of around 400 DKK.

2.5 Framework conditions

The End of Waste classification of Carbon8 aggregates in the UK is found not to be applicable in Denmark. The aggregates will be considered waste or perhaps hazardous waste. However, it is also concluded that the data available is found to be so scarce that even this conclusion is very uncertain. Also, for the washing technologies it is unclear how end products will be classified, and data is lacking for a further evaluation against current legislation. As a minimum total content analysis and comprehensive leaching tests must be performed meeting not only waste related legislation but also to meet product standards for the application proposed.

It is noted that the European legislation on End of Waste have changed during the project period and a new Danish legislation guideline have been published. This results in uncertainty in how the new legislation is to be interpreted and used in practice – this should be studied in more detail. Some uncertainty also exist around how authorities will handle applications of product use or end of waste and to some extend how different authorities (national and local) will work together and who will have decision authority. The working thesis is that if a WtE facility applies the national Environmental Agency will make the decision but if the applicant is another local company perhaps the decision could be made locally even without consulting the Environmental Agency.

2.6 Project conclusions

Several emerging and new (to the commercial market) technologies have been reviewed for their technical, environmental and financial performance. Starting with screenings of a wide range of technologies the number was narrowed down by the technological and commercial readiness as well as the environmental performance. For a limited number of relevant scenarios of technologies soon to be ready for the market further analysis was performed using Life cycle Assessment to evaluate environmental impacts and a financial model to evaluate their cost of treatment.

It is concluded that several technologies could be ready for commercial introduction within a 5-year time horizon and that they can be grouped into two groups:

1) Fly ash washing and Zn recovery.
2) production of lightweight aggregate.

Environmentally both the scenario with fly as washing and production of aggregate are worse than what is done today, and the best-case scenario is washing with Zn and Salt recovery even though the differences are too small for this to be significant. It is concluded that the use of light weight aggregate will result in big uncertainty with regards to human and environmental toxicity and the fate (spread in society) of potentially harmful substances is a real risk.

The financial model revealed big differences in the treatment costs of the different alternatives with the current situation as the probably cheapest option. Of the alternatives the production of light weight aggregates was by far the cheapest as it was four times cheaper than the scenario with the highest amount of recycling (Zn and salt recovery). However, the value of the materials recycled was far lower than the cost of treatment.

Evaluating the framework conditions revealed that the status of Carbon8 light weight aggregates as end of waste judged in the UK would not be relevant in Denmark where the aggregates would either be waste or hazardous waste. The data on all technologies on their products was found to be too poor to judge their legal status for reuse or even landfilling. Further analysis and evaluations must be done to further assess what can be recycled, exported, landfilled and perhaps be deemed end of waste.

3. APPENDICES

3.1 Memo 1: Technology screening and analysis

3.2 Memo 2: Environmental screening

3.3 Memo 3: LCA on relevant scenarios

3.4 Memo 4: Business case on relevant scenarios

3.5 Memo 5: Rammebetingelser for genanvendelse af flyveaske