Waste Batteries

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Overview

1. Introduction
2. European Battery Directive 2006/66
3. Implementation in Germany
4. Recovery technologies for waste batteries
1. Introduction

Main chemical systems

➢ Primary batteries (not rechargeable)
  • Zinc-carbon
  • Alkaline-manganese
  • Lithium
  • Silver oxide; Zinc Air
  • Mercury-oxide

➢ Secondary batteries or accumulators (rechargeable)
  • Lead-acid
  • Lithium-Ion, Lithium-polymer
  • NiMH
  • NiCd
1. German market 2010

- Automotive batteries: 130,000; 49%
- Industry batteries: 95,000; 35%
- Portable batteries: 43,000; 16%
2. The Batteries Directive 2006/66/EC

Aims:

- Prohibition on the placing on the market of batteries and accumulators containing hazardous substances.
- Promotion of a high level of collection and recycling of waste batteries and accumulators.

What is new?

- Applies to all battery types
- Ban on mercury and cadmium
- Producer responsibility: collection schemes and recycling
- Collection targets and recycling efficiency
2. The Batteries Directive 2006/66/EC

Definitions

 **Portable battery:**
  - is sealed and
  - can be hand-carried and
  - is neither an industrial nor an automotive battery.

 **Industrial battery:**
  - designed for exclusively industrial or professional uses
    or used in any type of electric vehicle.

 **Automotive battery:**
  - used for automotive starter, lighting or ignition power.

 **Producer:**
  - any person in a Member State that places batteries or accumulators, including those incorporated into appliances or vehicles, on the market for the first time within the territory of that Member State on a professional basis.
2. The Batteries Directive 2006/66/EC

Prohibitions

MS prohibit the placing on the market of

- all batteries or accumulators containing \( > 0.0005 \% \) of mercury
  Exemption:
  button cells up to 2 % Hg

- portable batteries or accumulators containing \( > 0.002 \% \) of cadmium
  Exemption:
  portable batteries and accumulators intended for use in:
  a) emergency and alarm systems, including emergency lighting;
  b) medical equipment; or
  c) cordless power tools (i.e.: biggest part of NiCd batteries)
    only until 31.12.2016.
Producer responsibility

- **Registration**
  Name; address; kind of batteries (portable, industrial, automotive); individual or collective system;

- **Organisational responsibility**
  - Collection schemes
  - information to end-users

- **Financial responsibility**
  Producers finance any net costs arising from collection, treatment and recycling

2. The Batteries Directive 2006/66/EC
Collection schemes for portable batteries

- End-users can discard waste portable batteries at any accessible collection point in their vicinity at no charge,
- Take back by distributors
- Collection scheme for batteries, individually or together with WEEE collection schemes
- Producers (and other economic operators) set up collection schemes
2. The Batteries Directive 2006/66/EC

Collection target for portable batteries:

Collection rate [%] = \[
\frac{\text{Weight of waste portable batteries collected in a year}}{\text{Average weight of portable batteries put onto the market in the last 3 years}}\]

- 25 % by 26 September 2012
- 45 % by 26 September 2016
2. The Batteries Directive 2006/66/EC

Collection schemes for industrial and automotive batteries

- **Industrial batteries:**
  Producers (or independent third parties) take back waste batteries from end-users.

- **Automotive batteries:**
  Producers or third parties set up collection schemes for batteries from end-users or from collection points in their vicinity, where no collection under ELV Directive 2000/53/EC is organized.
Removal of waste batteries

- Manufacturers are obliged to design appliances in order to facilitate the removal of waste batteries.
- Appliances into which batteries and accumulators are incorporated shall be accompanied by instructions showing how they can be removed safely.

Nobody cares about this regulation (e.g. Apple products etc.)
Treatment and recycling

- Best available technique (BAT)

- All collected batteries will be treated and recycled
  Exemption:
  no market for recovered products

- Minimum requirement for treatment:
  - Treatment shall, as a minimum, include removal of all fluids and acids
  - Treatment and any storage, including temporary storage, at treatment facilities shall take place in sites with impermeable surfaces and suitable weatherproof covering or in suitable containers.

- Minimum requirement for recycling:
  - recycling efficiency of **65%** for lead-acid batteries
  - recycling efficiency of **75%** for nickel-cadmium batteries
  - recycling efficiency of **50%** for other waste batteries
Disposal

- Member States shall prohibit the disposal in landfills or by incineration of waste industrial and automotive batteries and accumulators.
- However, residues of any batteries and accumulators that have undergone both treatment and recycling may be disposed of in landfills or by incineration.

National reporting to the Commission

- Reporting on implementation and national measures every three years
- Reporting on collection rates
- Reporting on recycling efficiencies
2. The Batteries Directive 2006/66/EC

Labelling
information for end-user for successful collection

- **Separate collection:** crossed-out wheeled bin

- **Heavy metals** (above threshold content)

- **Capacity labelling**
  - Primary portable batteries
  - Secondary portable batteries
  - Automotive batteries

2400 mAh
44 Ah/360 A
2. Situation in the EU
3. Implementation in Germany

Portable batteries:

The end-user has the guaranteed possibility to return the used batteries to:

- the common return system GRS, created by the majority of the producers, or
- a producer-owned return system, created by single producers which has to be approved by the competent authority

The return systems are obliged to submit a so-called success control until April 30 in the following year.
3. Return systems for portable batteries

End-user
Batteries from private households and small enterprises
No automotive batteries
No industrial batteries

Distributor

Municipality

Return System

Recovery/Disposal Companies
3. The common return system GRS

- Only for portable batteries
- Equally accessible for all producers of portable batteries
- Free take-back of waste batteries for all distributors, municipalities, treatment facilities for end-of-life vehicles and for WEEE
- Provision free of charge of containers
- About 90% of all portable batteries managed in this system
3. Automotive and industrial batteries

- The battery producer has to offer to distributors and treatment facilities for end-of-life vehicles and for WEEE an acceptable and free-of-charge return option.

- The owner of automotive and industrial waste batteries is not obliged to return the batteries to the producer.

- In case of industrial batteries producers, distributors and treatment facilities may negotiate different solutions.

- No collection and recovery targets
3. Automotive batteries

In Germany: refund system

- 7,50 € deposit when buying a new battery and not bringing back an old one
- No deposit when buying a new battery and bringing back an old one
- Completely separate collection system organised by the central association of the electrical engineering and electronic industry
- Positive market value for lead

→ Very high collection rate
3. Registration of all producers/importers

- Each producer/importer is obliged to notify his market participation in electronic format via Internet to the Federal Environment Agency.

- Publication of the list in the internet.
3. Success control

- Mass of the batteries put on the market and taken back detailed for each chemical system
- Qualitative and quantitative information on recovery and disposal
- Prices for sorting, recovery and disposal (only GRS)
3. Collection targets

<table>
<thead>
<tr>
<th>Date</th>
<th>Germany</th>
<th>EU</th>
</tr>
</thead>
<tbody>
<tr>
<td>September 26, 2012</td>
<td>35%</td>
<td>25%</td>
</tr>
<tr>
<td>September 26, 2016</td>
<td>45%</td>
<td>45%</td>
</tr>
</tbody>
</table>

Collection rate = \[
\frac{\text{collected mass in one year}}{\text{Average of the mass put on the market in the last 3 years}}
\]
3. Quantities of GRS 2013

<table>
<thead>
<tr>
<th>Category</th>
<th>Quantity</th>
<th>g/cap</th>
</tr>
</thead>
<tbody>
<tr>
<td>Put onto market</td>
<td>32.423 t</td>
<td>393 g/cap</td>
</tr>
<tr>
<td>Primary batteries</td>
<td>23.452 t</td>
<td>285 g/cap</td>
</tr>
<tr>
<td>Secondary batteries</td>
<td>8.971 t</td>
<td>109 g/cap</td>
</tr>
</tbody>
</table>
3. Collected quantities of GRS 2010

Average: 177 g/cap

This means:
Within Germany exist big differences as regards the collection rates.
3. Return paths to GRS 2013

- Retailers: 48%
- Municipalities: 24%
- Commerce: 28%
3. Sorting technology for portable batteries

- Separation with X-ray (SORBAREC by Redux company)
- Separation with electromagnetic field
- Simple hand-picking

Capacity: 15,000 t/y

Purity after separation: 98 – 99 %
3. REDUX sorting technology
3. Sorted quantities of GRS 2013

- Put onto market: 32.423 t = 393 g/cap
- Sorted batteries: 14.819 t = 180 g/cap = 46%
3. Recovery Rate and quantity for GRS
3. Recovery – disposal for GRS 2013

- Zinc (21%)
- Steel (containing nickel) (23%)
- Other residues for recovery (15%)
- Slag for recovery (15%)
- Lead (4%)
- Plastic for recovery (2%)
- Plastic for disposal (1%)
- Carbon (2%)
- Ferromanganese (5%)
- Cadmium (1%)
- Other metals (1%)
- Mercury (0%)
- Waste-water/exhaust-air (8%)
- Steel (containing nickel) (23%)
- Other residues for recovery (15%)
- Slag for recovery (15%)
- Lead (4%)
- Plastic for recovery (2%)
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- Carbon (2%)
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- Cadmium (1%)
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- Waste-water/exhaust-air (8%)
3. Prices

- Both collection and treatment create costs
- Silveroxide-button cells: no costs
- Lead- and NiMH-batteries: costs for collection, but recovery is profitable
- Lithium-ion/Lithium-polymer: \( \approx 25\% \) more expensive than Pb, NiMH
- Alkaline-manganese, Zinc-carbon: \( \approx 50\% \) more expensive than Pb, NiMH
- NiCd: \( \approx 100\% \) more expensive than Pb, NiMH
- Lithium: \( \approx 200\% \) more expensive than Pb, NiMH
4. Overview recovery/disposal options

- **Alkaline-manganese, Zinc-carbon, Zinc Air:**
  - Redux-process
  - Blast furnace process
  - Important: only batteries without mercury!

- **Lead-acid:**
  - Smelter

- **NiCd, NiMH:**
  - ACCUREC-process

- **Lithium:**
  - Rotary kiln

- **Mercury-oxide:**
  - Distillation
4. The blast furnace process

- **Filling**: The furnace is filled from above using an inclined elevator. Coke and crushed iron ore with chalk and batteries are fed into the furnace in alternating batches.

- **Top of the furnace**: Two cones hermetically seal the furnace during filling.

- **Water cooling**: The furnace wall must be cooled continually to prevent over-heating.

- **Ring pipe**: Carries hot air at a temperature exceeding 1300°C from the hot blast stove to the furnace. When the coke is being burned, the temperature increases to max. 2000°C.

- **Blast furnace gases**: Blast furnace gases collect at the top of the furnace. They contain 20% combustible carbon monoxide and 5% hydrogen. The zinc from the batteries is transported off with the gas. After purification, the blast furnace gas is burned to heat the hot blast stove. This is where hot air is generated from fresh air.

- **Size and operation period**: A blast furnace can be max. 50 m high and have a diameter of 30 m. It is usually in operation day and night for 10 years.

- **Reduction zone**: This is where iron oxide is reduced to iron. The oxygen from the iron oxide reacts with the carbon and carbon monoxide produced from burning coke.

- **Slag**: The slag floats above the pig iron preventing its oxidation to iron oxide. The slag can be used in road construction.

- **Pig iron run-off**: The liquid pig iron is heavier than the other materials. It sinks to the bottom of the blast furnace. Iron and manganese from the batteries is separated here. The run-off hole for pig iron is at the lowest point of the furnace.
4. REDUX process for ZnC / AIMn batteries

input
Sorted batteries

output waste / emissions
- other battery types for external recycling

Battery mixture

water vapour

Mechanical treatment and separation

water vapour, CO₂
slag for disposal

Black mass

Waelz kiln

output products
CuNiFe scrap
mercury

waels oxide
mercury

slag

ESWI: Study on the calculation of recycling efficiencies and implementation of export article (Art. 15) of the Batteries Directive 2006/66/EC
4. ACCUREC process for NiCd and NiMH

- **Incoming gross waste**
  - Sorting and removal of outer casings and electrolyte
    - Sealed batteries
    - Industrial batteries
    - Opening of cell: electrode separation
      - Carbon (reducing agent)
      - Electrode material
    - Pyrolysis and distillation
      - Air and water treatment and filtration
        - Treated air
        - Treated liquid and vapour water
  - Output waste / emissions
    - Outer Casing of Packs & Industrials
    - Flushable electrolyte (only industrials)
    - Non-recycled Plastic containers

©ESWI: Study on the calculation of recycling efficiencies and implementation of export article (Art. 15) of the Batteries Directive 2006/66/EC
4. Treatment of Lithium batteries
Thank you for your attention!
Typical composition of an AlMn battery

Manganese oxide 38%  Zinc 17%  Iron 19%  Other 10%  Electrolyte 6%  Water 10%

© GRS
Crusher
Black mass
Waelz kiln

Zinc-containing manganese dioxide from batteries and other zinc-containing products

Mixer

Intermediate Store

Water

Rotary Kiln

Filter

Coke

Slag

Waelz Oxide (Zinc Oxide)

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