Best Practice LCA: End-of-Life Modelling

October 28, 2014
Agenda

1. Modelling EoL in LCA
2. Recycled content approach
3. Avoided burden approach
4. Value-corrected substitution
5. PE’s recommendations
6. Current PEF discussions
Modelling EoL in LCA
Modelling EoL in LCA

General challenge

• “Allocation” is commonly used to assign burdens associated with the upstream supply chain to each product of multi-output processes.

• EoL modelling gives rise to a similar problem due to its multi-functionality – treat waste and produce valuable products (material and/or energy).

• Focus on how the burden of virgin material production and the burden of EoL treatment be allocated between the first application in one product system and its subsequent application in the same or another product system.

• Chosen allocation approach will affect modelling of other EoL pathways as well (e.g., landfill).
Modelling EoL in LCA

Most common approaches

- Recycled content approach (a.k.a. cut-off, 100/0)
- Avoided burden approach (a.k.a. End-of-Life recycling, 0/100)
- Value-Corrected Substitution
Recycled content approach
Recycled content approach

General description

• Scrap inputs to the product system are modelled as being free of any primary material burden (all assigned to the first life cycle).

• The recycling of scrap generated by the product system is not part of the product system and the system boundary is drawn at the point of scrap generation. **No credits for subsequent recycling.**

• When modelling other disposal processes (e.g., incineration with energy recovery, landfill with landfill gas capture), burdens are included, but no credits should be given for energy recovery.
No credits are given for energy recovery or other avoided processes when using the recycled content approach.

No burdens are given for scrap consumed by the products system.

No credits are given for scrap generated by the product system.
Recycled content approach

Example GaBi model

Plastic recycling
- No burdens are given to plastic scrap input to this process

Virgin plastic

Plastic component

End of Life
- Plastic recycling at end of life is not modelled... a dummy process can be included if it is desired to view the scrap output flow in the plan

- Landfill of plastic
- Incineration of plastic

No credits are given to energy recovery from these processes
Avoided burden approach
Avoided burden approach

‘Burden of scrap’ variant

- End-of-life scrap is recycled and offsets demand for an equivalent quantity of virgin material (assuming no changes in the inherent material properties).

- Scrap inputs to the product system are assigned an upstream burden of primary production which equals the credit that the previous product system would receive.

- If the product system is a net consumer of scrap (i.e. scrap input > scrap output), then the upstream burden overcompensates the EoL credit.
Avoided burden approach

‘Burden of scrap’ variant

• Adds primary material burden to the manufacturing phase of products with recycled contents

• Cradle-to-gate burdens of primary and secondary materials become indistinguishable

• May discourage the use of secondary materials in LCA studies where differences in cradle-to-gate burdens are critical (e.g., automotive lightweight studies where it affects the break-even mileage).
Avoided burden approach

‘Net scrap’ variant

• Scrap collected at End-of-Life is reduced by any scrap inputs to the product system.

• Remaining ‘net scrap’ is recycled and primary burden can be handed off to subsequent product system based on overall recycling rate (assuming no changes in the inherent material properties).

• If the product system is a net consumer of scrap (i.e. scrap input > scrap output), then this credit becomes a burden instead.
System boundary (*net scrap*)

In this example, there is a net scrap surplus resulting in a credit at end of life.
In this example, there is a net scrap deficit so the credit becomes a burden.
Avoided burden approach

Example GaBi model

Scrap arising at end of life satisfies demand for scrap input for recycled content

Virgin plastic

Remaining scrap is recycled and offsets production of virgin plastic. If scrap input exceeds scrap generation at end of life this will calculate the burden associated with net scrap consumption

Recovered energy from alternative disposal options is also credited

Plastic recycling

Avoided primary material

Incineration of plastic

Electricity credit

Energy credit

Electricity grid mix

Thermal energy from natural gas

Plastic component

End of Life

Plastic recycling

Landfill of plastic

Sustainability Performance
Value-corrected substitution
Value-corrected substitution

Addressing the downcycling issue

• Open-loop recycling with “change in inherent properties”
• System boundary drawn at scrap level
• Partial credit of primary burden based on scrap-to-virgin price ratio
• Aims to account for the (hypothetical) effort necessary to restore the virgin material quality due to scrap pollution with unwanted materials
• Able to distinguish different levels of downcycling based on scrap price
• System boundary to be set with caution: all ‘upcycling’ steps prior to remelting or mixing with other scraps need to be included

Value-corrected substitution

System boundary (VCS 2.0)
Value-corrected substitution

Examples of modelling in GaBi

Value-Corrected Substitution 2.0

EU and US data for Al and St scraps available in both ProfDB and US extension
Examples of modelling in GaBi

Value-Corrected Substitution 2.0

Enter product’s Al alloy content

Connect collected EoL scrap

![GaBi software interface](image)
Recommendations
PE’s recommendations

Scope dependent & pragmatic

• **Strive for consistency**

• **Avoided burden (net scrap)** is the method of choice for the metals industry and recommended for plastics.

• **Recycled content** should be applied for materials
  • which have significant recycled content, **AND**
  • where there is no 100% recycling from waste inventory available, **OR**
  • where there is no 100% primary inventory data available as a credit.

• **Value-corrected substitution (VCS 2.0)** can be used in all situations where open-loop recycling with downcycling is known or suspected to be relevant.
The choice of EoL allocation approach is a ‘book keeping’ issue → the numbers change, reality does not.

While it often will change your results, it should not completely flip the conclusions of your study.

Test your results using different approaches and/or substitution factors.

### Table 5-1. End-of-Life Scenario Evaluation

<table>
<thead>
<tr>
<th>EoL Scenario</th>
<th>Average Case Savings (t CO₂)</th>
<th>Mass-Restricted Savings (t CO₂)</th>
<th>Volume Restricted Savings (t CO₂)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value-Corrected Substitution</td>
<td>16.3</td>
<td>17.8</td>
<td>4.1</td>
</tr>
<tr>
<td>Avoided Burden</td>
<td>16.9</td>
<td>18.4</td>
<td>4.7</td>
</tr>
<tr>
<td>Cut-off</td>
<td>9.2</td>
<td>10.7</td>
<td>-2.9</td>
</tr>
</tbody>
</table>
Current PEF discussions
Modelling EoL in LCA

PEF 50/50 approach

\[
(1 - \frac{R}{2})E_v + \frac{R}{2}E_{\text{recycled}} + \frac{R}{2}E_{\text{recyclingfioL}} - E_v \times \frac{Q_s}{Q_p} + \frac{R}{2} \times (E_{\text{ER}} - LHV \times X_{\text{ER,heat}} \times E_{\text{SE,heat}} - LHV \times X_{\text{ER,elec}} \times E_{\text{SE,elec}}) + \left(1 - \frac{R}{2} - \frac{R}{2}\right)E_D - \frac{R}{2}E_D
\]

- Open issues have been noted
- Currently in pilot phase
- [http://www.gabi-software.com/resources/resources-PEF-test-kit/](http://www.gabi-software.com/resources/resources-PEF-test-kit/)
Modelling EoL in LCA

PEF 50/50 approach

Secondary as 50% primary

Material production

Production

Use

Collection

Material recycling

Qs/Qp

Credits 50%

Landfill

Credits 50%

Energy recovery

Credits 50%

Primary
EN 15804 “Module D” approach

Avoided burden approach

Secondary as 100% primary

Material production → Production → Use → Collection

Material recycling

Qs/Qp | Credits 100%

Landfill

Credits 100%

Energy recovery

Credits 100%

Looping back of the secondary material
Modelling EoL in LCA

PEF Integrated Approach?

<table>
<thead>
<tr>
<th>Sec. as 100% primary</th>
<th>Qsin/Qp</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material production</td>
<td>Production</td>
</tr>
<tr>
<td>Primary</td>
<td></td>
</tr>
<tr>
<td>%</td>
<td></td>
</tr>
</tbody>
</table>

- Material recycling: Qs/Qp, Credits 100%
- Landfill: Credits 100%
- Energy recovery: Credits 100%
Upcoming webinars

**Best Practice LCA**
- Water assessment methods - Dec 2, 2014, 16:00 CEST
- Water footprinting in GaBi - Dec 9, 2014, 16:00 CEST

Questions?

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