EV&HEV battery developments and prospectives: Closed-loop battery recycling

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The Saft Group in 2011 - Key figures

With over 4,100 employees worldwide, Saft is present in 19 countries

Sales 2011 €628.7m

**Specialty Battery Group**

€271.1m

43.6 %*

High performance primary and rechargeable lithium and silver batteries for the electronics, defence and space industries.

**Industrial Battery Group**

€350.2m

56.4 %*

Rechargeable nickel and lithium-based batteries for demanding industrial applications.

* % of total sales excluding non-recurring revenue of €7.4 million

With over 4,100 employees worldwide, Saft is present in 19 countries.
Saft e-mobility experience

More than 15 years designing and delivering batteries for Electric Vehicle & Hybrid Electric Vehicles with various electrochemistry: Ni-Cd, Ni-MH and Li-Ion technologies
# Main industrial recyclers of Li-ion batteries

<table>
<thead>
<tr>
<th>Company (Country)</th>
<th>Processes</th>
<th>2012 annual capacity</th>
<th>Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>UMICORE (Belgium)</td>
<td>Pyrometallurgy + hydrometallurgy</td>
<td>7000 t</td>
<td>LiCoO₂ et LiNiMnCoO₂ for new batteries, Cu, Fe, slag for concrete</td>
</tr>
<tr>
<td>XSTRATA Nickel (Canada + Norway)</td>
<td>Pyrometallurgy + hydrometallurgy</td>
<td>3000 t</td>
<td>Alloy Ni, Cu, Co</td>
</tr>
<tr>
<td>TOXCO (Canada)</td>
<td>Cryogeny + hydrometallurgy</td>
<td>3500 t</td>
<td>Li₂CO₃, Co cake</td>
</tr>
<tr>
<td>SONY/SUMITOMO (Japan)</td>
<td>Pyrometallurgy</td>
<td>-</td>
<td>Co + fractions of Fe, Cu, Al</td>
</tr>
<tr>
<td>ACCUREC (Germany)</td>
<td>Pretreatment + Pyrometallurgy</td>
<td>850t (increasing)</td>
<td>CoMn alloy, lithium chloride</td>
</tr>
<tr>
<td>AKKUSER (Finland)</td>
<td>Dry technology crushing</td>
<td>-</td>
<td>Co fractions to OMG, Ni fractions to Nolrisk Ni</td>
</tr>
<tr>
<td>BATREC (Switzerland)</td>
<td>Crushing under inert atmosphere</td>
<td>1000t</td>
<td>Co, NF scrap, Ni scrap, plastics</td>
</tr>
<tr>
<td>RECUPYLYL (France)</td>
<td>Hydrometallurgy</td>
<td>110 t</td>
<td>Co oxides, Li₂CO₃, NF metals, stainless steel</td>
</tr>
<tr>
<td>SNAM (France)</td>
<td>Preteatment + Grinding</td>
<td>350t (increasing)</td>
<td>Co powder, graphite</td>
</tr>
</tbody>
</table>
Large Li-ion battery systems at End of Life: dismantled fractions to be recycled

Li-ion battery systems at EoL are dismantled and recycled according to the following fractions:

- Modules/cells
- Electronics, PCBs
- Outer casing
- Cables, connections
Environmental benefits of Li-ion recycling

What resources can be saved through recycling Li-ion batteries?

Scenario A: the recycling scenario:

387.4 MJ/kg cathode

Necessary processes:
- 1: MnSO₄ supply
- 2: NiSO₄ recovery
- 3: CoSO₄ recovery
- 6: Precursor production
- 7: Cathode production
- 8: Transport

Scenario B: from virgin Nickel and Cobalt ores:

795.4 MJ/kg cathode

Necessary processes:
- 1: MnSO₄ supply
- 4: NiSO₄ from virgin resources
- 5: CoSO₄ from virgin resources
- 6: Precursor production
- 7: Cathode production
- 8: Transport

The closed-loop recycling scenario results in a 51.3% natural resource savings, not only because of decreased mineral ore dependency but also because of reduced:

- fossil resource (45.3% reduction) and
- nuclear energy demand (57.2%)

Importance of battery recycling: Saft LCA

The functional unit is the manufacture, use and end of life of a battery system (a Li-ion battery with electronics incorporated in a 20 feet steel container) acting as an energy buffer on a solar farm of several MW over a twenty year period.

Two scenarios were studied:

> Without recycling: 100% primary materials
> With recycling in 20 years:
  • Modules (zero-waste closed loop recycling process from Umicore)
  • Container
  • Copper cables
Battery recycling lowers environmental impacts!

- **65%** of PED
- **73%** of GWP

**Primary energy demand from renewable and non-renewable resources (net calorific value)** [MJ]

**CML2001 - Dec. 07, Global Warming Potential (GWP 100 years)** [kg CO2-Equiv.]

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Conclusion

- **Complex battery system** to be taken into account in the LCA
- **Need for robust primary data** for positive active materials at cell level
- No possibility to use only a black box “Li-ion batteries” as available in some LCA softwares
- **Avoided burden approach**: Closed-loop battery recycling allows a high decrease of environmental impacts compared to the use of primary materials