Metals of the future

FinEx 2016

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Aluminium – the wonder material

Growing end markets and the substitute material of choice
Unbalanced world

World ex-China supply gap, million tonnes

China supply gap, million tonnes

Aluminium consumption growth is well supplied
Performance and cost targets key for EVs

Vehicle Weight Reduction
Reduce vehicle weight by nearly 30% (includes body, chassis, interior, electric drive components, and compounding weight reductions)

Electric Drive System
Reduce cost from $30/kW in 2012 to $8/kW (1.4 kW/kg, 4 kW/L, 94% efficiency)

Battery
Reduce cost from $500/kWh in 2012 to $125/kWh (250 Wh/kg, 400 Wh/L, 2 kW/kg)

Reduce cost, weight and increase energy density and power output
Tipping point reached: exponential growth in electric vehicles in China

New EV sales, number of vehicles

- Plug-in Hybrids
- All Electric Vehicles

CAGR 150%

8,000

2011 2012 2013 2014 2015

330,000

Electric Vehicles market growth increases demand for batteries

Chinese Government Target of 5 Million EVs on road by 2020

5 Million
Reachable battery technology has advanced since the Walkman.

Size of the battery market is huge, with fast growing end use sectors.
## Demand by end-use

<table>
<thead>
<tr>
<th>End-Use</th>
<th>CAGR growth 2015-2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phones, Laptops, Tablets</td>
<td>3.13%</td>
</tr>
<tr>
<td>Energy Storage Devices</td>
<td>24.42%</td>
</tr>
<tr>
<td>eTransport (ex. EVs, HEVs, PHEVs)</td>
<td>7.39%</td>
</tr>
<tr>
<td>EVs</td>
<td>30.92%</td>
</tr>
<tr>
<td>HEVs</td>
<td>12.40%</td>
</tr>
<tr>
<td>PHEVs</td>
<td>20.34%</td>
</tr>
<tr>
<td>Other</td>
<td>-0.69%</td>
</tr>
</tbody>
</table>

*HEV = Hybrid electric vehicle, **PHEV = Plug-in hybrid electric vehicle
Lead acid remains the dominant battery type

Lithium batteries will show the highest growth
Lithium has become the dominant cell type for EVs and electronic applications.
Lithium demand is expected to grow at a CAGR of 6.3% through to 2025

Lithium central to chemistries of major battery applications
When demand surprises a commodity market – price reacts

Nominal, US$/t**

Where to next for lithium prices depends on how supply responds
Lithium is the battery metal of today and the future
Chinese brines would struggle to compete in 2016 but by 2020 are mid-curve.

By 2016, the Chinese brines were expected to face significant challenges in competing with other production sources. For instance, the costs of production were high compared to other brine sources. By 2020, however, the costs had decreased, allowing Chinese brines to become more competitive.

In the 2016 graph, the Chinese brines were shown in blue, and their costs were compared to other sources such as hard rock and brines from different locations. The cumulative production was also shown, indicating the volume of lithium produced over time.

The 2020 graph showed a similar comparison, but with a lower cost curve for Chinese brines, indicating improved competitiveness. The cumulative production was also shown, highlighting the growth in production over time.
Li and Co battery material supply constraints, sufficient supply of other metals

Proportion of metal demand for LIBs as a share of total demand, 2015

Proportion of additional demand growth driven by batteries, 2015-2020

Primary market driver Limited impact on market
Cobalt consumption in EVs was CAGR 185% 2010-2015

Li-ion will account for half global cobalt demand
Complex supply chain with half of supply from bi-product mines

Cobalt market is prone to bottlenecks as the market tightens.
All electric world needs to be connected

Copper will remain a central Metal
Metals of the Future – in a plugged in world

AI – The wonder material

Li – Battery metal rising

Co – Important by-product

Cu – The Ultimate connector
Metals of the Future – in a plugged in world
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