Lithium Ion Battery Recycling Market 2018

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What we are Dealing with?

These are mobile phone Li-Ion Batteries – Just a small part of the overall Li-Ion cells world production
2018 – The need for Li-Ion battery recycling

- x-EV vehicles market share is around 3% of the ~90M new vehicles sold via 2018
- 60% of the Li-Ion cells produce in 2018 use for x-EV sold in 2018.
- Recycling is mandatory for supplying the materials needed by the tremendous grow of the li-ion battery industry in the coming years!

Source: Avicene – Florida conference 3/2018
How do we change this...?

To this...?
Battery Recycling Benefits

- Reduced demand for limited raw materials
- Reduced imports when recycled near cell manufacturing sites
- Avoid environmental material processing impacts – Recycling impacts are smaller
- Avoid waste treatment costs
Lead-Acid Batteries
The Most Recycled Product

- The Lead Battery has the best recycle rate compared to other consumer waste
  - Batteries – 99%
  - Corrugated Boxes – 88.5%
  - Steel Cans – 71%
  - Newspapers / Paper – 67%
  - Aluminum Cans – 55%
  - Tires – 40.5%
  - Glass Containers – 34%
  - PET Plastic – 31.3%
  - HDPE Plastic – 28.2%


And what about Li-Ion Batteries???
L.A. Battery Recycling Is Simple

A typical lead-acid battery recycling process:

1. Used battery
2. Refining
3. Cleaning
4. Polypropylene
5. Moulded plastics
6. New batteries

Recycle
Material Content of Li-Ion Battery

- It is difficult to specify exact numbers for the material content of a Li-ion battery scrap mixture because of the different Li-ion sub systems manufactured.
- Cobalt, Nickel, Lithium are the most valuable materials.

<table>
<thead>
<tr>
<th>Battery component</th>
<th>Product data sheets in mass-%</th>
<th>Self-determined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Casing</td>
<td>~20–25</td>
<td>~25</td>
</tr>
<tr>
<td>Cathode material (LiCoO₂)</td>
<td>~25–30</td>
<td>~25</td>
</tr>
<tr>
<td>Anode material (graphite)</td>
<td>~14–19</td>
<td>~17</td>
</tr>
<tr>
<td>Electrolyte</td>
<td>~10–15</td>
<td>~10</td>
</tr>
<tr>
<td>Copper electrode foil</td>
<td>~5–9</td>
<td>~8</td>
</tr>
<tr>
<td>Aluminium electrode foil</td>
<td>~5–7</td>
<td>~5</td>
</tr>
<tr>
<td>Separator</td>
<td>–</td>
<td>~4</td>
</tr>
<tr>
<td>Others</td>
<td>Balance</td>
<td>Balance</td>
</tr>
</tbody>
</table>
What is Needed to Make Recycling Practical?

- Identification of different li-ion battery sub-chemistries for an easy separation process.
- Viable recycling processes for each sub-chemistry or technology for producing valuable materials from mix stream.
- Acceptance of cell makers to buy and use recycled li-ion battery materials.
- Design for recycling can reduce recycling costs.
- Support of regulations and incentives can help.
<table>
<thead>
<tr>
<th></th>
<th>Pyrometallurgical</th>
<th>Hydrometallurgical</th>
<th>Physical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Materials recovered</strong></td>
<td>Co, Ni, Cu (Li and Al to slag)</td>
<td>Metals or salts, Li$_2$CO$_3$ or LiOH</td>
<td>Cathode, anode, electrolyte, metals</td>
</tr>
<tr>
<td>Feed requirements</td>
<td>None</td>
<td>Separation desirable</td>
<td>Single chemistry required</td>
</tr>
<tr>
<td>Comments</td>
<td>New chemistries yield reduced product value</td>
<td>New chemistries yield reduced product value</td>
<td>Recovers potentially high-value materials; Could implement on home scrap</td>
</tr>
</tbody>
</table>
20 Companies to Recycle Li-Ion Cells in 2018

- Japan – 3
- South Korea - 2
- Germany – 2
- China – 4
- Belgium – 1
- America – 4
- Switzerland – 1
- France – 2
- Australia - 1

- Estimation: 5-7% of li-ion cells produce worldwide are recycled.
- Recycling is concentrated in Far East and Europe but many companies are investing in R&D for entering the business.
Umicore – Lithium Battery Recycler

Umicore (Belgium) Sorting batteries, Recycling, Marketing of recycled materials (http://batteryrecycling.umicore.com/).
SungEel HiTech (Korea)

http://www.sungeel.com

SungEel founded a joint venture company in the USA that started to recycle li-ion cell in the USA in cooperation with a local company.
GEM – China

The flowchart of recycling process for spent batteries

http://www.gemchina.cn
Brunp Recycling (China)

Brunp is one of the 2 larger li-ion recyclers in China
LithoRec (Germany)

http://www.lithorec.de/
Nissan, Sumitomo Corp. and 4R open plant in Japan to recycle EV batteries

26 March 2018

4R Energy Corporation, a joint venture between Nissan and Sumitomo Corporation, is opening Japan’s first plant specializing in the reuse and recycling of lithium-ion batteries from electric vehicles.

The availability of used lithium-ion batteries is expected to increase significantly in the near future as buyers of the first generation of electric cars look to replace their vehicles. The recycling and refabrication of such batteries is expected to have a substantial impact on the battery industry, affecting demand for new battery materials, and on the environment and society as a whole.

Established in 2010 by Nissan and Sumitomo Corporation to focus on the effective reuse of electric-car batteries, 4R has gained valuable expertise. [Earlier post.] The company has developed a system that quickly measures the performance of used batteries, and it plans to apply this innovative technology to batteries collected from all over Japan at the Namie plant in eastern Japan.

The plant will serve as the global center for 4R’s development and manufacturing. The batteries recycled and refabricated at the factory will be used to offer the world’s first exchangeable refabricated battery for electric vehicles, and will also be used in large-scale storage systems and electric forklifts.

The plant is the first new factory in Namie since the town was devastated by Japan’s March 2011 earthquake and tsunami, and is expected to help revitalize the local economy.
OnTo Technology – Li-Ion LFP Battery Recycling (USA)

Low Capital Cost, High Efficiency

1. Open Packs or Modules
2. Open cells / shred
3. Extract Ely

4. Separate Materials
5. Refurbish Electrodes
6. Dry and Prep.
7. Finished product

www.onto-technology.com
Chinese firm invests in South Korea battery recycling partnership

New Joint Venture with Taisen Recycling in South Korea will receive waste batteries from overseas at the refinery and export the Lithium-ion batteries raw materials to China for the final process of Cobalt, Nickel, 3-1 Compound (Co,Ni,Mn) and Lithium Carbonate Battery Grades
Retriev Technologies (USA)
Anaheim, CA, USA - company to recycle batteries including lithium batteries by freezing them at -196 °C through cryogenic processes.

The company has a technology for Li-Ion recycling and use to do that in the past. Today it the company is not recycling Li-Ion cells and batteries (Our best knowledge)

http://retrievtech.com/
Recupyl (France)

**RECUPYL: FROM WASTE TO STRATEGIC METALS**

Recupyl’s innovative process for recycling batteries and recovering their valuable metals fits in perfectly with the concept of "Urban Mine" or "Mine above ground."

Its exclusive hydrometallurgical recycling methods respond to numerous sustainability challenges:

- Limited CO₂ emissions
- Low energy consumption
- Reduced environmental impact
- High recycling rates

With operations in France, Poland, and in Singapore, Recupyl has carved out a leading position in the global Battery & Accumulator recycling market.

Recupyl’s focus on innovation is backed by extensive R&D and a broad patent portfolio.

**FROM WASTE TO INDUSTRIAL PIGMENTS**

Recupyl has developed a process for recycling steel dust and preparing it for use in industrial pigments based on similar hydrometallurgical technology.

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The company used to recycle Li-Ion cells in the past based on subsidies – The company stop to do that today and focus on Alkaline cell recycling

http://www.recupyl.com
Korea’s first EV battery recycling centre on Jeju island

A new recycling centre for batteries from electric cars will open on Jeju island, Korea. They broke ground for the 14.5 million euro facility at Jeju Technopark. Recycling as well as research and testing operations are set to start in 2020.

Supported by the Ministry of Trade, Industry and Energy, the project is expected to cost a total of 18.9 billion won (14.5M euros). Funding comes through the central government in Seoul, local government and the private sector.

The recycling center will cover an area of 2,458 square meters and will be three stories tall. The facility will include a space for checking batteries and a separate research lab.

The project is a partnership between the Korea Battery Industry Association, the Korea Automotive Technology Institute and Jeju National University. Together they are to work out a standard for batteries depending on their applications.

The government of Jeju says operations will begin in 2020, with equipment and researchers starting to move in from December 2019.

Korea EV Battery Recycling

 Jul 5, 2018

Project partners:
KBIA, KATI, Jeju National University
China EV Battery Recycling

Jul 26, 2018

China is launching local initiatives for battery recycling

China has selected 17 cities and regions to launch a pilot program for battery recycling for old EVs. The program will be launched in the major cities Beijing, Shanghai and Xiamen, as well as the provinces of Jiangsu, Anhui and Guangdong.

The plan was announced by the Chinese ministry for Industry and IT in a statement yesterday. City and regional governments are supposed to be motivated to cooperate in this area with automobile manufacturers, as well as including battery manufacturers as well as used-car sales and scrap dealers. This way, they hope to set up a whole recycling ecosystem to help deal with the expected flood of old EV batteries in the next years.

In February, the Chinese government already presented an outline for the plan, which also will see the development of a system to track batteries from the resource stage throughout their entire life-cycle. A core component of the plan is to issue codes for individual batteries.

For 2018, China is expecting a total amount of 170,000 tonnes of trash produced by EV batteries. For this reason, the government is taking measures to prevent the increasing amount of pollution from the industry. The February outline also included a preliminary ruling to require EV manufacturers to take responsibility for the batteries for their vehicles and set up provisions for the collection and recycling of used batteries, as well. Battery manufacturers will be required to set up standardized and easily disassembled batteries to ease the recycling process. Furthermore, technical schooling for automobile manufacturers will be required for the storage and disassembly of old batteries.

caixinglobal.com
Summary

• Li-Ion batteries are the system of choice for many applications

• Li-Ion battery market share is growing dramatically

• Efficient Li-ion battery recycling process is mandatory for cost reduction

• Around 5-7% of Li-Ion cells manufactured today are recycled worldwide (2018 estimation)

• Li-Ion battery recycling market is leaded by few companies (Umicore and 2 Chinese and 1 Korean) – These companies develop an economical cost effective process

• More R&D and business supporting policies are needed

• More details in our Li-ion battery recycling market report 2018
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Information for presentation obtained by:
1. Public web sources.
2. Shmuel De-Leon Battery/Energy Sources DataBase ® (Includes 29000 cell PDF data sheets) http://www.sdle.co.il/Default.asp?sType=0&Pageld=45580