Battery raw material pricing in a lithium ion era

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What is Benchmark?

Subscriptions

- Lithium
- Graphite
- Cobalt

Events

- Graphite Supply Chain 2016
- Cathodes 2017
- Benchmark World Tour

Membership
Benchmark’s Price Assessments

- Prices collected to a mineral specific methodology
- Specialising in battery grade materials
- Onsite visits key

Now quoting basic Benchmark Mineral Intelligence prices

Detailed prices & analysis exclusive to subscribers
How do we do this?

- First hand data collection...

Heilongjiang, Northern China

Hirschau, Germany

Palo Alto, California, US
Convergence of three multi billion dollar industries: Auto, Tech, Energy
The lithium ion battery megafactories

- Expansions an order of magnitude bigger than anything before
  - 2016: 29 GWh
  - 2020: 234 GWh

- Expansions from majors and new market entrants

- China: key to capacity growth

- N. America & Europe lagging behind but significant investments likely
How many pure EVs can this new capacity make?

2016: 29GWh Megafactory Capacity

483,000 Model 3s

2020: 234GWh Megafactory Capacity

3.9m Model 3s
How many pure EVs can this new capacity make?

2016: 29GWh Megafactory Capacity

- 23,000 tonnes Lithium LCE
- 34,800 tonnes Graphite anode
- 9,200 tonnes Cobalt chemical

2020: 234GWh Megafactory Capacity

- 188,000 tonnes Lithium LCE
- 282,000 tonnes Graphite anode
- 75,000 tonnes Cobalt chemical
Market growth required to meet this new capacity

Graphite: 650,000 tonnes (95%)
Lithium: 180,000 tonnes (105%)
Cobalt: 93,000 tonnes (80%)
How are raw material markets evolving?
Battery market share for critical battery raw materials

- Different levels of battery demand: from industrial-driven to battery-driven

- 3 case studies in battery demand growth:
  - **Natural flake graphite**: Li-ion to challenge for top spot
  - **Cobalt**: Li-ion dominance to grow
  - **Lithium**: Li-ion now driver
Lithium ion batteries to challenge for top spot...

Flake Graphite’s End Markets

- **2006**: 559,000 tonnes
- **2016**: 650,000 tonnes
- **2020**: 884,000 tonnes
Flake graphite price trend

1. Premature growth
2. Industrial drivers = commodity trend
3. Battery importance grows
Cobalt
Lithium ion dominance to grow...

Cobalt’s End Markets

<table>
<thead>
<tr>
<th>Year</th>
<th>2006</th>
<th>2016</th>
<th>2020</th>
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<tbody>
<tr>
<td></td>
<td>20%</td>
<td>51%</td>
<td>62%</td>
</tr>
<tr>
<td>51,000 tonnes</td>
<td>96,000 tonnes</td>
<td>126,000 tonnes</td>
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</table>
Cobalt price trend

1. Chemistry concerns
2. Prices fluctuation
3. Battery surge
Benchmark’s 2025 lithium demand based on battery forecasts

- **A/B**
  - 2016: [Graph data]
  - 2020: [Graph data]

- **Goldman Sachs**
  - 2016: [Graph data]
  - 2020: [Graph data]

- **BENCHMARK MINERAL INTELLIGENCE**
  - 2016: [Graph data]
  - 2020: [Graph data]

- **Cairn ERA**
  - 2016: [Graph data]
  - 2020: [Graph data]

**Tonnes**

- 0
- 100,000
- 200,000
- 300,000
- 400,000
- 500,000

*June 2017 | DERA Industrieworkshop | Berlin-Spandau*
Lithium ion batteries now the driver...

Lithium’s End Markets

- **2006**: 22%
  - Total: 110,000 tonnes

- **2016**: 42%
  - Total: 175,000 tonnes

- **2020**: 67%
  - Total: 280,000 tonnes
Lithium chemical price trend

1. Steady demand growth
2. Suppliers unable to react
3. High prices persist
**Where next for lithium prices?**

- Prices to remain significantly higher than 2015 levels
- New supplies to come into the market approaching 2020 but demand growth will outpace expansions in the short-term
- Key factor in supply/demand balance will be the amount of new material that is battery-grade
- Historically, very few lithium projects have come into the market on target
Final thoughts

1. Growth in the li-ion battery market out to 2020 will change the pricing structures of critical raw material markets

2. To meet even a fraction of the targeted battery capacity expansions by 2020, significant developments will be needed upstream

3. As the battery industry becomes the leading end-market for these niche minerals, their fates will become further removed from traditional industrial markets – already underway

4. The inelastic nature of critical mineral supply means the medium-term outlook for prices is strong
Battery raw material pricing and data