Does the recycling of rare earth elements fit in a strategy against climate change?

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“Does the production of 1 kg of recycled YOX cause lower impacts on global warming than the production of 1 kg of primary YOX?”

→ Consequential Life Cycle Assessment
LCA Inventory analysis

Avoided landfilling of powder

Avoided supply of primary glass

System boundaries of the LCA study

System boundaries of the foreground subsystem

Phosphorous powder

Treatment

Separation 1 → La/Ce → Separation 2

Separation 3 → Yttrium → Process YOX

Separation 4

Separation 5 → Europium → separation process

Glass

Lanthanum

Cerium

Terbium

Residual Europium

Recycled YOX

1 kg

Avoided supply of primary REEs ???
# LCA Inventory Analysis

<table>
<thead>
<tr>
<th>Element</th>
<th>Market outlook (EC, 2014)</th>
<th>Marginal supplier (considering current technologies)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Primary mining</td>
</tr>
<tr>
<td>Cerium</td>
<td>Increasing surplus</td>
<td></td>
</tr>
<tr>
<td>Lanthanum</td>
<td>Increasing surplus</td>
<td></td>
</tr>
<tr>
<td>Praseodymium</td>
<td>Increasing surplus</td>
<td></td>
</tr>
<tr>
<td>Neodymium</td>
<td>Tight</td>
<td></td>
</tr>
<tr>
<td>Samarium</td>
<td>Large surplus</td>
<td></td>
</tr>
<tr>
<td>Europium</td>
<td>Shortage</td>
<td></td>
</tr>
<tr>
<td>Gadolinium</td>
<td>Large surplus</td>
<td></td>
</tr>
<tr>
<td>Terbium</td>
<td>Shortage</td>
<td></td>
</tr>
<tr>
<td>Dysprosium</td>
<td>Increasing tightness</td>
<td></td>
</tr>
<tr>
<td>Yttrium</td>
<td>Shortage</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>Large surplus</td>
<td></td>
</tr>
</tbody>
</table>

- **Used in fluorescent lamps**
  - **Scenario 1**: Fluorescent lamps displace halogen lamps
  - **Scenario 2**: Fluorescent lamps compete with LED lamps

- **Used as substitute of dysprosium in magnets**

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“Does the production of 1 kg of recycled YOX cause lower impacts on global warming than the production of 1 kg of primary YOX?”

- **Scenario 1:** Fluorescent lamps displace halogen lamps
- **Scenario 2:** Fluorescent lamps compete with LED lamps

**Interpretation**

**Scenario 1:** Increased supply of “residual europium” results in an increased production and use of energy-saving lamps

**Scenario 2:** Increased supply of “residual europium” results in a delayed transition towards more energy-efficient LED lamps
Conclusions and perspectives

• Recycling of REEs is environmentally beneficial in the current market situation of the elements and the applications in which they are used

• The classification of materials as “critical” is well-reflected by a Consequential LCA

Medium-term (2015-2025) criticality matrix (US DOE 2011)