# LIFE CYCLE ASSESSMENT OF NOVEL TECHNICAL ROUTES TO VALORISE MSWI BOTTOM ASH

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## Introduction

Incineration processes produce solid residues, such as fly ash, APC residues and bottom ash, the latter representing around 85-95 wt%. of the residues amount.[1] Currently, MSWI BA is usually dried, mechanically treated, and eventually landfilled or used as road aggregate.[2] However, ongoing research is focusing on the potential to recover MSWI BA for higher value applications, such as the production of ceramics.[1] In this study, three different scenarios are evaluated to assess the potential for resource recovery of MSWI BA. In particular, the study aims at assessing the environmental impacts and resource recovery potential of different and novel MSWI BA valorisation routes in comparison with the more common solution of using it as unbound aggregate in road construction. The study focuses on the influence of quality and recoverability of Fe and non-Fe metals on the environmental performance of the alternative scenarios evaluated.[3] The quality and actual marketability of the recovered metal fractions is affected by the composition of the bottom ash, the agglomeration of the fractions, and mostly by the particle size.

## Materials and Methods

A life cycle assessment (LCA) was conducted to compare three scenarios which represent three possible valorisation routes. The scenarios, summarised in Figure 1, were built based on chemical and material quality analyses,[4,5] and on the vitrification and further processing of the slag for the production of glass ceramics.[6] In this preliminary assessment the system boundaries were limited to the production of the secondary materials and did not include their use phase and end-of-life. The impact of this choice on the results will be discussed in paragraph 3. The chosen functional unit (FU) was defined as “the treatment of 1 kg of MSWI BA in Belgium”.[3] The LCA was conducted using the GaBi software version 8.0. Data for material and energy requirements were obtained from the mentioned studies.[5] When data was not directly available it was estimated or obtained from related literature.[3] The Ecoinvent database v.3.2 was used for data on background processes such as energy production, recycling and primary materials production, and transport. The impact categories considered in the life cycle impact assessment (LCIA) of the scenarios are Global Warming Potential (GWP), Acidification Potential (AP), Resource Depletion (RD), Human Toxicity (HT), and Ecotoxicity (ET).[3,7]

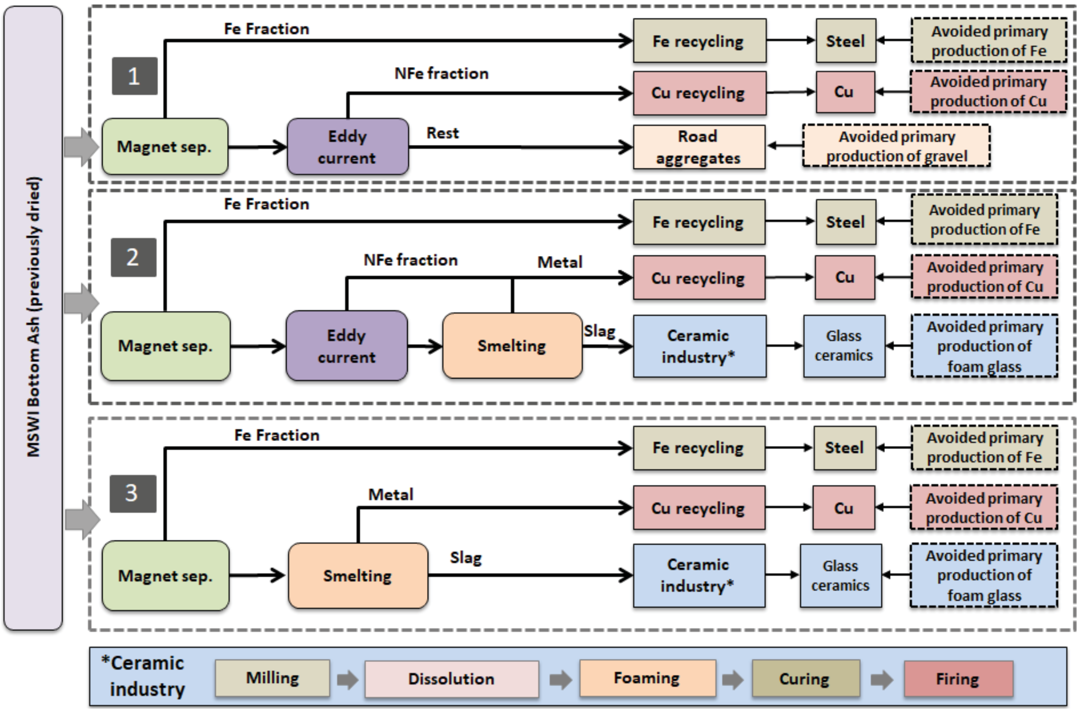


**Figure 1:** Summary of the three scenarios

## Results and Discussion

The study assessed the environmental performance of novel MSWI BA valorisation routes as studied by Lucas *et al.*[4,5] and Rabelo Monich *et al.*[6]. The outcome of their research enabled to better understand the influence of particle size, agglomeration and oxidation on the recovery efficiencies of the fractions (Fe, Cu). Recovery efficiencies and substitution rates were determined based on the outcome of the mentioned studies. The resulting metal recycling rates are reported in Table 1.

**Table 1:** Metal recovery efficiencies obtained[2,3]

| $\eta^{rec}$ [%] | Fe | Cu |
|---|---|---|
| Scenario 1 | 41 | 25 |
| Scenario 2 | 41 | 78 |
| Scenario 3 | 41 | 81 |

The higher recovery efficiency of copper in scenario 3, and the lower environmental impacts related to the mechanical treatment processes (see Figure 2), due to the lack of eddy current separation, highlight the influence of the particle size and the quality of the recovered fractions on the performance of the mechanical separation. Results in Figure 2 show the environmental benefits obtained for the avoided production of the primary resources, positively influencing categories such as GWP, AP, and resource depletion (Figure 3) which lead to overall environmental savings. However, the disposal of residues from the mechanical treatment and from the smelting process has significant influence on the toxicity categories (Figure 3), leading to increased overall impacts. Indeed, the choice of disposal of residues such as fly ash and APC residues can reflect a worst case scenario, and should further be addressed.

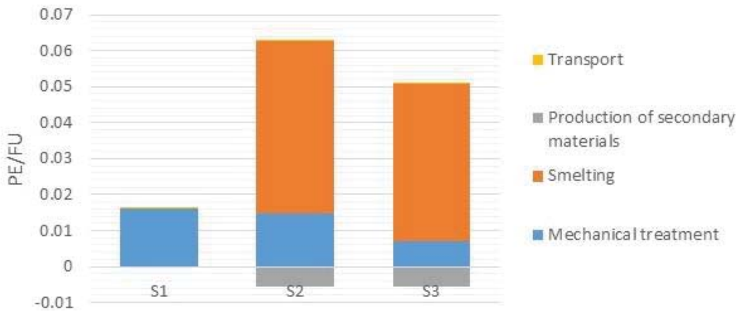


**Figure 2:** Normalised results for the three scenarios in Person Equivalent (PE)/FU

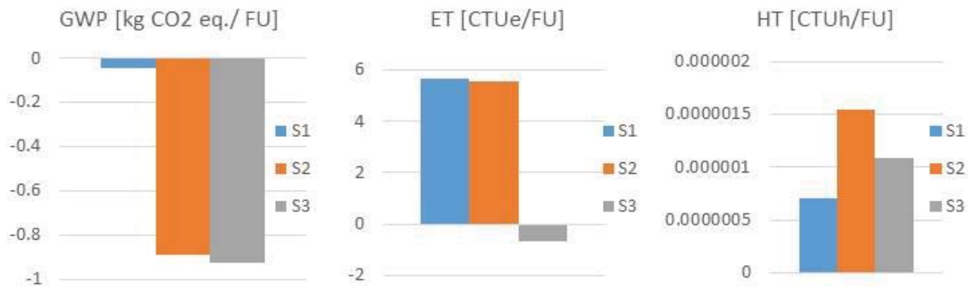


**Figure 3:** Total results for the three scenarios for the impact categories Global Warming Potential [kg $CO_2$eq.], Ecotoxicity [Comparative Toxic Units (CTUe)] and Human Toxicity [Comparative Toxic Units (CTUh)]

Life cycle assessment results are highly dependent on the goal and scope definition, modelling choices, and data availability. In this study, the system boundaries only take into account the treatment of the BA and the production of aggregates or foams. This choice neglects the emissions and impacts during the use phase and end-of-life (EoL) of the products. This choice should further be discussed, as results could vary significantly in relation to the impacts of the use phase and EoL of the materials.[3,7,8] Moreover, leaching tests EN 14405 should be conducted to assess the compliance of the quality and leaching properties of MSWI BA for use as unbound aggregates in road construction.[2] Studies on the environmental properties of MSWI BA aggregates used as subbase or in concrete blocks have shown how leaching potential and requirements depend on the pre-treatment, the application, the environmental conditions, and thus on the planned use phase and end-of life.[3] The assessment of the whole life cycle of the products would therefore give a more consistent understanding of the potential, burdens and benefits associated with the recovery of MSWI BA, and will be addressed in further studies.

## Conclusions

It has been proven that a more advanced and alternative management solution for pre-treated MSWI BA could be technically feasible. As the preliminary environmental impact results have shown, energy intensive processes and disposal of residues still represent a significant environmental burden. On the other hand, these new valorisation routes would lead to avoid the production of virgin materials and thus avoid the impacts associated with these processes in categories such as GWP, AP and resource depletion. Nevertheless, a more detailed assessment of the alternative valorisation solutions should be carried out in a whole life cycle perspective. The use phase and end of life of all potential applications of the new materials should be taken into account as to address also the related impacts and resource consumption.

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