Assessment of resource recovery within LCA: Innovative assessment of resource potentials in waste

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Assessment of resource recovery within LCA
Innovative assessment of resource potentials in waste

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Introduction

Environmental Life Cycle Assessment (LCA) studies of Waste Management Systems (WMS) have until now almost entirely been applied using Gate-to-Grave boundaries (zero-burden approach). This has several drawbacks:

- As the waste is "for free", it removes responsibility for optimal utilization of the input waste.
- Modern WMS becomes net saving systems without a possibility to compare to a baseline resource potential.

The purpose of this study is to investigate possibilities of including upstream raw material production as "Resource Potential" in LCA of Waste Management Systems.

This can contribute to:

- Emphasize on recovery efficiency and effectiveness by comparing savings and recovery cost with the resource potential.
- Performance comparison between different systems as well as for waste prevention modeling.

Method

A LCA case study of aluminum recovery from bottom ash is extended with virgin aluminum production corresponding to the amount present in the bottom ash.

- Functional Unit: 5,000 tonnes of bottom ash from incineration
- Geographical and temporal scope: Bottom ash management in Denmark, 2013
- Time horizon: 100 years
- Impact assessment: IPCC 2007, Climate change, GWP 100a

Two systems each with & without considering the Resource Potential, only difference is the aluminum content:

S1: 1.50 % Aluminum content in bottom ash
S2: 0.75 % Aluminum content in bottom ash

Recovery performance indicators are calculated as:

\[ \text{Resource effectiveness} = \frac{\text{Savings}}{\text{Resource cost}} \]

\[ \text{Resource efficiency} = \frac{\text{Savings}}{\text{Total cost}} \]

Results & Discussion

The goal of resource recovery is to optimize savings over costs given the available input material. Identifying the best combination of technologies in a system can be facilitated by assessing the effectiveness and efficiency of the recovery as done in the following.

Comparison of the systems without inclusion of the Resource Potential in Figure 3

- S1 is perceived better due to a larger numerical saving
- This does not take into account the difference in input flow composition.

Comparison of the systems including the Resource Potential in Figure 3

- S2 performs better due to smaller numerical losses in the system
- the aggregated impacts (Total) therefore represents a lost potential for recovery.

The recovery effectiveness (Table 1) for each system is the same, since the ratio of inputs to recovered amounts are identical.

The recovery efficiency (Table 1) is 1% lower for “S2 incl. RP” due to higher recovery cost (Sorting and Treatment) whereas S2 has a slightly lower performance than S1.

**Figure 1:** Inclusion of raw material production as extension to state-of-the-art Gate-to-Grave LCA of WMS

**Figure 2:** Conceptual model of the extended WMS as used for modeling Al recovery from bottom ash from incinerated household waste.

**Figure 3:** Characterized results of the two systems (S1 & S2) with and without including the Resource Potential (RP).

**Table 1:** Recovery performance indicators

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<thead>
<tr>
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<th>Recovery Effectiveness</th>
<th>Recovery Efficiency</th>
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</thead>
<tbody>
<tr>
<td>S1 incl. RP</td>
<td>23%</td>
<td>21%</td>
</tr>
<tr>
<td>S2 incl. RP</td>
<td>23%</td>
<td>20%</td>
</tr>
</tbody>
</table>

Conclusion

- The proposed extension enables comparison between material recovery systems by including the Resource Potential.
  - Ordinary Gate-to-Grave LCA in the case study shows significant advantage for S1
  - Inclusion of Resource Potential reveals identical rates of recovery with S2 being only slightly less efficient than S1. In addition, the inclusion of Resource Potential highlights the higher loss of potential for recovery in S1.
  - Recovery Effectiveness & Efficiency indicators provide information on the system performance useful for comparing and optimizing resource recovery in WMS systems.
  - The use of Resource Potential can facilitate modeling and comparison of upstream waste prevention activities.

- Future studies shall explore:
  - Recovery of energetic resources through e.g. incineration
  - Choice of where in the product chain to select level of raw material refinement for e.g. composite materials.

References